Why is French Unemployment so high ? new evidence from a WS-PS model estimation

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This draft
January 2001

Abstract

We propose a multivariate estimation of the WS-PS model on French macroeconomic quaterly data : we have estimated using a conditional VAR-ECM model, the relationships between unemployment rate, real labour cost and its determinants over the 1970-1/1996-4 period. The estimation leads to a rate of equilibrium unemployment nearing its effective level at the end of the period. The rise in equilibrium unemployment, by 10 points in 25 years, would be accounted for essentially by the rise of tax and social wedge, the slow down of labour productivity and by deterioration of job security. The terms of exchange which have essentially varied under the impact of oil crises and distortion between proposed and required qualifications on labour market, would only account for a slight part of the rise of equilibrium unemployment.

Keywords : *labour market, ws-ps model; equilibrium unemployment; cointegration; conditional VAR-ECM model.*

JEL Classification : *C32, E24*

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1. Introduction

Equilibrium unemployment theoreticians commonly substitute a structural relation called WS for *Wage Schedule* (Lindbeck, 1993) for the labour supply from households in the traditional equilibrium of the labour market. The shape of this relation is deduced from theoretical models most often based on the micro economic behaviours described by the new labour market theories (efficiency wages, bargaining models, insiders/outsiders approach...). This relation intersects another one which describes structural price setting (PS). They jointly determine the equilibrium unemployment level that will be modified by structural shocks affecting the determinants of wage or price setting, notably oil crises, shocks on the level of direct or indirect taxes and real interest rate shocks. This sensibility to structural shocks distinguish the approaches in term of equilibrium unemployment, qualified of structuralism by Phelps (1994) from those in term of natural unemployment, in the tradition of Friedman (1968). Moreover, it leads to a more numerous unemployment determinant set than the one usually considered by a Phillips' curve approach (Bean, 1994). The theoretical WS-PS models have been popularised through the work of Layard, Nickell et Jackman (1991). They have now integrated employed worker heterogeneity (see for instance Laffargue, 1995) and the dynamic aspects of wage setting (Manning, 1993; Cahuc et Zylberberg, 1998). This theoretical maturity has translated into an impressive extension in the list of potential unemployment explanations, which both rest on explicit micro economic bases and are connected to wage or price schedule in a general equilibrium framework.

This theoretical maturity contrasts with the state of empirical research whose aim is to estimate the WS-PS model. The literature on this topic can be categorised into two separate groups. The univariate estimations of the WS and PS relations are compatible with a large number of unemployment equilibrium determinants, in accordance with the theory, but don't take the interdependencies between variables into account. Inversely a too large number of variables becomes in practice incompatible with a multivariate estimation of the WS and PS relations, yet it is more satisfactory to take the interdependencies between wage and price setting into account. On French macroeconomic data, the equilibrium unemployment rise since the early seventies, has thus been entirely explained by real interest rate evolution, technical progress and the terms of exchange in Bonnet and Mahfouz (1996), by the evolution of the wage wedge, the replacement ratio and productivity in L'Horty and Sobczak (1997), by the evolution of capital cost and the wage wedge in Cotis, Méary et Sobczak (1997). These multivariate estimations put the emphasis on the crucial role of some variables but don't tell everything on unemployment rise and persistence.

The purpose of this paper is to propose an estimation of the WS-PS model on French macroeconomic data that both uses Johansen's multivariate estimation techniques and is compatible with a large number of variables. This re-estimation is made possible by taking the weak exogeneity properties of variables into account. One can effectively partition the multivariate model in two blocs whose parameters vary freely : a marginal model gathering the weakly exogenous variables for the long run parameters of the VAR-ECM model, and a conditional model composed of other equations. Cointegration vectors can then be estimated only from the conditional model, which permits to reduce the system size without loosing any information from the full VAR-ECM.

Starting from a quarterly database composed of 16 series and covering the 1970-1/1996-4 period, we estimate the WS-PS model using an unrestricted VAR-ECM approach, composed of ten variables. Two cointegration relations are estimated from a partial system composed of seven equations, conditionally on the three equations describing the evolution of weakly exogenous variables. Finally, exclusion tests lead to keep only five determinants to unemployment equilibrium development in France : hourly productivity, through which real interest rates can have an impact, the terms of inside exchange, which essentially vary under the impact of oil crises and the exchange rate; the quit ratio, the aggregate wage wedge through which the different deduction rates can have an influence, and the skilled mismatch.

The used method permits to calculate the respective influence of these determinants and their retrospective contributions to unemployment development. On the other hand, the replacement ratio which depends on the generosity of the unemployment benefit system, working hours, the French minimum wage (Smic) increase and the progressiveness of social wedge would only have had a non significant role in the evolution of equilibrium unemployment according to this estimation.

The second section is a theoretical reminder of the WS-PS model. It presents the list of potential variables that can account for unemployment equilibrium, the mechanisms through which these variables have an influence and the data used in this study which requires the buildings of several original indicators for the different variables. Finally, the third section presents the model estimation results.

2. Equilibrium unemployment determinants and their measures

The richest theoretical model would start from wage and price setting micro-economic bases, in a dynamic framework that would take agent anticipation setting into account, where labour would be a heterogeneous factor, where the whole deductions and transfer systems would be modelled, including the modalities of unemployment benefit payments, their digressiveness in time and more generally the degree of progressiveness of the whole deductions and transfers, and would deduce the structural form of WS and PS in the short and long run, in a general equilibrium framework which enables to describe the whole determinants of equilibrium unemployment. Given all these enrichments, no analytic solution probably exists to the log-linearisation of structural wage and price curves. Moreover the specification of log-non-linear structural expressions of these curves would be highly dependent on the whole successive modelling choices, and would make a non- linear estimation very delicate. In all cases, writing such a full model seems to be out of reached.

The estimation strategy adopted here is less ambitious. We have chosen to keep from theory a list of variables, their expected signs, possibly some bounds for their elasticities and not more. Then, we let data speak for themselves in a multivariate log-linear estimation framework.

Theoretical variables

A first list of variables is given by a WS-PS model inspired from Layard, Nickell and Jackman (1991). In that model, goods market are in imperfect competition and wages are the result of a negotiation between unions and employers, the latter keeping their right to manage. This static homogenous labour factor model, enables us to describe the traditional determinants of price and wage schedule and equilibrium unemployment (see appendix 1 for a formal presentation).

This model can be completed by specification enrichments which enable to introduce new variables, by taking into account dynamic aspects of wage and price schedule and by the introduction of labour heterogeneity. A first specification enrichment consists to introduce working hours. If hours and men are perfect substitutes concerning the technology used by firms, and if working hour reduction isn’t compensated by a rise in hourly wages, taking working hours into account wouldn’t change the PS expression. Working hour reduction can also affect wage setting, according to the individual and union utility functions and the way this reduction is implemented (imposed or bargained). Another specification enrichment is not to suppose anymore that the different deductions are flat. Then, if the progressiveness of social or fiscal deductions is taken into account, price equation remained unchanged but wage equation is distorted, a stronger progressiveness having the same effect as a reduction of union market power in the bargaining. Moreover in the Layard, Nickell and Jackman model (1991), a φ parameter is introduced to weight unemployment rate in the expression of the employed workers’ withdrawal in the bargaining. This parameter represents the risk to become unemployed as a function of unemployment rate. Unemployment risk can also be measured in reference to short length unemployment rate or to quit ratio extracted from data flows on the labour market. This latter extension is also essential when the dynamic aspects of the wage setting are taken into account. Finally, taking employed worker heterogeneity into account leads to other enrichments in the understanding of employment setting. If one distinguishes different qualifications, one takes the consequences of the skilled mismatch on the labour market into account.

All in all, the initial theoretical model and its enrichments lead to make price and wage schedule depend on apparent labour productivity or on real interest rate, on demand elasticity to prices, on the efficiency of the labour factor (which corresponds with a Cobb-Douglas production function to the share of wages in added value) and on working hours. As far as real wage setting is concerned, it depends on unemployment rate, on union bargaining power, on the degree of competition on the goods market, on employed workers' risk aversion, on replacement ratio, on wage wedge and its components, on working hours, on wage wedge progressiveness, on quit ratio and on the skilled mismatch. Equilibrium unemployment depends on all these determinants as soon as their elasticities differ in price and wage equations.

Indicators for those variables

The empirical evaluation of equilibrium unemployment is faced with a data deficit. Some determinants of the WS-PS models are not directly observable and can't therefore be found in any existing database. It's the case of price elasticity of goods demand which embodies the degree of competition between offers on the product markets. It's also the case of the battle of mark-up between employed workers' and employers' representatives in wage bargaining, of employed workers' risk aversion or of their psychological discount rate. Other theoretical determinants of equilibrium unemployment can be observed in a more or less direct way, but are not the subject of standardised statistic series (it's the case of replacement ratio or of wage wedge progressiveness for instance). Confronted with this data deficit, an answer is to build indicators for these variables. The asset of building indicators is to produce new statistics which contain information on the market labour evolution.

Most traditional data are gross wage, prices, added value, employment and unemployment rate. We use the average gross hourly wage rate calculated in non financial non agricultural manufacturing sectors, which has been extracted from quarterly accounts. It's also the case for consumption prices (P31-V0T6), and for added value prices and employment, which have all been re-calculated in the field of non financial non agricultural manufacturing sectors. Two labour apparent productivity indicators have been used : productivity per capita which is the ratio of added value to employed workers, hourly productivity which is the ratio of per capita productivity to working hours.

Working hours is the synthetic indicator calculated by the French Ministry of Labor. It takes part-time job development into account, which has been promoted over the recent period by the state specific assistance (a basic reduction of social wedge to share part-time jobs, some modalities of social contribution reduction on low wages which were encouraging part-time job). This indicator decreases throughout the nineties and in a more important way after 1993, because of the accelerated diffusion of part-time jobs. It's closer to average working hours really performed by workers.

Real interest rate is the price of public and semi- public bonds. Its direct introduction into a price equation justifies itself when one considers the capital setting as endogenous and when one consider the existence of an asymmetry in capital and labour mobilities. In the case of a small open economy on a perfectly integrated world-wide capital market, the interest rate is fixed from abroad and entails capitalistic intensity and equilibrium productivity, which is decisive for price behaviours. An increase in interest rates reduces equilibrium capitalistic intensity, which leads to a decrease in equilibrium labour costs and to a rise in unemployment (PS is horizontal and moves downwards)

Wage wedge is composed of inside exchange terms, which are the ratio of consumption prices to producer prices, and of the social and fiscal wedge, which is itself composed of the social wedge (employers' and employee's contribution rates) and of the fiscal wedge (VAT, income tax rate). Employers' and employee' contribution rates (cse et css) are extracted from social scales, applied to medium wage, given the evolution of social security ceiling. Direct or indirect (ir et tva) income tax rates, are extracted from the databases of the French Ministry of Finances. Theoretically, only the deductions that are not considered by employed workers as benefits or postponed income compensations exert an upward pressure on labour cost and equilibrium unemployment.

For the replacement ratio, we use the indicator built by the Unédic (1997) which is an average of the situations of all unemployed workers at a given date. An extension of unemployment duration leads to a replacement rate reduction, which is a satisfactory result. This quarterly indicator has been available since 1986. For previous years, we have used the unemployment benefit scales applied to the situation of a medium unemployed worker whose period out of work is given by employment survey long series (we have supposed moreover a 6 to 12 month affiliation duration). Spontaneously, the two series are very close in 1986. The replacement ratio is clearly decreasing after the 1992 reform of unemployment benefits.

To measure the quit ratio, we have used the transition rate between employment and unemployment, extracted from employment survey, and quaterlised by a simple linear interpolation. It's important to notice that this rate is not directly connected to unemployment rate : more intensive flows from employment to unemployment don't imply an increase of unemployment rate, as soon as transitions from inactivity can decrease and exit employment rate can rise. Controversially, an employment flow reduction to unemployment doesn't imply an unemployment decrease, as soon as they can be compensated by an increase of the transitions from inactivity to unemployment, or by a reduction of unemployment exits to employment or inactivity. This transition rate from employment to unemployment is an approximate measure of the probability to be laid off, which can vary in an inverse way to unemployment rate.

Employed workers bargaining power is one of the parameters on which we have very little information. Instead of using a simple trend or a unionisation rate, whose reading is complex in the case of France, we have used the complete set of hikes, given to the minimum wage (SMIC). It's an indirect proxy, whose justification is less to demonstrate the wage scale rigidity when SMIC is increased, than to sum up in a synthetic way the evolution of the general climate around wage setting.

The progressiveness of wage wedge (prog) is calculated here using the residual progressiveness indicator proposed by Jakobsson (1976). The progressiveness of the contributions of employers and employees are here calculated separately and the aggregate indicator is obtained by summation.

The mismatch indicator (mm) is the semi-variance of relative employment rates by qualification, whose theoretical reading has been given by Jackman, Layard and Savouri (1991) : when wage curves are convex, a more important dispersal of unemployment rates induces an upward pressure on wages, that leads to a higher equilibrium unemployment rate. Sneessens' indicator (1994) has also been tested. It deals with the ratio of the share of qualified employed workers in employment to their share in labour force.

Univariate properties of the series

The database is composed of 16 quarterly series; it concerns the non agricultural manufacturing sector and covers the 1970-1 to 1996-4 period. Deduction rate can be regrouped in two levels of aggregation and progressiveness indicators can be once, which add up five indicators.

u : unemployment rate,

w-p : labour real cost, (deflated by added value price),

prodh : hourly productivity,

tr : replacement rate ,

cp : Complete set of Smic hikes,

r : real interest rate ,

ec : quit ratio,

mm : mismatch, (mismatch unemployment indicator),

h : working hours,

coin : global wedge wedge,

- pc-p : the terms of exchange,
- coinfs : fiscal and social wedge,
  - coins : social wedge,
    - css : employee contribution rate,
    - cse : employer contribution rate,
  - coinf : fiscal wedge,
    - tva : added value tax,
    - tir : income tax rate,

prog : progressiveness of social wedge,

- progcse : employers' social contribution progressiveness,
- progcss : employees' social contribution progressiveness,

The analysis first step is simply to look at the data univariate properties and to determine their integratedness degree. Theoretically a process is either I(0), I(1) or I(2). Nevertheless in practice many variables or variable combinations are bordeline cases, so that distinguishing between a strongly autoregressive I(0) or I(1) process (interest rates are a typical example), between a strongly autoregressive I(1) or I(2) process (nominal prices are a typical example) is far from being easy. We have therefore applied a sequences of standard unit root tests (Augmented dickey Fuller tests, namely Jobert's procedure (1992)), as well as Schmidt and phillips'test (1992), Kwiatkowsky, Phillips and Shin test (KPSS) (1992)), to investigate which of the I(0), I(1), I(2) assumption is most likely to hold. The results of the Jobert procedure, of the Schmidt and phillips' test and of the KPSS tests are reported in appendix 2. Most variables seems well characterised as an I(1) process, some with non-zero drift. Nevertheless, concerning (u, cp, pc-p et tr) the results given by the different tests aren't all concomitant and don't permit us to decide between an I(0) or I(1) process : they diverge on the number of lags to introduce to have white noise residuals, and on the applied unit root test.

3. WS-PS model estimation

This section describes the results of the unrestricted VAR-ECM modelling that we have finally adopted (see appendix 3 for an estimation strategy description). Before choosing this model, we have made many prior estimations whose main results we can only sum up. Firstly it has been impossible to estimate a satisfactory model when the complete set of Smic hikes and progressiveness indicators were taken into account. Moreover, it hasn't been possible to get a satisfactory estimation when Sneessens' indicator (1994) was introduced and the estimations have been made using Jackman, Layard and Savouri indicator (1991), which was significantly different from zero in almost all the prior estimations we have made. We had to limit wage wedge split up between inside exchange terms and fiscal and social wedge without being able to split up within the latter. In other respects, the most satisfactory models have been obtained using hourly labour cost and productivity specifications (and not per capita). Finally modelling attempts with unemployment rate rather than its logarithm have been unsuccessful.

The adopted model is composed of the following ten variables : unemployment rate, hourly real cost, hourly productivity, replacement ratio, mismatch, real interest rate, quit ratio, working hours, the terms of exchange, fiscal and social wedge (which combine four deduction rates). The point is to study the interdependencies between these variables, transformed in natural logarithm, without making any *a priori* hypothesis on the value of the elasticities linking them and to test the existence of long run relations.

Two cointegration relations

The lag length choice used in the specification of the unrestricted VAR-ECM model is based on the results of two information criteria (Schwarz' bayesian information criterion and Hannan-Quinn criterion), and on global Fisher's tests. These different methods all indicate an optimal value of two quarters. One must notice that the lag length choice used in the VAR-ECM model is a crucial stage of the analysis, since it can noticeably affect the determination of the dimension of the cointegrating space, that is, the rank of the Π matrix : The simulations made by Boswijk and Franses [1992], Gonzalo [1994] show that underfitting leads to underestimate the number of long run relations, whereas overfitting leads to overestimate this number. Moreover these simulations show that asymptotic distributions of the trace and eigenvalue tests proposed by Johansen [1988], can be rather bad approximations to the true small sample distributions, and should be therefore used with caution. Boswijk and Franses [1992] advocate to use the corrected version of these two tests, which perform better in the case of small or medium sample size. These small sample corrected versions of test statistics denoted by $l_{\max}^{adj}$ and l_{trace}^{adj}, are obtained by premultiplying the usual test statistics by (T – np) instead of T, where n is the model variable number and p the VAR order.

Once the lag length used in VAR-ECM model specification has been determined, the next step is to test the number of cointegrating relationships existing between the ten variables of the system. At this stage, a prior point must be underlined : the asymptotic distributions of the cointegration tests depend on the deterministic components (which are not explicitly modelled) in the system. In particular, these tests are conditional on the possible presence of a constant or a linear deterministic trend in the long run relations. For instance, if the linear deterministic trend is not constrained to lie in the cointegrating space, the presence of a non-zero deterministic trend outside the long run relations indicates the presence of a quadratic trend in every component of the system taken in level, since the system is written in first differences. In the same way, if the constant is unrestricted, this modelling allows for a linear deterministic trend in the level of series.

To know how to model these deterministic components, one can possibly use the results of the sequences of standard unit root tests applied previously and especially Schmidt-Phillips [1992] ones, that haven't turned down the possibility that some of these series have a linear drift. That's why all the cointegrating rank tests have been investigated in a system with an unrestricted constant, as well as a linear deterministic trend constrained to lie in the cointegrating space. The small sample corrected versions of the two LR test statistics (trace test and Lambda max test) and also the critical value taken from Johansen [1995], are reported in table 1 :

TABLE 1 – **Estimation of the number of cointegrating relationships**

Ho against Ha	$l_{\max}^{adj}$		l_{trace}^{adj}	
	Statistic	Critical value (à 5 %)	Statistic	Critical value (à 5 %)
r = 0 against r = 1	77.22 **	66.2	310.90 **	263.4
r ≤ 1 against r = 2	60.46	61.3	233.60 *	222.2
r ≤ 2 against r = 3	48.07	55.5	173.20	182.8
r ≤ 3 against r = 4	39.97	49.4	125.10	146.8
r ≤ 4 against r = 5	32.50	44.0	85.14	114.9
r ≤ 5 against r = 6	16.97	37.5	52.64	87.3
r ≤ 6 against r = 7	14.43	31.5	35.66	63.0
r ≤ 7 against r = 8	10.52	25.5	21.23	42.4
r ≤ 8 against r = 9	7.67	19.0	10.71	25.3
r ≤ 9 against r = 10	3.03	12.2	3.037	12.2

These test statistics indicate the existence of two cointegrating relationships[1] between the ten considered variables.[2].The estimation of the cointegrating vectors and of the adjustment coefficients will be given later.

Once the cointegrating rank has been determined, systematic LR tests on the deterministic components have been made. These tests confirm the results and lead to accept a specification of the Vector Error Correction Model (VAR-ECM), with an unrestricted constant in the short run, as well as a linear deterministic constrained to lie in cointegrating relationships. From now model specification is completely determined (two lags, two cointegrating relationships and a linear deterministic trend constrained to lie in cointegrating relationships).

Weakly exogenous variables and those excluded from cointegrating space

The next step is to ask oneself if some system variables can be considered as weakly exogenous for the parameters of the two cointegrating relationships found previously. If it is the case, these parameters can then be estimated without loss of information from the more manageable conditional model, because extracted from the full VAR-ECM model. This hypothesis of weak exogeneity is expressed by the nullity of some coefficients of the α.matrix. The following table produces the results of these weak exogeneity tests :

TABLE 2 – **Weak exogeneity tests of the different variables for all long run (α and β) parameters**

Variable	Weak exogeneity	LR test statistic
w-p	rejected	χ^2 (2) = 19.13 (0.00)
u	rejected	χ^2 (2) = 11.39 (0.00)
tr	not rejected	χ^2 (2) = 2.56 (0.27) [3]

[1] The outcome of the cointegration analysis remains unchanged if we use the critical values recently tabulated by Pesaran, Shin and Smith [1999].

[2] Given that the calculated statistic value of the $l_{\max}^{adj}$ test is very close to the 5 % critical value, it's reasonable to think as economic theory suggests that there exist two long run relations between the considered variables: that's what indicates besides the l_{trace}^{adj} test.

[3] The number in brackets indicates the marginal asymptotic level, namely the probability to exceed the value of the computed statistic. Thus a marginal asymptotic level of 27 % (0.27), means that for a α level smaller than 27 %, the null hypothesis H_o of weak exogeneity of the variable under study is accepted.

r	not rejected	χ^2 (2) = 0.97 (0.61)
coinfs	not rejected	χ^2 (2) = 4.03 (0.13)
h	rejected	χ^2 (2) = 19.27 (0.00)
mm	rejected	χ^2 (2) = 17.23 (0.00)
pc-p	rejected	χ^2 (2) = 12.84 (0.00)
prodh	rejected	χ^2 (2) = 10.78 (0.00)
ec	rejected	χ^2 (2) = 27.98 (0.00)

The results can be synthesised as follows : at a 5 % level, one reject the weak exogeneity of real labour cost, of unemployment rate, of working hours, of mismatch, of the term of exchange, of hourly productivity, of quit ratio. Moreover at a 5 % level, the joint weak exogeneity hypothesis of these three variables is easily accepted by data (χ^2 (6) = 5.24 (0.51)) : so, we have chosen to estimate the two long run relations from a partial VAR-ECM model composed of seven equations (w-p, u, h, mm, pc-p, prodh, ec), conditionally on the three equations describing the evolution of the weakly exogenous variables (tr, r, coinfs).

Then a first sequence of tests has been applied in order to determine if some system variables can be considered as not belonging to the two long run relations. The following table shows that at a 5 % level, replacement rate, real interest rate and working hours don't belong to the cointegrating space. Moreover at a 5 % level, the joint exclusion hypothesis of these three variables of the cointegrating space is easily accepted by data (χ^2 (6) = 2.30 (0.89)). Replacement ratio and real interest rate are thus both weakly exogeneous and excluded from the cointegrating space, which means in other words that they only have an influence on the short run dynamic of the price and wage schedule.

TABLE 3-**Tests of the structure of cointegrating space** [4]

Variable	Belonging to cointegrating space	LR test statistic
w-p	yes	χ^2 (2) = 31.46 (0.00)
u	yes	χ^2 (2) = 15.91 (0.00)
tr	no	χ^2 (2) = 0.19 (0.90) [5]

[4] The results given in this table have been obtained for some of them after, several iterations. In fact, two weekly exogenous variables have shown moreover not to belong to the cointegrating space. We found more logical to take step by step these two pieces of information into account, instead of making these two variables directly belong in the short run : for this purpose, we have first estimated a VAR-ECM in which the replacement rate only belonged in the short run dynamic, and have then re-tested in this framework, if the other variables belonged to the cointegrating space.

r	no	χ^2 (2) = 1.12 (0.57)
h	no	χ^2 (2) = 0.50 (0.77)
coinfs	yes	χ^2 (2) = 6.36 (0.04)
pc-p	yes	χ^2 (2) = 6.97 (0.03)
prodh	yes	χ^2 (2) = 6.39 (0.04)
ec	yes	χ^2 (2) = 26.15 (0.00)
trend	yes	χ^2 (2) = 6.46 (0.03)

Next it's interesting to ask oneself if there exists a variable belonging to the cointegrating space, which constitutes a cointegration relation alone. In this respect, table 4 presents the results of the stationarity tests around a linear deterministic trend of the different variables. For instance, to test if unemployment rate (u) is stationary around a linear deterministic trend, one has to test if vector b' = (0 1 0 0 0 0 0 a) belongs to the cointegrating space. The results of these tests are categorical, since they reject in every case the stationarity hypothesis around a linear deterministic trend of the seven variables belonging to the cointegrating space. Thus, the results of the stationarity tests applied in the multivariate framework, where the interdependencies between variables are explicitly modelled, are concomitant with those applied previously in the univariate framework. These tests indicate that the variables are characterised by a stochastic non stationarity (namely integrated of order 1), rather than a deterministic non stationarity (namely stationary around a linear deterministic trend).

TABLE 4 - **Stationarity tests of the different variables around a linear deterministic trend**

Variable	Stationarity around a linear deterministic trend	LR test statistic
w-p	rejected	χ^2 (6) = 33.11 (0.00)
U	rejected	χ^2 (6) = 31.02 (0.00)
Mm	rejected	χ^2 (6) = 52.65 (0.00)
Coinfs	rejected	χ^2 (6) = 29.74 (0.00)
Pc-p	rejected	χ^2 (6) = 58.59 (0.00)
Prodh	rejected	χ^2 (6) = 41.84 (0.00)
Ec	rejected	χ^2 (6) = 34.03 (0.00)

Table 5 gives the estimation of the two long run relations and the error correction coefficients obtained from the conditional model. :

[5] The number in brackets indicates the marginal asymptotic level, namely the probability to exceed the value of the computed statistic. Thus a marginal asymptotic level of 90 % (0.90), means that for a α level smaller than 90 %, the null hypothesis Ho of exclusion from the cointegrating space of the variable under study is accepted by the data.

TABLE 5 – **Maximum likelihood estimations of the normalised cointegrating vectors and of the error correction coefficients**

Variables	Normalised cointegrating vectors (**β matrix**)	
w-p	1.000	1.000
u	0.254	-0.506
mm	-0.083	-0.000
pc-p	-0.733	1.042
prodh	0.087	-3.012
ec	-0.403	0.260
coinfs	0.764	1.642
trend	-0.001	0.014

Variables	Error correction coefficients (**α matrix**)	
w-p	-0.091	0.087
	(-3.84)[6]	(6.77)
u	0.047	0.155
	(1.73)	(4.50)
mm	0.294	0.054
	(3.52)	(1.20)
h	-0.062	-0.034
	(-3.52)	(-4.06)
pc-p	-0.045	0.053
	(-1.64)	(3.48)
prodh	-0.042	0.068
	(-1.96)	(4.06)
ec	0.430	0.122
	(5.10)	(2.40)

PS and WS identification

Spontaneously, each of the two cointegrating vectors has an unemployment rate coefficient with an opposite sign, which indicates both a price and wage setting behaviour. Nevertheless, it’s important to notice that these two cointegrating vectors have no economic meaning at this stage, and are nothing other than a vectorial basis of the cointegrating space. Strictly, they are obtained as the eigenvectors of the long run Π matrix and any linear combination of these two vectors forms a new cointegrating relationship between the seven variables. These vectors have then only a purely statistical value. Econometrics modelling alone doesn’t permit to determine ex nihilo the structural form of (WS) and (PS) curves. So it doesn’t exempt from a theoretical thought about the form of structural equations, but requires on the contrary the a priori specification of identification conditions, using a theoretical model, before beginning the estimation. The identification of the two curves is investigated here using the following two theoretical restrictions : the wage determination (curve WS) is supposed to be made

[6] The number in brackets represents the T Stats.

independently of productivity level (Manning's identification restriction [1993]) and unemployment is supposed not to influence wage determination (curve PS). Structural forms are then obtained by calculating the two linear combinations of the estimated cointegrating vectors which satisfy identification constraints. It must be emphasised that it's not a test, but simply a change of basis in the cointegrating space, in order to distinguish statistically the two structural equations. After normalisation, the two just-identified long run relations are given by :

$$\begin{cases} w-p = 0.055\,mm + 0.138\,pc-p + 0.944\,prodh - 0.041\,coinfs + 0.181\,ec - 0.004\,trend & (PS) \\ w-p = -0.232\,u + 0.080\,mm + 0.679\,pc-p + 0.693\,coinfs + 0.384\,ec + 0.001\,trend & (WS) \end{cases}$$

Finally, over-identifying restrictions have been tested, the results are reported in table 6 : the exclusion of the fiscal and social wedge, of the terms of exchange and of the linear deterministic trend from the PS curve are accepted at a 5 % level.

TABLE 6 - **Tests of over-identifying restrictions**

Null hypothesis	Accepted hypothesis	LR test statistic
exclusion of h from (PS) and (WS), and exclusion of pc-p from (PS)	yes	χ^2 (3) = 0.94 (0.82)
exclusion of h from (PS) and (WS), and exclusion of pc-p and of coinfs from (PS)	yes	χ^2 (4) = 0.95 (0.92)
exclusion of h from (PS) and (WS), and exclusion of pc-p, coinfs and of the linear deterministic trend from (PS)	yes	χ^2 (5) = 6.21 (0.29)

Additional structural hypotheses have also been tested, as the exclusion of mm and ec variables from (PS), but they have all been rejected. The presence of these variables in price equation is not theoretically justified, which is a reason for dissatisfaction. Finally, the two over-identified long run relations are given by :

$$\begin{cases} w-p = 0.073mm + 0.204\,prodh + 0.230ec & (PS) \\ w-p = -0.050\,u + 0.078\,mm + 0.117\,pc-p + 0.159\,coinfs + 0.274\,ec + 0.001trend & (WS) \end{cases}$$

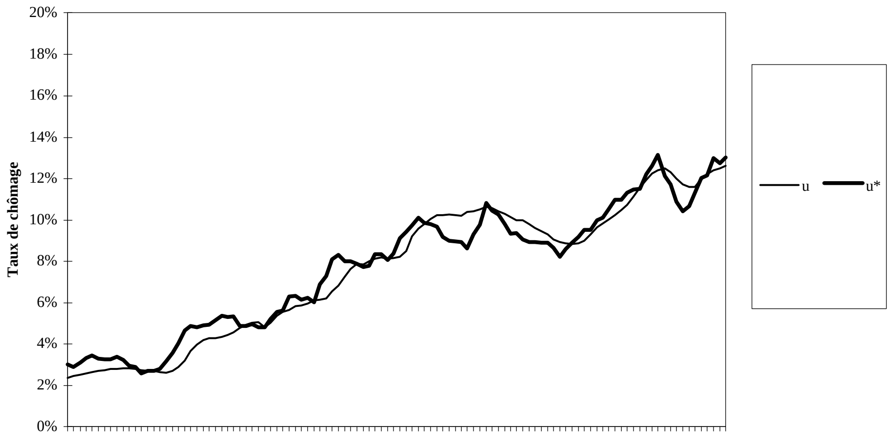
It's now possible to determine the equilibrium unemployment from the two estimated structural equations. For this purpose, one must solve the obtained equilibrium partial system of labour market. This resolution gives the following expression of equilibrium unemployment.

$$u^* = -4.1\,prodh + 2.34\,pc - p + 0.1\,mm + 0.88\,ec + 3.18\,co\inf s + 0.02\,trend$$

All equilibrium unemployment determinants have a sign in accordance with the theoretical idea. Equilibrium unemployment decreases when productivity speeds up (it moves closer a part of its trend) and increases with the terms of exchange (an oil crisis for instance, increases unemployment, since it leads to a higher rise of the consumption prices than added value prices), with the growing of skilled mismatch, with quit ratio, with fiscal and social wedge and its components. The contributions of the terms of exchange and of mismatch would remain quite small (it’s about 5 % of equilibrium unemployment increase).

The following graph represents effective unemployment rate and equilibrium unemployment rate. The latter is defined up to a constant which implies to choose a reference value : we have chosen the 1973 average rate, so we have supposed the equality between effective unemployment and equilibrium unemployment that year. Equilibrium unemployment hasn’t been smoothed here, and neither have its determinants.

Graph 1 : effective unemployment rate and equilibrium unemployment rate



Diagnostic tests on the residuals

The last step is to establish whether the estimated VAR-ECM model is a reasonably congruent representation of the data. We have therefore implemented two kind of tests, misspecification and constancy tests.

Firstly, several test statistics have been calculated in order to check the quality of the multivariate estimation (Lagrange Multiplicator test (LM) and Ljung-Box test for serial correlation of order 16, ARCH tests (Autoregressive Conditional Heteroscedasticity), Jarque-Bera normality test). The tests constitute a good way to detect possible failing of some hypotheses made during the system estimation. These tests indicate that the conditional VAR-ECM model is well behaved and not subject to misspecification, since the usual hypotheses concerning the residuals of each of the seven equations are verified[7] (see table 2).

TABLE 7 –**Specification tests of the residuals of the conditional VAR model**

Equation	Test statistics			
	LB (16)	WHITE (F-Form)	ARCH(16)	JB(2)
Dw-p	19.43 (0.14)[8]	0.69 (0.87)	20.15 (0.21)	1.59 (0.44)
Du	14.64 (0.40)	1.37 (0.16)	18.99 (0.26)	32.21 (0.00)
Dmm	17.03 (0.25)	1.57 (0.07)	15.81 (0.46)	4.53 (0.10)
Dh	24.55 (0.03)	0.67 (0.93)	24.85 (0.07)	61.39 (0.00)
DPc-p	30.23 (0.007)	0.98 (0.52)	23.79 (0.09)	4.21 (0.12)
Dprodh	11.69 (0.63)	0.56 (0.92)	11.74 (0.76)	5.68 (0.05)
Dec	21.87 (0.08)	1.01 (0.48)	13.86 (0.60)	75.01 (0.00)

[7] The residuals of the conditional VAR-ECM model equations have on the whole good properties : they don’t suffer from serial correlation, are not of ARCH type, even if they sometimes have normality problems. This lack of normality assumption in some equations is actually not very serious for the conclusions of the study, since as noted by Johansen (1995), the asymptotic properties of the Maximum Likelihood method only depend on the i.i.d assumption of the errors.

[8] The number in brackets indicates the marginal asymptotic level, namely the probability to exceed the value of the computed statistic. Thus a marginal asymptotic level of 14 % (0.14), means that for a Ho level smaller than 14 %, the null hypothesis Ho of absence of residual serial correlation of order 16 is accepted by data.

Secondly, the conditional and marginal VAR-ECM models have been re-estimated by recursive least squares until 1996-4. This estimation method is commonly used in empirical studies since it enables to follow the evolution of the estimated vector of coefficients when one adds a new piece of information at each step in this estimation. Moreover it also offers the possibility to build graphs and to carry out tests in order to appreciate the parameter constancy through time and to perform Chow tests so as to detect a possible break. The graphs reported in Appendix 4 have been built in re-estimating successively the two models, but each time always for a longer period (the first estimation has been done for the 1974-4-1980-1period). We have applied Onestep ahead, as well as Backward and Forward Chow tests. The graph examination doesn't reveal any particular break, so that the parameters of the conditional and marginal VAR-ECM models seem to be constant through time as it is confirmed by the global stability graphs.

Thus the misspecification and constancy tests indicate that the estimated conditional VAR-ECM model is a satisfactory representation of the data.

Conclusion

One can consider a great number of possible explanations to the rise and persistency of unemployment in France. The aim of this paper was to confront some of these determinants to the data in a WS-PS model estimation framework, on French macroeconomic data.

First and foremost, one has chosen a selection of about fifteen variables whose influence rested both on explicit micro-economic bases and had been founded in a general equilibrium framework. To this first filter, of a theoretical order, a second one of a statistical order has been added up, resulting in the possibility to build indicators for these determinants, and a third one of an econometric order, resulting in the model estimation. Finally, only five variables have come to the end of this procedure. The equilibrium unemployment increase in France would reflect the slowing down of productivity gains, the increase of social and fiscal wedges, the job security deterioration and in a more marginal way, the terms of exchange increase and the skilled mismatch.

Considering a richer set of variables and a different methodology from the previous studies, and particularly taking the weak exogeneity properties of the model variables into account, this paper nevertheless confirms on some points the main accepted facts of former papers (Bonnet and Mahfouz 1996; L'Horty and Sobczak; 1997 Cotis, Méary and Sobczak, 1997). It gives a main role to the rise of social and fiscal wedge and is compatible with a predominant role attributed to the influence of real interest rates, as soon as this influence is well mediated by productivity gains downturn. This study moreover leads to questioning the influence of numerous other determinants : the lesser digressiveness of social wedge wouldn't have had any impact on the increase of equilibrium unemployment and it would be the same for replacement rate, the reduction of working hours, and the minimum wage increase.

Appendix 1
A WS-PS model

In a monopolistic competition framework, each firm faces a demand all the more sensible to prices as the degree of competition, namely market atomicity is important. The aim of the representative firm is to fix the price that maximises its profit. The firm simultaneously determines its output level and its factor demands in labour and capital. Price and labour are thus jointly determined and so the causality between labour demand and its cost isn't univocal. In real terms, the representative firm programme is given by:

$$Max\, \Pi i = \frac{p_i}{p} Y_i - w_i L_i - c_i K_i$$
$$s.c.: \mathrm{Y}_i = D\left(\frac{p_i}{p}\right)^{\frac{1}{k-1}} aveck \in \left]0,1\right[\qquad (1)$$

The Π_i real profit depends on the amount of Y_i output produce weighted by its p_i price, devised by the p average price of output in the economy, and on the factor demands L_i labour and K_i capital, weighted by their respective prices : w_i real labour cost; c_i real opportunity productive capital cost. The firm faces a demand for its output which depends on relative prices and on price elasticity, often compared to the competition degree on the market (for κ=1 it's a situation of perfect competition and the demand is infinitely elastic to price). Implicitly, the choice of a constant elasticity demand function supposes the existence of entrance barriers on the goods markets, so for monopolistic incomes not to disappear with the entrance of new firms on these markets.

To determine its labour demand, the firm fixes its prices so as to equalise real cost and marginal productivity, taking the market competition degree into account. In fact the firm market power enables it to pay employees under their marginal productivity. In the case of a CES, and if we suppose that labour is augmented by an γ exogenous technical progress, neutral in Harrold's sense, the production function can be written as follow :

$$\mathrm{Y}_i = \left[a\left(gL_i\right)^{-w} + \left(1-a\right)K_i^{-w}\right]^{-\frac{x}{w}} \qquad 0 < a < 1 \qquad -1 < w < \infty \qquad (2)$$

Afterwards, we'll suppose that the scales are constant, ie namely $\left(x = 1\right)$. Then, if substitution elasticity is unitary ($w = 0$)[9], we find again the special case of a Cobb-Douglas function, where a represents the share of wages in added value, at the producer equilibrium and in the situation of pure competition. At the symmetric equilibrium, labour demands write as

$$\text{(PS)} \qquad \frac{wL}{Y} = a\,k\left(\frac{Y}{gL}\right)^{w} \qquad (3)$$

$$\frac{cK}{Y} = \left(1-a\right)k\left(\frac{Y}{K}\right)^{w} \qquad (4)$$

Coefficient productivity is no more unitary in PS and depends on the substitution elasticity between factors. If factors are little substitutable, firms are ready to pay more a similar level of labour productivity. A productivity increase always rises wages, but all the more as factors are little substitutable (given that labour demand is more steeper, wage rises translate into a lower employment decrease).

If we consider productivity as endogenous, and suppose an exogenous real interest rate, the PS curve is horizontal. An increase of the real interest rate leads to a decrease in productivity, what reduces real wages.

$$\text{(PS-LT)} \qquad w = a\ k\ g\left[\frac{1}{a} - \frac{1-a}{a}\left(\frac{\bar{r}}{\left(1-a\right)k}\right)^{\frac{w}{w+1}}\right]^{\frac{w+1}{w}} \qquad (5)$$

---

9 The elasticity of substitution is : $s = \dfrac{1}{1+w}$

Wage schedule

To set wage bargaining, one traditionally uses the generalised Nash criterion whose solution corresponds to a non co-operative game of Rubinstein (Binmore, Rubinstein, Wolinsky, 1986). The bargaining actors choose the wage that maximises the product of their respective surplus, namely the difference of their objective in the bargaining (U_i and Π_i) and their point of withdrawal (U_0 and Π_0). A battle of wills b, comes to weight this surplus. It's all the more important as union preferences in collective bargaining are taken into account and can be considered as a report of present preferences in a strategic game framework. The bargaining end corresponds to the solution to the following program :

$$Max_{w_i}\left(U_i - U_o\right)^b\left(\Pi_i - \Pi_o\right)$$

The general form of the maximisation result is defined by :

$$\frac{\dfrac{\partial U_i}{\partial w_i}}{\left(U_i - U_0\right)} = -\frac{\dfrac{\partial \Pi_i}{\partial w_i}}{b\left(\Pi_i - \Pi_0\right)} \tag{6}$$

For the right member of the equation, which describes the marginal cost for the employer of an additional unit of salary, we use the envelope theorem to the program of profit maximisation of the firm and we suppose that in case of bargaining failure pure profit is locked-out.

$$-\frac{\dfrac{\partial \Pi_i}{\partial w_i}}{b\left(\Pi_i - \Pi_0\right)} = \frac{L_i}{b\,\Pi_i} \tag{7}$$

For the left member of the equation, which corresponds to the union marginal gain of an additional salary unit, it's necessary to explicit the union preferences (U_i and U_o). Following Oswald (1985) we suppose that the aim of the representative union is to maximise wage purchasing power, net of all deductions (lack of monetary and fiscal illusion for employees). This hypothesis is realistic since employment bargaining are in the facts very scarce. It's compatible with an union rational choice composed of different members whose medium voter has a low probability to be laid off (because of seniority rule for instance)[10]. We also suppose that his utility function is at constant relative risk aversion δ[11]. He's objective U_i can be written :

$$U_i = \frac{\left(w_i W\right)^{1-\delta}}{1-\delta} \tag{8}$$

where W is the wage wedge. It depends on employers' and employees' contribution rates, t_1 et t_2, of income tax rate, t_3, of added value tax rate (TVA), t_4,and of tax non inclusive consumption prices, p_c. The welfare compensation of these deductions can be taken into account (unemployment insurance, retirement, infrastructures financing,…) in weighting each t_i rate by a λ_i power (the deduction is entirely considered as a postponed income for λ_i equal to 0 and as a pure tax for λ_i equal to 1). Moreover, all theses deductions are supposed flat for the time being. The wage wedge depends equally on the terms of exchange ($\frac{P}{P_C}$).

$$W = \frac{\left(1-t_2\right)^{\lambda_2}\left(1-t_3\right)^{\lambda_3}}{\left(1+t_1\right)^{\lambda_1}\left(1+t_4\right)^{\lambda_4}}\cdot\frac{P}{P_C} \tag{9}$$

---

10 Taking employment as the union objective into account isn't in fact a crucial hypothesis. Manning (1993) reaches a structural form qualitatively similar to the one described here in assuming so. The aim of this remark is to show that it's not necessary to suppose that unions bargain employment to theoretically justify the presence of an unemployment rate in the wage structural equation.

11 The relative risk aversion is equal to : $-\frac{wU''(w)}{U'(w)} = \delta$

It's equally necessary to explicit the withdrawal point of union U_0. If bargaining fails in the firm, employed workers can find a new job with a 1- φu probability and get the common wage w, or become unemployed with a complementary probability φu. In this case, their remuneration is made of unemployment benefits B, namely the product of their common wage by the replacement ratio (TR).

$$TR = \frac{BW'}{wW} \tag{10}$$

where W' indicates the deduction-free unemployment benefit ratio to gross benefits. Thus, the union point of withdrawal in bargaining writes as follow :

$$U_o = U(A) \text{ and } A = (1-\varphi u)Ww + \varphi u(TR)Ww$$

$$\Rightarrow U_o = U\left[wW\left(1-\varphi u(1-TR)\right)\right] \tag{11}$$

If we retain equations (8) for U_i and (11) for U_o, the left member of expression (6) corresponding to the union marginal gain in the bargaining, writes as follows

$$\frac{\frac{\partial U_i}{\partial w_i}}{\left(U_i - U_0\right)} = \frac{1-\delta}{w_i\left[1-\left(\frac{w}{w_i}\right)^{1-\delta}\left(1-\varphi u(1-TR)\right)^{1-\delta}\right]} \tag{12}$$

At the symmetric equilibrium, bargained wages in each firm are the same and so are employment and monopolistic incomes. A general expression of the WS wage curve is deduced from (7) and (12). It links together the ratio wage bill-profits and the unemployment rate.

$$\frac{(1-\delta)}{1-\left(1-\varphi u(1-\mathrm{TR})\right)^{1-\delta}} = \frac{wL}{\Pi}\frac{1}{\beta} \tag{13}$$

This relation can be rewritten in share of wages in the value added tax since the monopolistic income represents a constant share in the output equal to (1-κ) (it vanishes in pure competition situation) (see. equation 3 and 4).

$$\text{(WS)} \qquad \frac{(1-\delta)}{1-\left(1-\varphi u(1-\mathrm{TR})\right)^{1-\delta}} = \frac{1}{\beta(1-\kappa)}\frac{wL}{Y} \tag{14}$$

This wage equation remains the same whatever production function is used by the representative firm and doesn't contain any PS parameters. That's why it can be qualified of structural relation, even if the envelope theorem has been necessary for its derivation, which supposes that the producer's equilibrium is reached. Real labour cost is thus all the more important as the degree of competition on the goods market is low (κ) and that the union bargaining power is important (β). Moreover it decreases with the replacement rate (which depends itself on the whole parameters characterising the tax system and the terms of exchange.

Determinants of equilibrium unemployment

To define formally the value of unemployment equilibrium, one solves the system composed of the WS and PS structural equations by substituting on the wage share in the added value. One thus obtains a reduced form equation of (WS') wage equation which defines the level of equilibrium unemployment. In the Layard, Nickell and Jackman's (1991) model, this reduced form is presented as the structural form of WS.

$$\text{(WS')} \qquad 1-\varphi\,(1-\mathrm{TR})\,u^* = \left[1-\frac{\beta(1-\delta)(1-\kappa)}{\alpha\kappa}\right]^{\frac{1}{1-\delta}} \tag{15}$$

$$\Rightarrow u^* = f\left(\underset{-}{\varphi}, \underset{+}{TR}, \underset{-}{\kappa}, \underset{+}{\beta}, \underset{-}{\alpha}, \underset{+}{\delta}\right)$$

Equilibrium unemployment increases ceteris paribus with union power (β), replacement ratio (TR) and employees' risk aversion. It decreases with the risk to become unemployed, (φ), with the degree of competition on the goods market, (κ), and with the labour factor efficiency parameter, (α). It is also sensitive to the terms of exchange and to all the parameters characterising the tax system, which play a role in the wage wedge and modify replacement ratio.

In the case of a CES production function, the structural wage equation remains the same, but it’s not the case anymore of the equilibrium unemployment expression, which has now in addition a productivity term, whose impact depends on the substitution elasticity of factors (it depends on -ω sign) :

$$1-j\ (1-\mathrm{TR})u^{*}=\left[1-\frac{b\,(1-d)(1-k)}{a\ k}\left(\frac{Y}{gL}\right)^{-w}\right]^{\frac{1}{1-d}} \tag{16}$$

If factors are less substitutable than in the case of a Cobb-Douglas technology (ω > 0 which implies σ < 1), the equilibrium unemployment elasticity to the labour productivity in efficient unit is negative. In this case, an increase of productivity leads both to a wage increase and to an unemployment decrease. If factors are more substitutable than in the case of a Cobb-Douglas, productivity in efficient unit has a positive impact on equilibrium unemployment. In other respects, one can notice that technical progress has no impact on equilibrium unemployment level and that it only leads to a real wage increase. It clearly appears if we consider again productivity as endogenous, and suppose an exogenous real interest rate :

$$1-j\ (1-\mathrm{TR})u^{*}=\left[1-\frac{b\ (1-d)(1-k)}{k\ -(k\ (1-a))^{\frac{1}{w+1}}(\bar{r})^{\frac{w}{w+1}}}\right]^{\frac{1}{1-d}} \tag{17}$$

When the hypothesis of a Cobb-Douglas production function is eliminated in a bargaining model of Layard, Nickell et Jackman (1991), equilibrium unemployment becomes sensitive to labour productivity and the impact of a real interest rate chock, for instance, depends on the substitution elasticity between factors. An increase in real interest rate always leads to a decrease in productivity, but it yields to a decrease in equilibrium unemployment if factors are more substitutable than in the case of a Cobb-Douglas technology, and to an increase in the opposite case (PS variations make more than compensates those of WS in the former case). This result is not non-intuitive : when factors are little substitutable, a capital cost increase limits the use of all factors and thus increases equilibrium unemployment; when they are very substitutable, the substitution effect is bigger than the income effect and equilibrium employment increases.

Appendix 2
Unit root test results [12]

TABLE 1 - **Dickey-Fuller unit root tests : Jobert's sequential test procedure [13]**

Series in logarithm	Number of lags to whiten residual according to the criterion :		
Non agricultural manufacturing sectors	Bic	Hannan	Kmax
w-p (real labour cost)	0 I(1)	2 I(1)	0 I(1)
prodh (hourly productivity)	1 I(1) + T	1 I(1) + T	0 I(1) + T
tr (replacement rate)	0 I(1)	0 I(1)	0 I(1)
cp (Complete set of Smic hikes)	4 I(1)	8 I(0) + C	0 I(1) + T
r (real interest rate)	1 I(1)	5 I(1)	0 I(1)
ec (quit ratio)	1 I(1)	3 I(1)	0 I(1)
mm (mismatch)	5 I(1)	9 I(1)	0 I(1)
u (unemployment rate)	1 I(0)	2 I(0)	0 I(1)
h (working hours)	2 I(1)	3 I(1)	1 I(1)
coin (global wedge wedge)	0 I(1)	4 I(1)	0 I(1)
pc-p (terms of exchange)	0 I(0)	4 I(1)	0 I(0)
coinfs (fiscal and social wedge)	0 I(1)	5 I(1)	0 I(1)
coins (social wedge)	8 I(1)	8 I(1)	2 I(1)
coinf (fiscal wedge)	1 I(1) + C	2 I(1) + C	0 I(1)
css (Employees' social contributions rate)	8 I(1)	8 I(1)	3 I(1)
cse (Employers' social contributions rate)	0 I(1)	0 I(1)	0 I(1)
tva (Value added tax)	1 I(1)	1 I(1)	0 I(1)
tir (Income tax rate)	7 I(1)	7 I(1)	0 I(1)
prog (Progressiveness of social wedge)	4 I(1)	4 I(1)	0 I(1)

TABLE 2 - **Schmidt-Phillips unit root tests**

Series in logarithm	Number of lags to whiten residual according to the criterion :		
Non agricultural manufacturing sectors	Bic	Hannan	Kmax
w-p (real labour cost)	0 I(1) + T	2 I(1) + T	0 I(1) + T
prodh (hourly productivity)	1 I(1) + T	1 I(1) + T	0 I(1) + T
tr (replacement rate)	0 I(1)	0 I(1)	0 I(1)
cp (Complete set of Smic hikes)	4 I(1)	8 I(0) + T	0 I(1) + T
r (real interest rate)	1 I(1)	5 I(1)	0 I(1)
ec (quit ratio)	1 I(1)	3 I(1) + T	0 I(1) + T
mm (mismatch)	5 I(1)	9 I(1)	0 I(1)
u (unemployment rate)	1 I(1) + T	2 I(1) + T	0 I(1) + T
h (working hours)	2 I(1) + T	3 I(1) + T	1 I(1) + T
coin (global wedge wedge)	0 I(1) + T	4 I(1) + T	0 I(1) + T
pc-p (terms of exchange)	0 I(1)	4 I(1)	0 I(1)
coinfs (fiscal and social wedge)	0 I(1) + T	5 I(1) + T	0 I(1) + T
coins (social wedge)	8 I(1) + T	8 I(1) + T	2 I(1) + T
coinf (fiscal wedge)	1 I(1)	2 I(1)	0 I(1)
css (Employees' social contributions rate)	8 I(1)	8 I(1)	3 I(1) + T
cse (Employers' social contributions rate)	0 I(1) + T	0 I(1) + T	0 I(1) + T
tva (Value added tax)	1 I(1)	1 I(1)	0 I(1) + T
tir (Income tax rate)	7 I(1) + T	7 I(1) + T	0 I(1) + T
prog (Progressiveness of social wedge)	4 I(1)	4 I(1)	0 I(1)

12 All theses tests have been programmed with the GAUSS software.

13 We have of course checked that all these series aren't integrated of order 2.

TABLE 3 - **Kwiatkowski, Phillips, Schmidt and Shin unit root tests (KPSS)**

Unlike the previous two unit root tests, the null hypothesis is here the deterministic non-stationarity against the alternative hypothesis of stochastic non-stationarity (presence of a unit root). For this purpose, two tests have been proposed by KPSS :

$$\textit{first test} \quad \begin{cases} H_0 : I(0) + C \\ H_1 : I(1) \end{cases} \qquad \textit{second test}: \quad \begin{cases} H_0 : I(0) + T \\ H_1 : I(1) \end{cases}$$

The results of these two tests are reported in the following table for every series used in this study.

Series in logarithm	Number of lags to calculate the long run variance estimator[14]					
Non agricultural manufacturing sectors	0		4		8	
	first test[15]	second test[16]	first test	second test	first test	second test
w-p (real labour cost)	9.88 I(1)	2.52 I(1)	2.08 I(1)	0.53 I(1)	1.21 I(1)	0.31 I(1)
prodh (hourly productivity)	10.65 I(1)	2.16 I(1)	2.23 I(1)	0.49 I(1)	1.29 I(1)	0.30 I(1)
tr (replacement rate)	1.76 I(1)	1.38 I(1)	0.39 I(0)+ C	0.30 I(1)	0.24 I(0) + C	0.19 I(1)
cp (Complete set of Smic hikes)	9.38 I(1)	2.16 I(1)	1.98 I(1)	0.46 I(1)	1.16 I(1)	0.28 I(1)
r (real interest rate)	6.70 I(1)	0.82 I(1)	1.45 I(1)	0.20 I(1)	0.86 I(1)	0.14 (?)[17]
ec (quit ratio)	9.62 I(1)	1.92 I(1)	2.03 I(1)	0.43 I(1)	1.18 I(1)	0.27 I(1)
mm (mismatch)	7.71 I(1)	1.87 I(1)	1.58 I(1)	0.40 I(1)	0.91 I(1)	0.24 I(1)
u (unemployment rate)	9.79 I(1)	2.30 I(1)	2.04 I(1)	0.48 I(1)	1.18 I(1)	0.28 I(1)
h (working hours)	9.74 I(1)	2.26 I(1)	2.05 I(1)	0.49 I(1)	1.20 I(1)	0.29 I(1)
coin (global wedge wedge)	9.32 I(1)	1.89 I(1)	1.95 I(1)	0.41 I(1)	1.14 I(1)	0.24 I(1)
pc-p (terms of exchange)	1.31 I(1)	1.32 I(1)	0.31 I(0) + C	0.30 I(1)	0.19 I(0) + C	0.18 I(1)
coinfs (fiscal and social wedge)	10.33 I(1)	1.80 I(1)	2.17 I(1)	0.41 I(1)	1.26 I(1)	0.26 I(1)
coins (social wedge)	10.05 I(1)	2.04 I(1)	2.11 I(1)	0.48 I(1)	1.22 I(1)	0.29 I(1)
coinf (fiscal wedge)	2.29 I(1)	0.82 I(1)	0.54 I(1)	0.21 I(1)	0.47 (?)	1.49 I(1)
css (Employees' social contributions rate)	5.98 I(1)	2.16 I(1)	1.33 I(1)	0.50 I(1)	0.80 I(1)	0.30 I(1)
cse (Employers' social contributions rate)	10.80 I(1)	1.00 I(1)	2.23 I(1)	0.24 I(1)	1.28 I(1)	0.15 I(1)
tva (Value added tax)	8.74 I(1)	0.31 I(1)	1.87 I(1)	0.08 I(0) + T	1.16 I(1)	0.06 I(0) + T
tir (Income tax rate)	9.54 I(1)	1.16 I(1)	2.01 I(1)	0.25 I(1)	1.17 I(1)	0.17 I(1)
prog (Progressiveness of social wedge)	8.38 I(1)	1.53 I(1)	1.76 I(1)	0.34 I(1)	1.05 I(1)	0.21 I(1)

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14 L is the truncation used in the Bartlett window W (S, l) to calculate the « long run variance estimator», S^2 (l), which appears at the denominator of the KSS. If l is equal to zero, the errors are supposed to be iid, whereas if l is greater than zero, the estimator takes the possible effects of errors autocorrelation into account.

15 The critical value at a 5 % level is for the first test 0.463.

16 The critical value at a 5 % level is for the second test 0.463.

17 The (?) interrogation point in some boxes indicates the difficulty to conclude between an I (0) or I (1), given that the computed test is too close to the 5 % critical value.

Appendix 3
Estimation strategy

Given that the different variables that do enter the wage and price schedule are non-stationary trending variables, our analysis will be conducted in a framework that allows both for non-stationary and potentially cointegrated variables. As it is now widely known in econometric literature, several estimations and techniques are available for cointegration investigation among a set of non-stationary time series (see Banerjee and al [1993], Gonzalo [1994]). In this paper, in order to be able to detect the existence of multiple long-run relations, we use Johansen's gaussian maximum likelihood framework (Johansen [1988], [1991], Johansen and Juselius [1990] [1992]). This method is currently used in empirical studies[18] and has been shown to be a valuable starting point for numerous theoretical works of derivation of dynamic structural error correction models (Urbain [1992], Boswijk ([1992], [1994], [1995], [1996]). To distinguish between stationarity by linear combinations and by differencing, Johansen consider the following Vector Error Correction Model (VAR-ECM), which implies no loss of generality in comparison to a VAR model (see Rault [1997] for a detailed presentation) :

$$\Delta X_t = \sum_{i=1}^{P-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-1} + \Phi D_t + \varepsilon_t,\ t = 1,..,T \qquad \textbf{(1)}$$

where

$(X_t)_{t=1,...,T}$, is a n dimensional vector process of stochastic variables ,
(ε_t) ~iid N $(0_n, \Sigma)$,
Γ_i, i = 1,...p-1 are (n, n) matrices, supposed constant in time,
Π is a (n, n) matrix of rang r,
D_t is a vector of non-stochastic variables (constant drift, linear deterministic trend, ...),
Σ is a regular, positive define variance-covariance matrix.

When equation 1 is written as Φ (L) $X_t = \varepsilon_t$., the root of the characteristic polynomial Det [Φ (z)] are supposed to be either equal to one, or of modulus strictly greater than one.

Several cases are then possible depending on the Π = - Φ (1) matrix rank :

- If rank (Π) = 0, then the P matrix is null and equation 1 is a VAR model on the variables taken in differences.
- If rank (Π) = n, then the X_t process is stationary and equation 1 is a VAR model on the variables taken in level.
- If 0 < rank (Π) = r < n, then there exist r cointegrating relationships and (n, r) matrices α and β of full rank column r, such as $\Pi = \alpha\,\beta'$.

We assume to be in Johansen's framework, namely in the third case. X_t is assumed to be an order 1 integrated vector process , that is, we exclude the existence of integrated variables of order greater or equal to 2. This imposes in particular that the matrix $\alpha'_\perp \Gamma \beta_\perp$ is of full rank (n-r); where $\Gamma = I_n - \sum_{i=1}^{p} \Gamma_i$ is a (n, n) matrix and $\alpha_\perp$ et $\beta_\perp$ are (n, n-r) matrices, of full column rank, such as $\alpha' \alpha_\perp = \beta' \beta_\perp = 0$ (see Johansen [1995], theorem 4.2).

Under these hypotheses, equation 1 can be written as follows :

$$\Delta X_t = \sum_{i=1}^{P-1} \Gamma_i \Delta X_{t-i} + \alpha\,\beta' X_{t-1} + \Phi D_t + \varepsilon_t,\ t = 1,..,T \qquad \textbf{(2)}.$$

The cointegrating vectors are the β_j columns of the β matrix. In particular, the $\beta_j' X_t$ (j = 1,..,r) can be regarded as stationary linear combinations of non-stationary variables and the α as the weights of these different combinations in each equation of the model.

Once the number of cointegrating vectors has been determined, using the trace and lambda max tests (Johansen [1988]), it seems natural to begin by apprehending more precisely the structure of the adjustment space, spanned by the α. Applying a test on α, boils down to asking oneself if the long run relation (s) belongs to all the model equations. It deals with a weak exogeneity test of the different variables of the system for long run parameters,

[18] Some software (PC-GIVE, RATS) enables us at the present time to apply these tests.

whose aim is to check if the sufficient condition given by Johansen [1992] is verified empirically. According to Johansen, if the (X_t) variables of the system are divided into (Y_t, Z_t), a sufficient condition for a variable (or a group of variables) Z_t to be weakly exogeneous for long run parameters is that the cointegrating vectors don't belong to the model equation (s) describing the evolution of ΔZ_t. In this case, the joint density function can be factorised into two blocs whose parameters vary freely : a ΔZ_t marginal model gathering the weakly exogenous variables for the long run parameters of the VAR-ECM model, and a conditional ΔY_t model composed of the other equations. The cointegration vectors can then be estimated only from the conditional model which enables to reduce the size of the system without losing any information from the full VAR-ECM[19]. It must be emphasised that the asymptotic distributions of the rank test statistics differ in the partial VAR-ECM from those of the full VAR-ECM. Moreover, Harboe and al [1995] have shown that the inclusion of deterministic terms makes it more difficult to determine this rank in a partial system. Thus in all this study, the rank of the cointegrating space will be tested in the full system, and we will then consider this rank as a given fact in the conditional model.

Furthermore, it is now well understood that without any identifying restrictions, the different cointegrating vectors (if they exist) are not yet identified : in fact, any linear combination of these r cointegrating relationships preserves the stationarity property, so an infinity of cointegrating relationships between the n variables of the system exist and consequently only the cointegrating space (the row space of Π), is uniquely defined by the estimation. The identification of the different cointegrating relationships is therefore made a posteriori by imposing restrictions on the β matrix (Johansen and Juselius [1994]). It's important to note that some of these restrictions may not be identifying, that's why identification criteria exist (order condition, rank condition), which formalise the idea that an equation is identified only if it's possible to distinguish it statistically from the others. Once the number of cointegration relationships has been determined and identified, particular structural hypotheses on the α and β matrices can be tested using asymptotic standard Khi^2 LR test statistics.

If the cointegrating space is of order one, normalisation is sufficient to ensure just-identification, and then, any additional restriction is an over-identifying testable restriction. Inversely, if more than one cointegration relationship exists (it's for instance what economic theory suggests in our study of price and wage schedule), some economic hypothesis like for example the exclusion of unemployment from the (PS) curve and the exclusion of productivity from the (WS) curve, can be used as restrictions to just identify the two long run relationships. But in this case, these restrictions are not tested, since it is possible to impose (r-1) restrictions deduced from economic theory, plus the normalisation on each cointegrating vector, without changing the likelihood function.

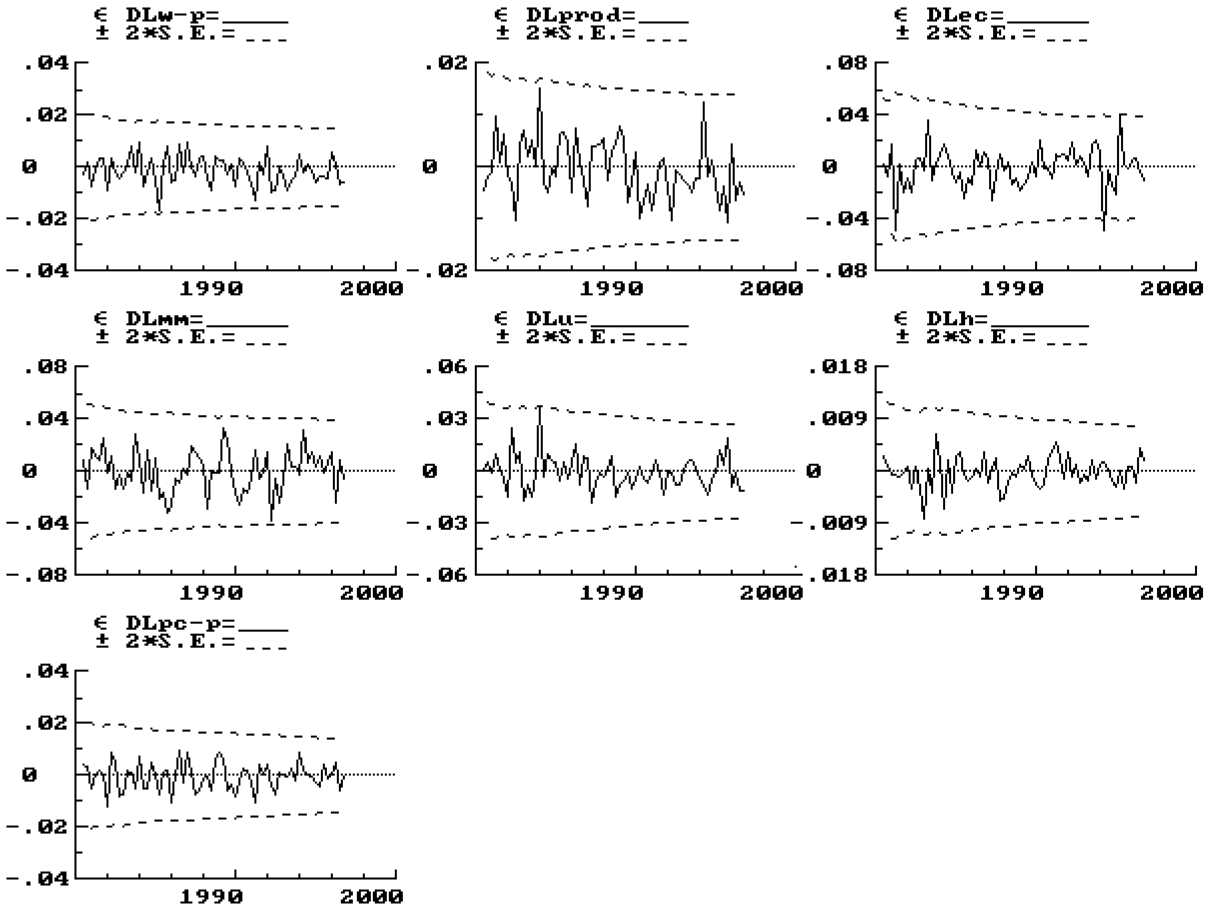
19 See Rault [2000] for a discussion on weak exogeneity and causality.

Appendix 4

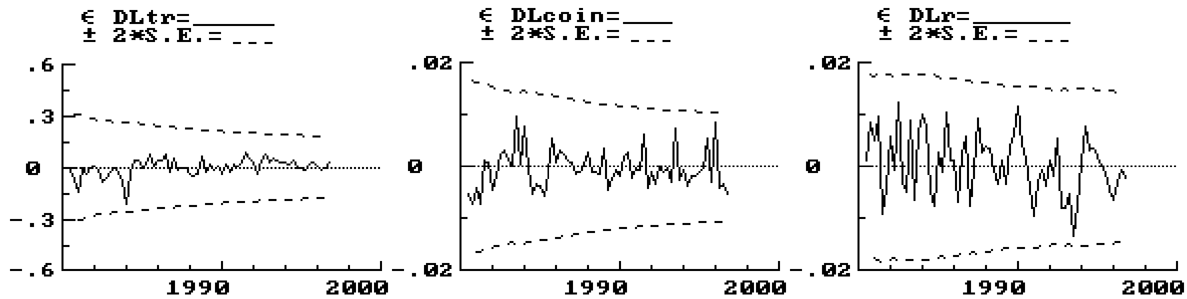
Chow tests (Onestep ahead, Backward and Forward) to evaluate coefficients constancy of the conditionnal and marginal VAR-ECM models

<u>Onestep ahead Chow tests</u>

• ***Modèle VAR-ECM conditionnel***

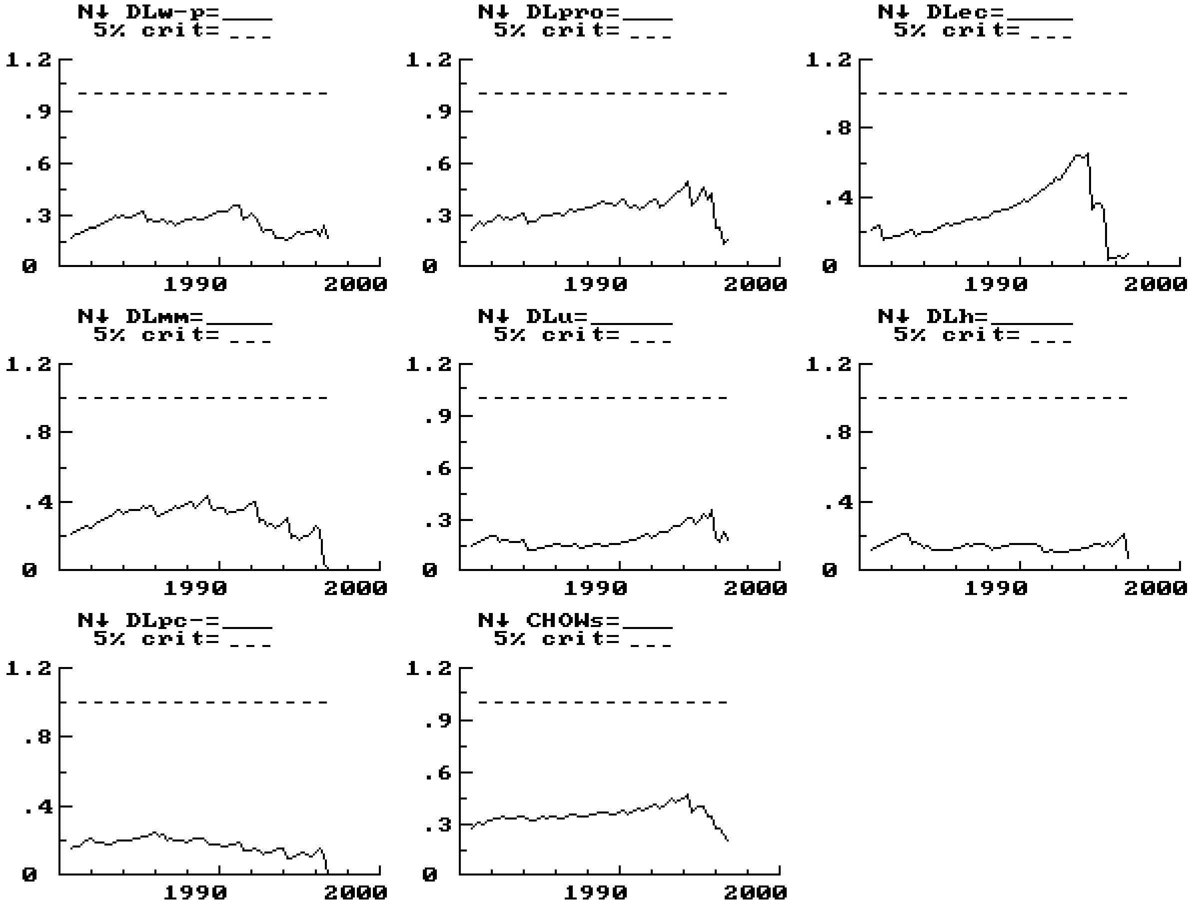


• ***Modèle VAR-ECM marginal***

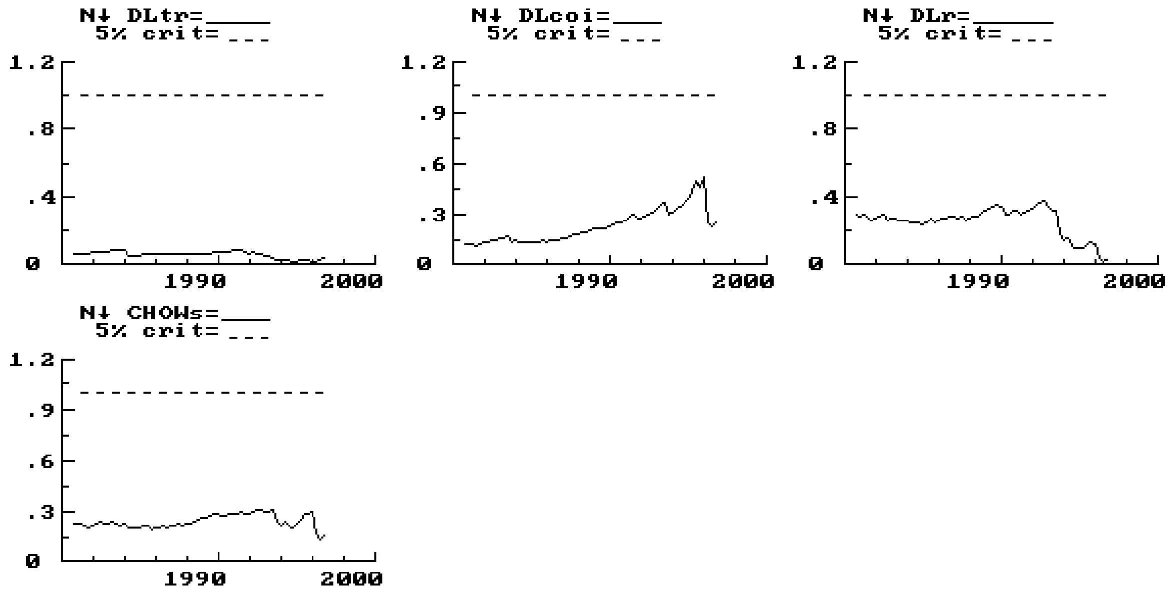


Backward Chow tests

• ***Modèle VAR-ECM conditionnel***

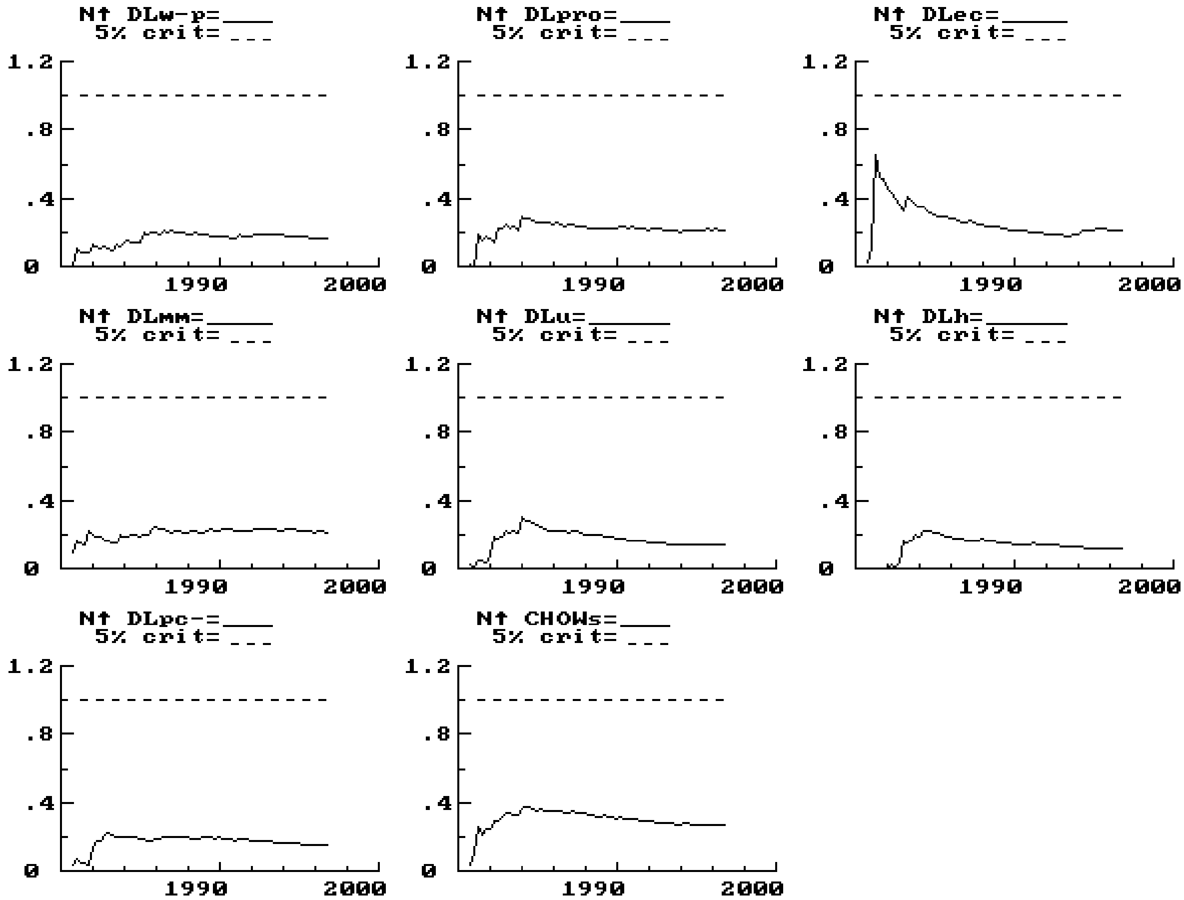


• ***Modèle VAR-ECM marginal***

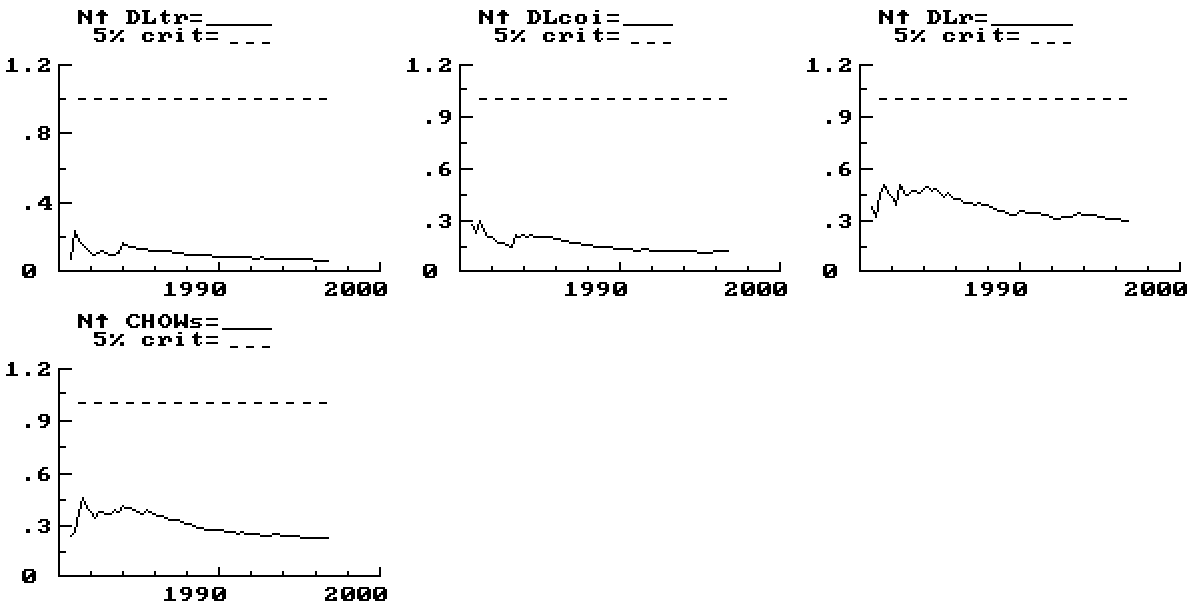


Forward Chow tests

- ***Modèle VAR-ECM conditionnel***



- ***Modèle VAR-ECM marginal***



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