CIM

Centre for International Macroeconomics

Discussion Paper No. 2000.06

The determination of wage and price inflation in Greece:
An application of modern cointegration techniques

by

Stephen G. Hall
(Imperial College Management School)

And

Nicos Zonzilos
(Bank of Greece)

May 2000

The determination of wage and price inflation in Greece:
An application of modern cointegration techniques

Stephen G. Hall
(Imperial College Management School)

And

Nicos Zonzilos
(Bank of Greece)

ABSTRACT

This paper investigates the determination of wage and price inflation in Greece over the last twenty years by applying recent developments in the field of multivariate cointegrated systems. In particular it draws on recent work by Hall, Henry and Greenslade (1999) which investigates the performance of a range of tests of identification in small samples and recommend a particular sequence of testing and nesting of the model. Using these techniques we argue that macroeconomic policy in Greece has been one of the main driving forces behind the determination of inflation. In particular we are able to clearly isolate successful regime periods and less successful ones. We are also able to then use the estimated model to investigate the possible effects of either extending or shortening some of these regimes on Greek economic history.

JEL Classification:

Keywords

Contents

1. Introduction

Greece has enjoyed considerable success in controlling inflation over the last 20 years, but this success has neither been achieved easily not has it happened in a continuos or uniform way. It is always true that statistics are most informative when a data set contains considerable variation. Thus we may learn little about the process of inflation from a country such as German while Greece may be much more informative. Greece has moved through periods of full indexation, strong incomes policy, unstable policy regimes and exchange rate and intermediate targeting. In many ways it is therefore a natural economic experiment and undoubtedly deserves to receive much more academic scrutiny than has so far occurred. This paper seeks to bring the tools of modern econometric analysis to bare on the Greek experience partly for the inherent interest of the unusual data set and partly because of the obvious interest and relevance of the result to policy makers and politicians in Greece.

The issue of identification in cointegrated systems has received considerable attention in recent years and we now have a thorough understanding of the theoretical underpinnings of the identification issue. Recent work has also concentrated on the twin issues of the practical application of these theoretical ideas and the effects of structural change on cointegrated systems, notable Greenslade, Hall and Henry(1999) and Hall, Mizon and Welfe(1999). This paper will apply these techniques to the case of Greece with a particular view to examining the effects of the various policy regimes, which have been attempted in Greece over the last 20 years. We will argue that the major contributing factor to Greek success has been the stance of policy. While policy has not always been positive or effective the majority of the time it has operated in a positive way. We will be able to use the final model to evaluate the NAIRU for Greece and to investigate both how inflation and the NAIRU might have changed if various policy episodes had been either shortened or lengthened.

The Plan of the paper is as follows. Section 2 will outline the policy episodes, which have occurred in Greece over the last twenty years. Section 3 will then summarise some of the recent work on cointegrated systems. Section 4 will outline our model and estimation results. Section 5 will perform a range of policy experiments with the model and section 6 will conclude.

2. Recent Greek History and Policy Regimes

If there is one single indicator that summarises the progress which has been made in Greece over the last twenty years it is the inflation rate (figure 1). This shows a steady decline in inflation from an annual rate of almost 25% in the early 80s to well under 5% by the late 90s. There are two major breaks in this trend and they are well explained by shifts in policy.

In the remaining part of this section we briefly review the macroeconomic developments in Greece in the last two decades, giving particular emphasis to the developments of wages and prices and to the prevailing policy regimes.

The macroeconomic record of Greece in the 1980s and the early 1990s was not impressive. Real GDP in the period 1980 to 1993 grew at the annual rate of 0.75 percent against 2.6 percent in the period 1973-79. The average growth rate of real business investment was effectively zero in the period 1980-94 and unemployment, which stood at about 4 percent in 1981, rose more steeply than the other EU economies reaching 8 percent of the labor force by the early 1990s. The effective nominal devaluation of the Greek currency was around 70 percent between 1981 and 1990. However, and despite the considerable devaluation of the drachma, the external sector was a binding constraint to economic growth in Greece. The current account deteriorated sharply in 1985 (4.5 percent of GDP) and 1989-90 (4.7 percent of GDP). A possible factor which can be identified as the main cause of the two balance of payment crises is the large fiscal deficit, which remained persistently high throughout the 1980s and early 1990s reaching 12 percent of GDP in 1985 and 16.5 percent in 1990. A graphical exposition of macroeconomic developments are given in Figures 1-4

.

We now turn to a more thorough examination of wage and price developments (Figures 2 and 3). After the second oil price shock, in most EU countries economic policies was restrictive. However, after 1981 official policy guidelines in Greece changed to emphasize income redistribution and generous minimum wage increases. Full wage indexation was established in 1982 as the official policy and at the same time price control was strengthened. As we would expect with real wage growth exceeding productivity the wage-price system was highly unstable and the inflation rate peaked at 25 percent at the end of 1985. The government was faced with an inflation rate three times as high as in the EU and a sharp deterioration of the current account. From the autumn 1985 a two-year stabilisation program in order to restore macroeconomic stability and put the country on a path to convergence with the other EU countries was begun. The program was mainly based on a restrictive income policy, a devaluation of the drachma, the application of an import deposit scheme and a reduction in public spending (mainly infrastructural investment). Full wage indexation was abolished in October 1985 and replaced by a forward looking indexation scheme excluding imported inflation. As a result real wages fell by 13% during 1986-87 and inflation was reduced to 15 percent by the end of 1987. Inevitably this drastic reduction in real earnings lead to considerable political tensions, the stabilization program was abandoned and the policy of wage restraint ended at the end of 1987.

In 1988 while there was an inevitable bounce back in real wages, this did not negate a large part of the gains, which had been made, and real wages resumed their former trend growth from a reduced level. However inflation rebounded and at the end of 1990 and peaked at 23 percent.

From the beginning of the 1990 the authorities attempted to stabilize the economy by reducing fiscal deficits and trying to implement structural reforms through liberalization and privatization of public enterprises. A regime of strict targeting of the exchange rate was instituted as part of the monetary policy regime (see figure 4) and this much tighter stance of policy again managed to control the growth in real wages. However economic performance was poor: inflation remained high at rates above 15 percent, output grew at a low pace and unemployment rose to 8,7 percent in 1992.

Since 1994 the performance of the Greek economy has improved considerably, the implementation of stabilization policies within the framework of the convergence programs proved very effective. The success on all three fronts: inflation reduction, output growth and the correction of fiscal imbalances was impressive. The new economic policy relies on the following factors. The commitment to exchange rate stability within the ERM. A moderate incomes policy aiming at real wage increases lower than productivity growth. An effective fiscal restraint. And the implementation by the Greek Government of a number of structural reforms which enhance the supply side of the economy and, hence, improve both inflation and the economy's productive capacity. These factors together with the stance of monetary policy, which is targeted to reduce inflation resulting in high short-term interest rates in the short run, are the key elements for the achievement of a rate of inflation below 2% by the end of 1999.

Figure 1

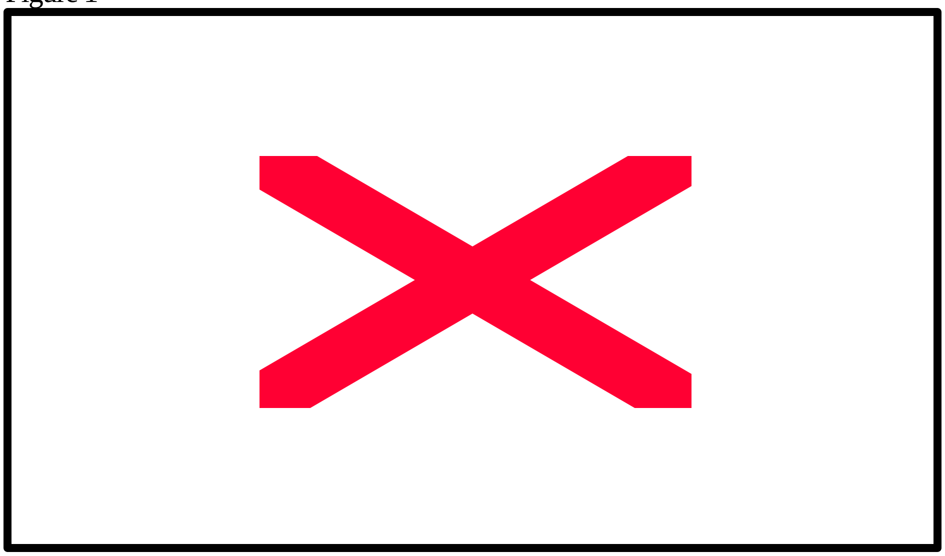


Figure 2

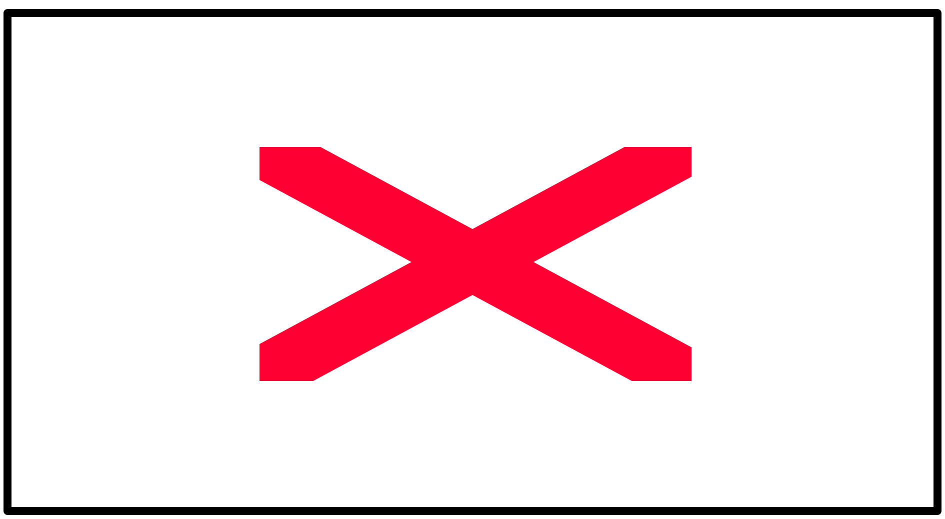


Figure 3

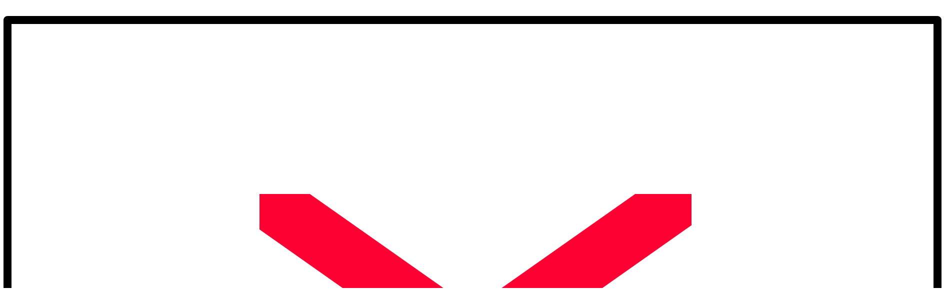
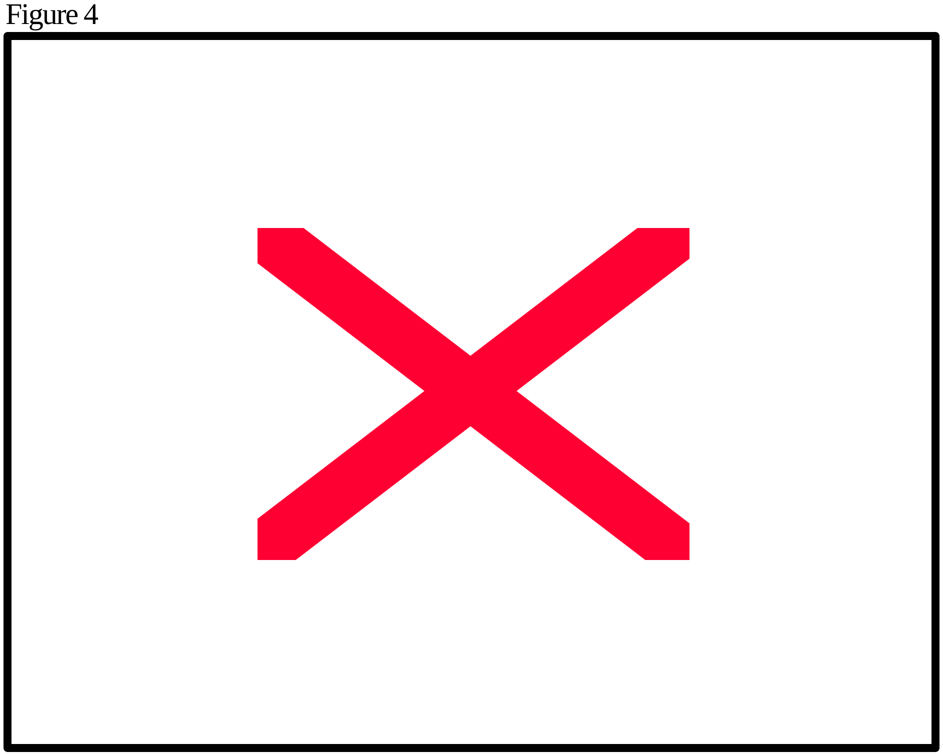


Figure 4



3. Identification in VECMs

In this section we will summarise the recent developments in the identification of cointegrated systems. Beginning with the contribution of Davidson and Hall (1991) it has become increasingly apparent that the structural identification of cointegrated systems is a crucial step in making economic sense of any statistical system, which includes more than one cointegrating vector. In his original contribution, Johansen (1988,1991) used purely statistical criteria to achieve identification in the general case of multiple cointegrating vectors, with the assumption of orthogonality between the vectors. Phillips (1991) presented a more structural approach in that the set of variables was partitioned into an exogenous and endogenous subset of variables with a recursive structure and this provided sufficient restrictions to give formal identification. Johansen (1992) considers the imposition of restrictions on the cointegrating vectors directly and proposes an algorithm for estimating some cointegrating vectors conditional on restrictions placed on others. Saikkonen (1993) discusses the complete identification of a vector error correction model (VECM) which has a similar exogenous split to the Phillips (1991) system. Most recently Pesaran and Shin (1994) and Johansen (1995) have developed a full theory of identification for a general unrestricted model along with some suggestions for an estimation and testing strategy.

The basic problem may be stated as follows, we begin by setting out the complete or closed form, VAR

$$D(L)Z_t = V_t \qquad \textbf{(1)}$$

Where Z is an N dimensioned vector which may be partitioned in general to give $Z_t = (Y_t, X_t)$ where Y is an Mx1 vector of endogenous variables and X is a Qx1 vector of weakly exogenous variables (N=M+Q) and D(.) a suitably dimensioned matrix in the lag operator. We may then state the VAR as a structural VECM (Vector Equilibrium Correction model) as,

$$A_0 \Delta Z_t = \sum_{i=1}^{p-1} A_i \Delta Z_{t-i} + A^* Z_{t-p} + u_t \qquad \textbf{(2)}$$

Where there are r cointegrating relations in Z, and r < N which implies that A^* has rank r. This rank may be imposed in the usual way by defining $A^* = a^* b^{*\prime}$ where both a^* and b^* are Nxr matrices. However it is important to stress that a^* and b^* are the structurally identified loading weights and the cointegrating vectors, as defined by Davidson and Hall (1991) as the target relationships, not the unidentified ones which are produced in unrestricted estimation.

The Structural VECM (2), will normally be estimated as an unrestricted version of the reduced form given as

$$\Delta Z_t = \sum_{i=1}^{p-1} \Gamma_i \Delta Z_{t-i} + \Pi Z_{t-p} + v_t \qquad \textbf{(3)}$$

Where $A_0^{-1} A_i = \Gamma_i$, $A_0^{-1} u_t = v_t$ and $\Pi = A_0^{-1} A^*$. Identification in the presence of cointegrating vectors is different from that traditionally used for stationary VARs (i.e. The Sims or Blanchard-Quah identification criteria), this is discussed in detail in Robertson and Wickens (1994). In particular there are now two parts to the identification problem. Given that we impose the cointegrating rank of the system r by the standard decomposition of the long run matrix $\Pi = ab'$ where both a and b are Nxr matrices, we need to consider both the identification of the contemporaneous coefficient matrix A_0 and the identification of the long run coefficients b. Restrictions on the long run coefficient matrix can in general tell us nothing about the identification of A_0 as this can only come from the dynamic part of the model using information either from Γ_i or a. In a similar fashion the dynamic part of the model can not help us in general to identify the long run structure, b. This may be seen easily as $\Pi = ab' = A_0^{-1} a^* b^{*\prime}$, so even if we knew A_0 this would not allow us identify b^* without additional restrictions on b. For this reason Pesaran and Shin (1994) have set out a formal theory of the identification of the long run structure in isolation.

In general the complete exact (or over) identification of the system will involve a combination of four types of restriction.

a) Restrictions on the cointegrating rank of Π, r<N
b) Restrictions on the dynamic path of adjustment (the Γ_i)
c) Restrictions on the cointegrating vectors , b where $\Pi = ab'$
d) Restrictions on the exogeneity or long run causality of the system, which will imply restrictions on α.

The conventional VAR conditions (see Robertson and Wickens (1994)) for identification apply to the dynamic identification of the system and as long as a combination of restrictions across the Γ_i and a matrices meet the standard conditions then the model is identified with respect to the dynamics. These restrictions can come from a number of sources, some models have theoretical restrictions on the adjustment process, which may be used to simplify the Γ_i matrix, e.g. the well-known quadratic adjustment cost model is one such. The alternative practise in the absence of theoretical restrictions is to base the restriction process on a data based set of simplifications of the dynamics. In either case some further restrictions may be necessary to identify A_0.

The formal identification of the long run is the main subject of Pesaran and Shin (1994). Where it is demonstrated that the identification of b^* requires knowledge of r and then there is a necessary condition equivalent to the order condition which states that exact identification of the long run coefficients requires $k=r^2$ restrictions. So the number of restrictions necessary to identify the long run is a direct function of the number of cointegrating vectors. Pesaran and Shin (1994) also give a necessary and sufficient rank condition for exact identification, which is also a function of r^2. In general if the number of available restrictions $k<r^2$ the system is under identified, if $k=r^2$ then the system is exactly identified and when $k>r^2$ the system is over identified, according to the order condition and these over identifying restrictions may be tested. Based on asymptotic results from Phillips (1991) and Johansen (1991), Pesaran and Shin also demonstrate that the standard likelihood ratio test of the over identifying restrictions follows a $c^2(k-r^2)$ distribution.

This suggests that the long run may be estimated and identified and the over identifying restrictions tested from the unrestricted VECM without identifying the model's dynamic structure. Greenslade Hall and Henry(1999) (GHH) have argued that while this is certainly true asymptotically there may be very severe problems with the performance of the tests (both size and power) in realistic samples. It is worth noting that if we have 8 variables with 6 lags in the VAR we will be estimating around 350 parameters from a typical data set of 100 observations. In this context small sample problems may be crucial. To illustrate this GHH perform a series of Monte Carlo experiments, which show that the performance of the tests for cointegration and weak exogeneity both have very poor power and size. They then go on to investigate the performance of the tests of the overidentifying restrictions, The following table summarises their main result.

Table 1: the size of over identifying restriction tests

General unrestricted VAR	3.8
VAR with weak exogeneity imposed	58.5
VAR with weak exogeneity and restricted dynamics	77.0

This table shows the percentage of times the true overidentifying restrictions were accepted at a 5% critical valu e in the Monte Carlo simulations. Source GHH(1999).

This table illustrates that if the test of the overidentifying restrictions are imposed at the start of the testing procedure before assuming that any of the variables are weakly exogenous and on the basis of the complete unrestricted VAR then the true overidentifying restrictions were accepted less than 4% of the time. If a set of weak exogeneity assumptions are correctly imposed then this acceptance rate increases to nearly 60% and if the dynamics of the VAR are also simplified this proportion increases to nearly 80%. The argument put forward by GHH is therefore that the order of the testing procedure is crucial in a successful implementation of these techniques in small data samples. The following broad estimation strategy is then recommended and will form the basis of the application here.

(i) Use economic theory to decide what the split between endogenous and weakly exogenous variables should be and to verify this by testing the a matrix.

(ii) Then determine the cointegrating rank of the conditional system.

(iii) Find a parsimonious representation of the dynamic terms in the system.

(iv) Then test the over identifying restrictions on the long run coefficients b and test any further restrictions on the loading matrix a to arrive at the final, fully restricted model of the form given in (3).

4.1 The Model

As a starting point for this analysis we take the standard bargaining model of wages and prices due to Layard, Nickell and Jackman (LNJ) (1991), recent implementations of this model include Henry, Nixon and Williams (1997), Greenslade, Henry and Jackman (1998) and Greenslade Hall and Henry(1999) This provides basic models for wages and prices (W, P_c.). In addition, because of the obvious openness of the Greek economy we also wish to allow for the interaction of the exchange rate and imported goods prices, we therefore postulate a third is for import prices (P_m) and a fourth equation for the exchange rate. In schematic form, the long-run structural (static) form of the equations is (variables in logs, except for the unemployment variables).

$$W = a_0 + a_1 P_c + a_2 PROD + a_3 u + a_4 u^L + a_5 PR \qquad \textbf{(4)}$$

Equation (4) is a standard wage equation, the variables are consumer price (P_c), productivity, (PROD), unemployment (u), and the ratio of long and medium duration unemployed to total unemployment (u^L), In addition we have introduce a policy regime variable PR which is designed to capture the effects on real wages of the various policy regimes outlined in section 2. Equation 5 shows that consumer prices depend upon unit labour cost (ULC defined as W - PROD, variables in logs) and import costs.

$$P_c = b_0 + b_1 ULC + b_2 P_m + b_3 Z_{pc} \qquad \textbf{(5)}$$

In equation 6 import prices depend upon the nominal effective exchange rate (E) and world prices (PW).

$$P_m = g_0 + g_1 E + g_2 PW \qquad \textbf{(6)}$$

Finally the exchange rate is driven in the long run by a purchasing power parity effect and possible another policy variable

$$E = d_0 + d_1 P_m + d_2 PW + d_3 EP \qquad \textbf{(7)}$$

Where EP is a variable capturing exchange rate interventions of the policy maker. Note that 6 and 7 may not be distinct cointegrating vectors and the same basic PPP relationship may be governing the evolution of both sectors. This is not unusual in a reduced rank cointegrating system.

Each equation allows for additional factors as appropriate.

In terms of theoretical restrictions we would expect that the following restrictions should hold.

In (4) $P_{m,}$ E, PW, are excluded and $a_1 = 1, a_2 = 1$

In (5) u, $u_{L,}$ E, PW, are excluded and $b_1 + b_2 = 1$

In (6) $P_{c,}$ W, u, $u_{L,}$ are excluded and $g_1 = g_2 = 1$, and the same restrictions in 7.

These are of course only the cointegrating target relationships of the model. The full model will be in vector equilibrium correction form with a complete set of dynamics.

4.2 Estimation Results

4.2.1 Weak Exogeneity and the cointegrating rank

The full set of variables consists of 9 variables and we begin by assessing the cointegrating rank of the system, noting our theoretical prior that there should be at least three cointegrating relationships. Table 2 gives the results for both the standard LR test of the number of cointegrating vectors and the small sample correction for this test.

Table 2. TEST OF THE COINTEGRATING RANK OF THE SYSTEM

R	ASYMPTOTIC LR TEST	SMALL SAMPLE LR TEST	CRITICAL VALUE
0	512.9	205.1	192.9
1	388.8	155.5	156.0
2	289.7	115.9	124.2
3	201.1	80.45	94.15
4	148.0	59.20	68.52
5	100.2	40.06	47.21
6	55.66	22.26	29.68
7	25.20	10.08	15.41
8	6.318	2.527	3.762

On the basis of the standard asymptotic test we would be led to conclude that there are 9 cointegrating vectors. This result would suggest that all the variables in the model are in fact stationary, which is clearly untrue. This result is completely in line with the Monte Carlo findings of GHH who suggest that the tests find far too many cointegrating vectors. If we consider the small sample adjusted tests then we would strictly be led to conclude that there are only 2 vectors. However the test for the third vector is quite close to its critical value and again GHH suggest that the small sample adjustment tends to find too few vectors and so we feel reasonably safe in proceeding on the assumption that there are in fact three vectors.

We now turn to the issue of simplifying the model through conditioning the system on a subset of weakly exogenous variables. In table 3, we begin by showing the Wald test for weak exogeneity on the basis of 8 cointegrating vectors and here we are unable to accept the hypothesis that any of the variables are weakly exogenous. This is again compatible with the GHH Monte Carlo results even if some of the variables are weakly exogenous. The second column of the table then repeats the test on the assumption that there are 3 cointegrating vectors. This then allows us to accept the hypothesis that the wage policy variable and the short run long run unemployment differential are weakly exogenous. We may then repeat the test on the remaining variables conditional on this assumption and then productivity may be accepted as weakly exogenous. Imposing this assumption and repeating the test again does not allow us to further simplify the system (with the exception of dropping wages, which would clearly be undesirable). However at this point we decide to view the world price level as exogenous, on prior theoretical grounds and then repeat the test on this assumption which then allows us to view unemployment as weakly exogenous. Finally repeating the test on this assumption we are left with four endogenous variables, prices, wages, import prices and the exchange rate.

Table 3. Test of weak exogeneity

	r=8	r=3	r=3	r=3	r=3	r=3
Consumer prices	97.83	33.8	23.9	15.3	22.9	23.6
Exchange rate	92.3	118.9	84.4	85.2	79.8	55.8
Foreign prices	118.4	50.76	35.9	33.0	-	-
Import prices	152.0	80.5	47.8	49.1	25.3	18.1
Productivity	98.01	31.9	9.1	-	-	-
Wages	119.6	38.9	20.6	5.2	22.5	32.0
Wage policy	79.55	10.9	-	-	-	-
Unemployment	66.89	25.3	31.1	41.7	12.4	-
Long/short unemp	42.71	11.3	-	-	-	-

4.2.3 The dynamic model

Having achieved a suitable marginalisation of the model and determined a cointegrating rank which we believe makes economic sense for this marginalisation we now proceed to derive a simplified set of dynamic terms for the model based on the unrestricted set of cointegrating vectors produced by the Johansen procedure.

The following is the estimates for the parsimonious dynamic model. We report the dynamic part only at this stage as the just identified long run part of the model has no economic interpretation so far.

$$\underset{}{\Delta W} = \underset{(3.9)}{-0.46} + \underset{(7.5)}{0.72}\Delta P_{ct-4} + \underset{(1.3)}{0.09}E_{t-1} + \underset{(4.7)}{0.68}\Delta PW + \underset{(3.3)}{0.006}u^{L}$$

$$\Delta P_c = \underset{(0.27)}{-0.027} + \underset{(2.5)}{0.28}\Delta P_{ct-1} - \underset{(2.25)}{0.18}\Delta W_{t-1}$$

$$\Delta P_m = \underset{(1.2)}{0.07} + \underset{(2.4)}{0.2}\Delta P_{mt-1}$$

$$\Delta E = \underset{(0.55)}{-0.05} - \underset{(1.34)}{0.05}E_{t-2}$$

The model also contained dummy variables for outliers in 85Q4, 90Q3 and centred seasonal dummies. The value of the likelihood function for this model is -166.91.

As can be seen the dynamics of the restricted model are quite parsimonious, especially in comparison with the general VECM. This reduction in the parameterisation of the model is a considerable advantage in achieving reasonable performance of the tests of the long run structure.

4.2.5 Tests of Long Run Restrictions

The next stage of the modelling process is to identify the long run structure of the model according to the theory set out in equations 4-6. To do this we re-estimate the complete model subject to a set of over identifying restrictions, holding the dynamic structure constant but re-estimating the parameter values. This yielded the following set of long run restrictions; (we will not present the new dynamic parameter values, as there is no significant change here.

$$W = P_c + 1.8PR + 1.2PROD - 0.1u + 0.002u^L \qquad \text{ECM1}$$
$$(25.1) \quad (5.5) \quad (9.0) \quad (1.1)$$

$$P_c = 0.44W + 0.03PROD + (1 - 0.44)P_m \qquad \text{ECM2}$$
$$(8.8) \quad (0.15)$$

$$P_m = -1.15E + 0.65PW \qquad \text{ECM3}$$
$$(76.0) \quad (46.2)$$

.

The value of the likelihood function for this restricted model is –174.34, which gives a likelihood ratio test of the restrictions of 14.9. There are 9 overidentifying restrictions in this model so the restrictions are accepted at the 5% level (the critical value is17).

The first equilibrium correction term is the wage relationship which is homogeneous in prices, has a near unit coefficient on productivity, finds a significant role for the wage policy variable and significant negative unemployment effects. The second equilibrium term is the price mark up equation, which is again homogeneous in prices (wages and import prices) with a coefficient of just under half on wage costs. The third equilibrium term is not homogeneous in prices and indeed if we try and impose homogeneity this restriction is significantly rejected. The interpretation we give to this relationship is as follows. If we re-normalise this relationship we can write it in terms of the nominal exchange rate

$$E = -0.87P_m + 0.56PW$$

If the two coefficients were respectively –1 and 1 then the nominal exchange rate would move in line with prices to maintain a constant real exchange rate. These coefficients instead indicate that the nominal exchange rate will not fully reflect changes in prices and so, for example, as domestic prices rise the exchange rate will not fully accommodate these changes and as a result a real appreciation will result. Exactly as is shown in figure 4. This non-homogeneity may then be viewed as a second stabilising influence on the part of the monetary authorities.

The final part of the full model, which needs to be reported, is the loading weights of the identified equilibrium correction terms. These are presented in the following table.

Table 4: The loading weights for the fully identified model

	ECM1	ECM2	ECM3
Wages	-0.17 (16.6)	0.21 (5.2)	-0.26 (3.3)
Prices	-0.06 (4.0)	-0.06 (2.0)	-0.04 (0.8)
Import Prices	-0.1 (11.1)	0.06 (2.9)	0.17 (2.9)
Exchange Rate	0.019 (1.9)	0.04 (2.8)	-0.18 (4.3)

It is interesting that almost every element of the a matrix is significant, as we would expect given the endogeneity of all four variables and the reduced form we are working with (see equation 3).

As evidence that the model is congruent with the data and reasonable well specified dynamically we report the following set of diagnostics for each of the equation residuals.

Table 5: Residual Diagnostics for the full model

	Wages	Prices	Import Prices	Exchange Rate
Bera-Jarque(2)	0.74	7.3*	2.6	14.6*
ARCH(4)	5.2	1.8	4.5	4.5
LM(4)	6.5	5.1	4.4	3.8
Box-Pierse(1)	0.9	1.1	0.7	0.5
Box-Pierse(4)	7.6	5.6	3.7	3.3
Box-Pierse(8)	10.4	10.5	6.1	7.3
Standard error	0.008	0.011	0.0086	0.0099

* Significant at the 5% level

This table shows no sign of serial correlation or heteroskedasticity. There is some small signs of non normality in the price and exchange rate equations which could not be removed without adding a fairly large number of extra dummy variables, which was decided against on the grounds of parsimony.

A final issue to address within this model is the presence of derivative homogeneity. This is simply a restriction that the long run solution to the model is independent of the rate of growth of the variables. It is often imposed on theoretical grounds, e.g. most of the work of Layard and Nickel. However if we now estimate a version of this model imposing derivative homogeneity across the system this is easily rejected with a likelihood ratio test value of 208 against a critical value of 9.5 ($c^2(4)$). This is not really surprising given that all the dynamic coefficients reported above are clearly significantly different from homogeneity.

To conclude this section; We have developed a fully identified dynamic system for wages, prices, exchange rates and import prices for the Greek economy. There are two major policy influences on this system; the first is the explicit variable in the wage equation, which has allowed us to capture the effects of deliberate intervention in the labour market. The second is the highly significant non-homogeneity in the exchange rate-import price relationship, which has meant that in the long run domestic inflation is not fully accommodated by nominal exchange rate movements. A final third policy route, which is not fully explored here, is the interaction of unemployment with the wage price system. Clearly one conventional stabilisation tool which policy makers use to control inflation is the rate of economic activity and unemployment. Our model captures this in part as unemployment affects wages but unemployment itself is not modelled here and so the full feedback of inflation control through unemployment is not captured. However in the next section we will be able to simulate the model to investigate the relative trade of which exists between unemployment, wage policy effects and the exchange rate determination.

5. Some Policy experiments with the model

In this section we explore some of the basic properties of the model we have estimated with the objective of both understanding the effects of past economic policies and the way policy may operate in future. Within our model policy essentially operates in three main ways; There is the real wage policy variable which proxies the effects of the wage policies which have been conducted in the past. There is the non-homogeneity in the long run relationship between exchange rates and import prices. And finally there are the movements in unemployment. In a full model of course unemployment would respond to economic events more generally and should be an endogenous part of the system. It would then be one of the main stabilising effects on the economy. Our model is conditioned on unemployment, so we do not model this feedback. We can however still calculate the effect of a given change in the level of unemployment on the wage price system.

Before proceeding to the results it is worth stressing that this model is inherently a unit root system with a near homogeneous price system. This means that shocks and policy changes can have lasting or even permanent effects on the levels of the system and even the rates of change could potentially take many decades to come back to there baseline level. So we should expect to see long term effects within the system.

We now turn to investigating these three effects in turn.

The effect of changing the wage policy regime variable (PR).

Figures 5 and 6 show the effect of reducing the real wage by 9%, which was the historical fall in real wages achieved between 1986 and 1987, the simulation begins in the first quarter of 1986. The simulation actually shows the effect of a step fall in the real wage rather than the actual fall, which happened fairly smoothly over the two-year period. We see in figure 6 that there is a large impact on wage inflation due to the initial effect of the incomes policy. This does not immediately fully feed through into prices of course and so the initial fall in wage inflation is not maintained. Although of course as wage inflation is still less than the original base level the level of wages always remains lower and wage inflation also remains lower than the base. Over time however we see in figure 5 that price inflation also begins to fall as a result of the reduced wage inflation and so the fall in both wage and price inflation then increases steadily as the dynamics of the system devebp. Overall the impact of the simulation is long lasting and substantial, after 10 years the rate of inflation has been reduced by more than 10%.

The effect of changing Unemployment.

Throughout most of the 1980's unemployment in Greece was very stable at around 7.5%. During the first five years of the 1990's it rose fairly steadily to around 10%, an increase of one third. In this section we will simulate a step increase in inflation of 33%. This is unrealistic in two respects; first clearly a step increase of such a large amount would be unreasonable. Second we are not allowing for any feed through from short run to long run unemployment which would mitigate the overall effect. The essential objective here however is to calibrate the overall size and dynamics on the price system of unemployment changes in Greece.

The results of this experiment are shown in figures 7 and 8. Once again we see the complex interaction of the dynamics of wages and prices. Figure 7 shows that wages initial respond more strongly than prices and so real wages decline. This causes the initial fall in wage inflation to be larger than the effect after one or two years. As the effect on price inflation begin to cumulate however we see that the fall in wage inflation then begins to accelerate until a virtuous wage price spiral builds up. After 5 years the general fall in inflation is of the order of 10%.

The effect of Damping the Exchange Rate Response

The final form of policy intervention, which we believe has taken place over this period, is the less than complete pass through of price effects onto exchange rates. That is as Greek prices have risen the exchange rate has not been allowed to devalue to fully reflect the price change and thus a steady rise in the real exchange rate has been achieved. The effect of this on the system is to formally remove the unit root from the price system and thus to damp the effect of any inflationary shock which occurs. We illustrate this in Figure 9 which shows a simulated increase in real wages under two conditions; first the model as we have estimated it. And second the same model except that we have replaced the coefficients in the exchange rate cointegrating (ECM3) vector with -1 and 1 to produce a fully homogeneous system. This figure shows that while over a three or four year period the effect of a price shock is very similar as we look further ahead the homogeneous model is much more inflation prone. After 10 years the inflation effect is halved in the estimated model by the damping effect coming from the exchange rate relationship.

This then illustrates the important long-term effect, which this exchange rate behaviour has had in controlling the inflationary process. It is not possible to evaluate the contribution of this policy in isolation from the incomes policy and unemployment effects as the simulations outlined in Figure 5-8 are done as a combination of exchange rate behaviour and **the** particular policy change being investigated. Figure 9 does however stress the importance of this part of the model to the overall long-term developments in Greece.

A NAIRU Calculation

Finally we address the question of using our model to evaluate the non-accelerating inflation rate of unemployment (NAIRU) for the Greek economy. There are a number of technical problems to the conventional way of calculating the NAIRU for our model. In particular, most models used for NAIRU calculations are homogeneous in both levels and rates of change. If this is not the case then the NAIRU becomes a function of both the level of prices and the rate of inflation. To avoid these difficulties we have used our model to numerically calculate the rate of unemployment in each quarter that would have held the inflation rate at a constant level for the following five years. This means that we take full account of all the non-homogeneities in the model by using actual data and the model. However we need to know the actual inflation rate for the following five years and so we are only able to perform this calculation for the period up to 1993. The results of this calculation are reported in figure 10. This shows that in the late 1980's actual unemployment was close to the NAIRU. During the early 1990s however the NAIRU actually fell while unemployment rose to produce between a 3 and 4 percentage point gap between the two. While as noted above, we can not bring the NAIRU calculation fully up to date on this data base it would seem to be clear that there is some scope for a reduction in unemployment without undue inflationary pressure throughout the late 1990's.

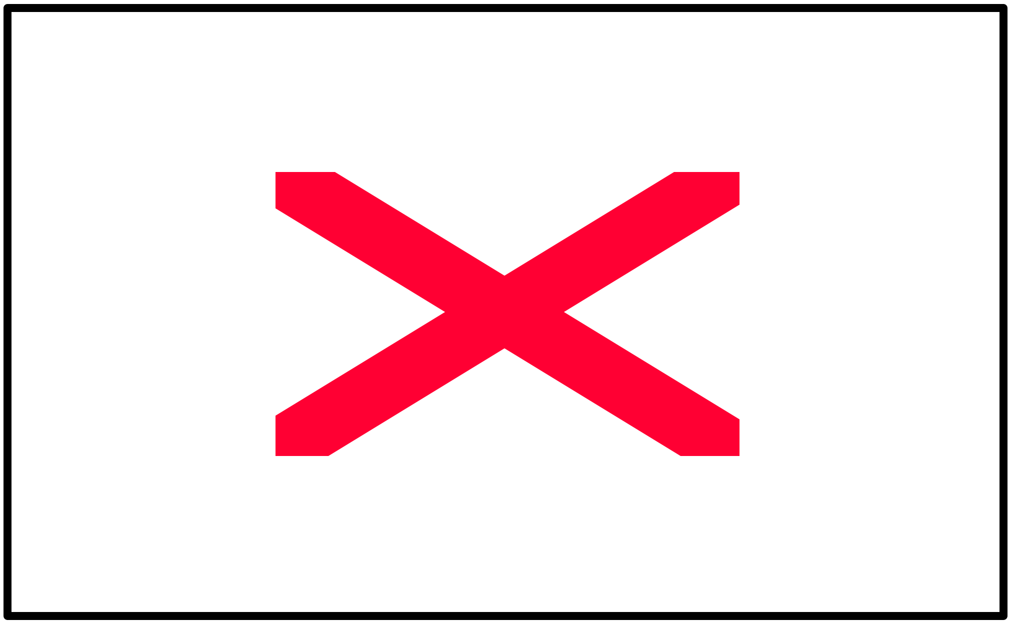


Figure 5.

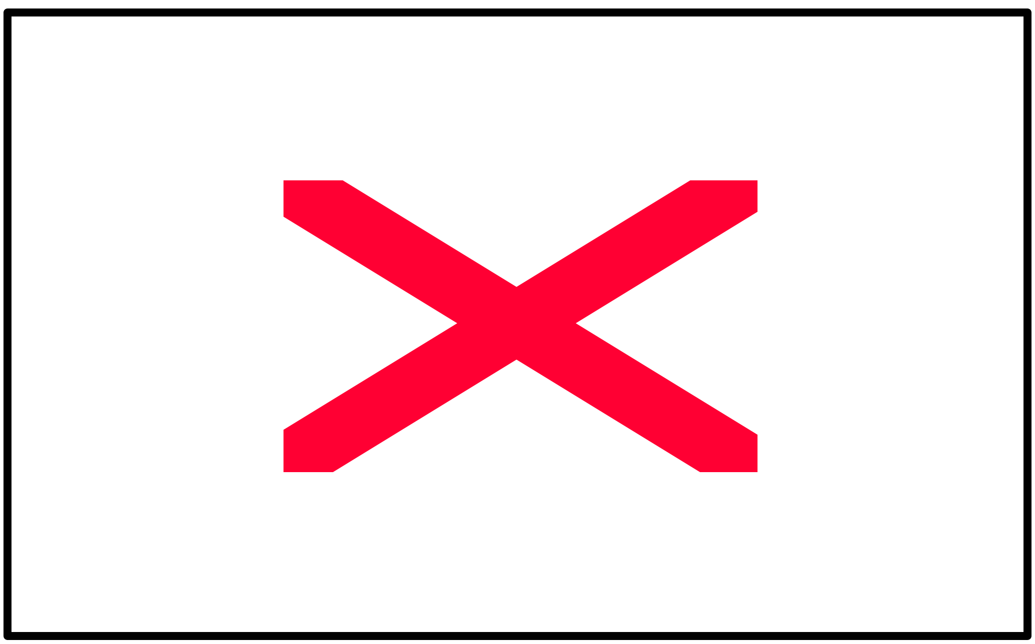


Figure 6

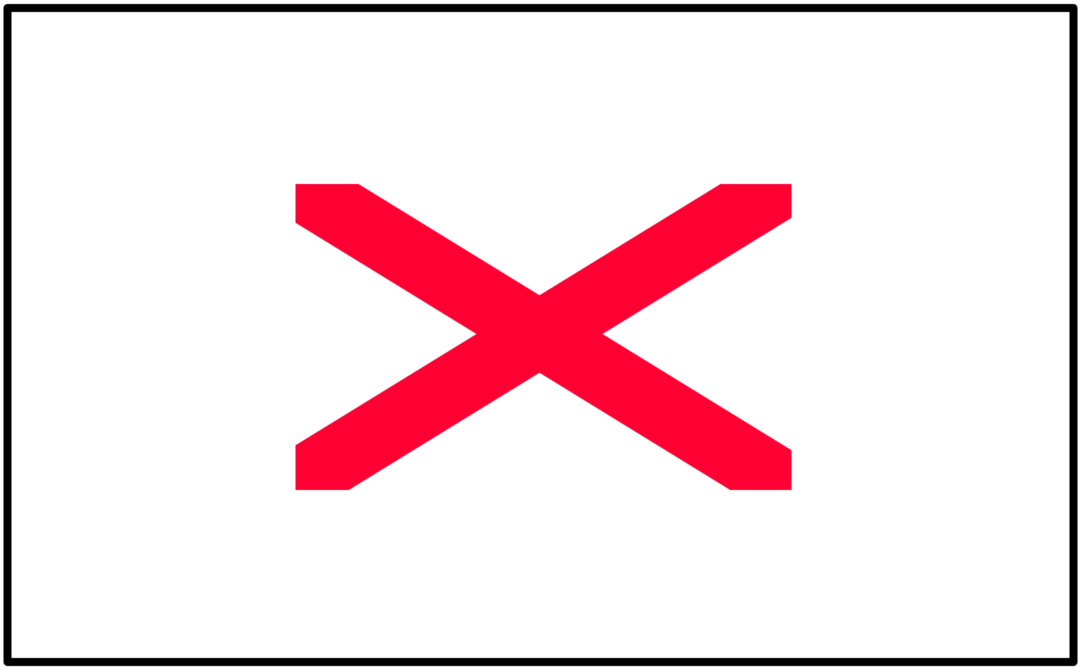


Figure 7

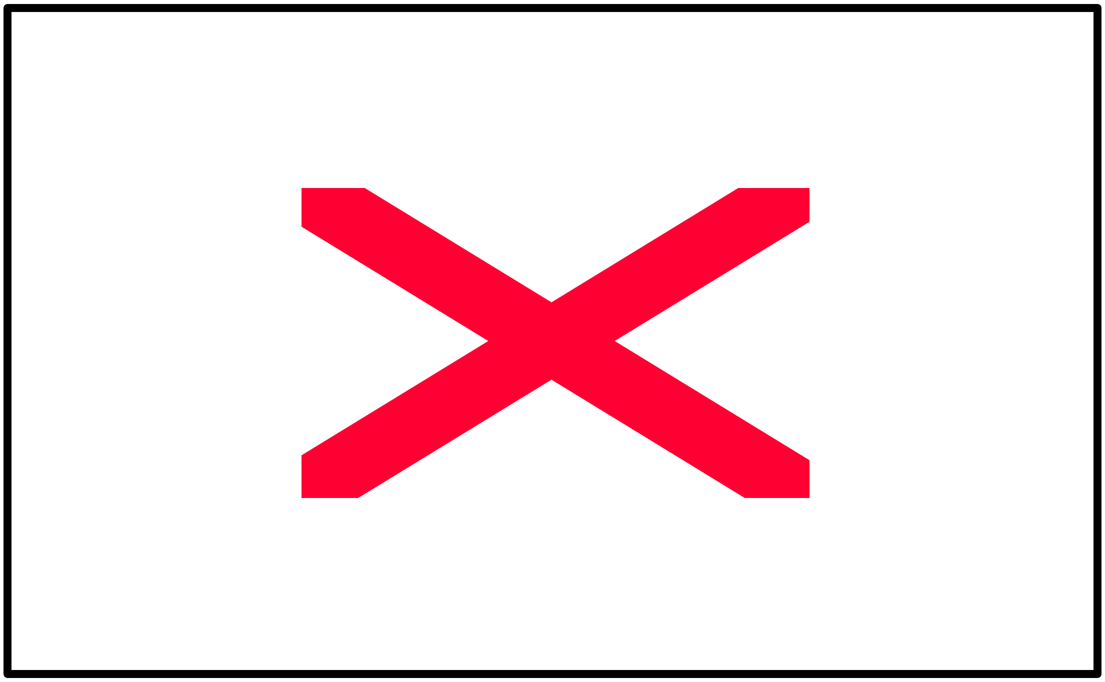


Figure 8

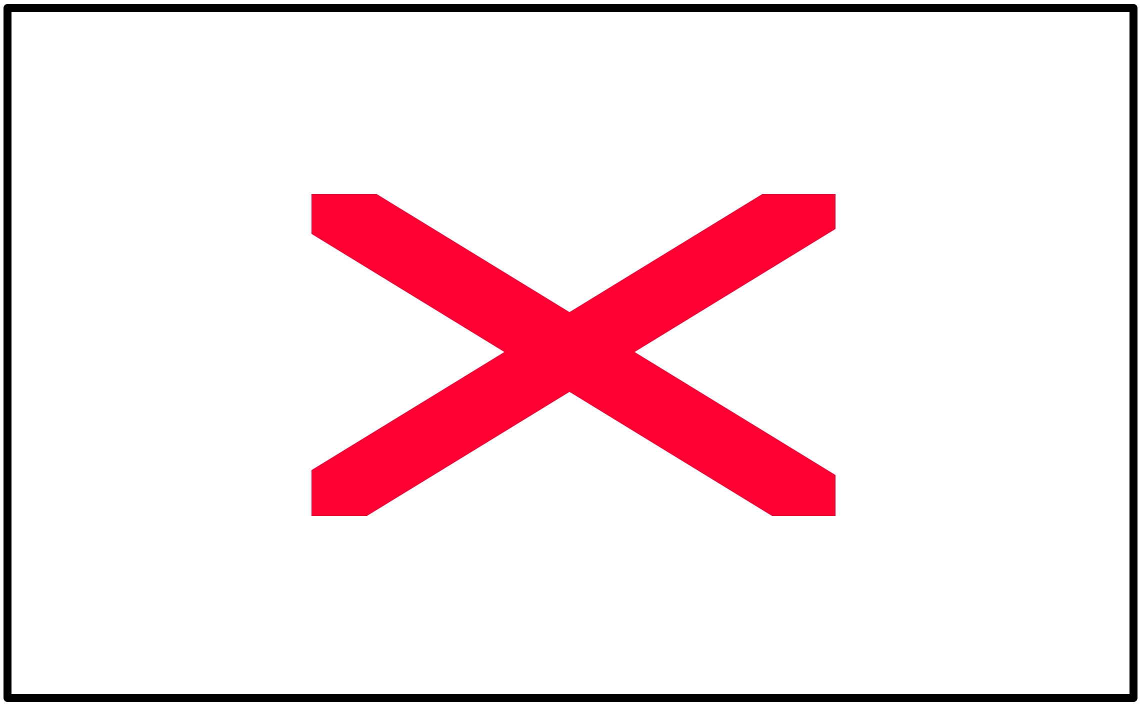


Figure 9.

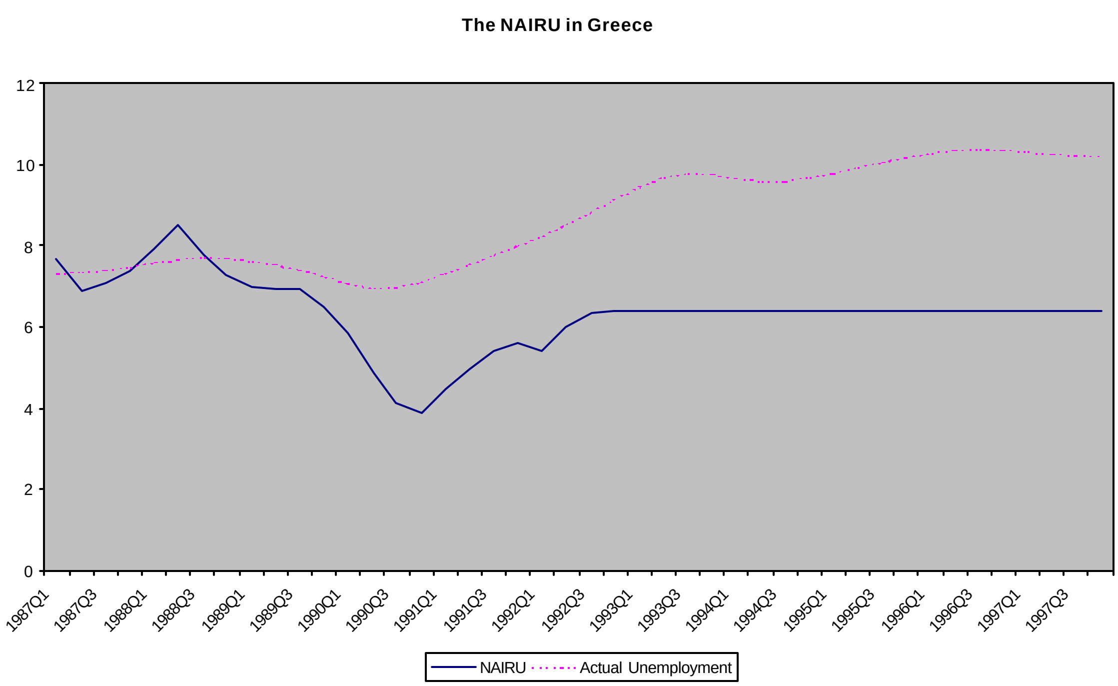


Figure 10

6. Conclusions

In 1986 price inflation in Greece was approximately 24%, by 1997 this had fallen to under 5%. Our model would suggest that something of the order of 14% points of this reduction are due to the lasting effect of the 1986 price restraint period which successfully achieved a permanent reduction in the level of the real wage. Much of the rest of the reduction would probably be due to the increase in unemployment experienced during the early 1990's. These two policies have achieved a dramatic, if slow acting transformation of the Greek economy.

References

Ball, L. (1994), Credible Disinflation with Staggered Price Setting, American Economic Review, Volume 84, 282-289.

Banerjee, A., Dolado, J., Hendry, D., and Galbraith, J., (1993), "Cointegration, error correction, and the econometric analysis of non-stationary data", A dvanced Texts in Econometrics, Oxford University Press.

Bardsen, G. and Fisher, P. (1995), "The Importance of being Structured", working paper, Norges Bank, Norway.

Blanchard, O. and Muet, P. (1993), Competitiveness through Disinflation: An Assessment of the French Macroeconomic Strategy, Economic Policy, Number 16, April.

Blanchard, O. and Quah, D. (1989), They Dynamic Effects of Aggregate Demand and Supply Disturbances, American Economic Review, Volume 79, Number 4, 655-73.

Chadha, B., Masson, P.R. and Meridith, G. (1992), Models of Inflation and the Costs of Disinflation, IMF Staff Papers, Volume 39, Number 2, 395-431.

Clark, P. and Laxton, D. (1997), Phillips Curves, Phillips Lines and the Un employment Costs of Overheating, Centre for Economic Performance, London School of Economics, Discussion Paper Number 344.

Church, K.B., Mitchell, P.R. and Wallis, K.F. (1996), Short -Run Rigidities and Long Run Equilibrium in Large Scale Macroeconometric Models, ESRC Macroeconomic Modelling Bureau, mimeo.

Davidson, J., and Hall, S. G., (1991), "Cointegration in Recursive Systems", Economic Journal, Volume 101, Number 405, March.

Gallant, A.R. and Jorgenson, D. (1979), "Statistical Inference for a System of Simultaneous, non-linear, Implicit Equations in the Context of Instrumental Variable Estimation", Journal of Econometrics , Volume 11, 275-302.

Greenslade, J., Henry, S. G. B., and Jackman, R., (1998), A Dynamic Wage-Price Model for the UK , Centre for Economic Forecasting, London Business School, Discussion Paper Number 10-98.

Hall, S. G., and Wickens, M., (1993), Causality in Integrated Systems, Centre for Economic Forecasting, London Business School, Discussion Paper Number 27-93.

Henry, S. G. B., Nixon, J., and Williams, G., (1997), Pricing Behaviour in the UK , London Business School, Centre for Economic Forecasting, Discussion Paper Number 05-97.

Henry, S. G. B., and Lee, K., (1997), "Identification and Estimation of Wage and Employment Equations: An Application of the Structural VAR Modelling Approach", Department of Applied Economics, mimeo.

Henry, S. G. B., and Snower, D. J., (eds.) (1996), "Economic Policies and Unemployment Dynamics in Eu rope" International Monetary Fund.

Ireland, S., and Wren Lewis, S., (1995), "Inflation Dynamics in a New Keynesian Model", University of Strathclyde, mimeo.

Johansen, S., (1988), "Statistical analysis of cointegration vectors", Journal of Economic Dynamics and Control, Volume 12, 231-54.

Johansen S., (1991), "Estimation and Hypothesis Testing of Cointegrating Vectors in Gaussian vector Autoregressive Models", Econometrica, Volume 59, 1551-80

Johansen S.(1992) “Identifying Restrictions of Linear Equations”, Pre-print, Institute of Mathematical Statistics, University of Copenhagen.

Johansen S., (1995), “Identifying restrictions of Linear Equations with Applications to simultaneous Equations and Cointegration”, Journal of Econometrics , Volume 25, 309-42

Johansen, S., and Juselius, K., (1990), “Maximal likelihood estimation and inference on cointegration - with applications to the demand for money”, Oxford Bulletin of Economics and Statistics, Volume 52 (2), 169-210.

Layard, R., Nickell, S. and Jackman, R (1991), “Unemployment: Macroeconomic Performance and the Labour Market”, Oxford University Press.

Lucas, R. (1976), “Economic Policy Evaluations: A Critique” in “Phillips Curve and Labour Markets”, eds. K. Brummer and A. Meltzer. North-Holland.

Martin, C., (1997), “Price Formation in an Open Economy: Theory and Evidence for the United Kingdom”, Economic Journal, Volume 107, 1391-1404.

Nixon, J. and Urga, G. (1997), Unemployment and the Capital Stock: Modelling the Supply Side of the UK Economy, London Business School, mimeo.

OECD, (1995), UK Economic Survey, OECD.

Osterwald-Lenum, M., (1992), “A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics”, Oxford Bulletin of Economics and Statistics, Volume 54 (3), 461-472.

Pesaran, M. H., and Shin, Y., (1994), “Long Run Structural Modelling”, University of Cambridge, mimeo.

Pesaran, M.H., Shin, Y., and Smith, R.J., (1997), “Structural analysis of vector error correction models with exogenous I(1) variables”, University of Cambridge, mimeo.

Phillips, P., C., B., (1991), “Optimal Inference in Cointegrated Systems”, Econometrica, Volume 59, 283-306

Price, S. (1991), “Costs, Prices and Profitability in UK Manufacturing”, Applied Economics, Volume 23, 839-850.

Reimers, H-E., (1991) “Comparisons of Tests for Multivariate Cointegration”, Institute for statistics and econometrics, Christian-Albrechts University of Kiel, Working Paper Number 58.

Robertson, D., and Wickens, M., (1994), “VAR Modelling”, in Hall S G (ed.) Applied Economic Forecasting Techniques’ Simon and Schuster.

Sentance, A., Nixon, J. and Greenslade, J. (1997), “Inflation Constraints on Growth in the UK Economy: Is there a Speed Limit?”, London Business School, mimeo.

Turner, D., Richardson, P. and Rauffet, S. (1996), Modelling the Supply Side of the Seven Major OECD Economies, OECD Economics Department Working Paper Number 167.