EUROPEAN UNIVERSITY INSTITUTE
Department of Economics

Macroeconomic Modelling of the Greek Economy

Dimitris Sideris

Thesis submitted for assessment with a view to obtaining the Degree of Doctor of the European University Institute

Florence, September 1997

EUROPEAN UNIVERSITY INSTITUTE
Department of Economics

Macroeconomic Modelling of the Greek Economy

Dimitris Sideris

The Thesis Committee consists of:

Prof. Michael Artis, EUI
" Katarina Juselius, University Copenhagen, Visiting Fellow EUI
" Grayham Mizon, EUI, Supervisor
" Yannis Stournaras, Ministry of Finance, Athens

Acknowledgements

This thesis was written between early 1994 to early 1997, at the Economics Department of the European University Institute in Florence. It benefited significantly by a number of persons who contributed to the final outcome with invaluable professional advice and whom I would like to thank.

First and foremost my supervisor Grayham Mizon, whose suggestions, comments and patience were fundamental to my work.

Thanks for comments go to Mike Artis, Katarina Juselius, Dimitris Moschos and Yiannis Stournaras. My gratitude also goes to my colleage Ide Kearney for discussing points of my thesis with me.

Preliminary versions of this work have been presented at the econometrics and students workshops at the EUI and at the econometric society meeting in 1996. Participants in these seminars are thanked for comments and suggestions.

Moral support from my family and friends was not less important than professional advice. I would also like to thank my friends Ide Kearney, Gonzalo De Cordova, Marion Kohler, Effi Gazi, Chiara Monfardini, Massimiliano Marcellino and Stefan Dillmann for their support. Last but not least my dear friend Norbert Wuthe whose support was constant during all this period: fortunately cyclical booms and slumps of our lives were almost always in different phases.

Finally, I would like to thank Jacqueline Bourgonje and Jessica Spataro for the role they had in many moments of my life at the E.U.I.

Contents

Chapter 1

Introduction.

1.1 Background

The present thesis consists of three applied studies dealing with aspects of the recent macroeconomic performance of the Greek economy.

They all aim to pursue and to link two different kinds of issues:

a) The first one is to derive useful insights into the functioning of the Greek economy during the post 1974 period. That is of particular interest given the country's poor macroeconomic performance in comparison with its post-war experience. In addition, the period covers the effects of a number of important policy regime shifts (restoration of democracy in 1974, admission to the EU in 1981, switch in macroeconomic policies in the mid 80's) and therefore can be of use for making inference on the effects that institutional and policy regime changes have on economies.

b) The second one has to do with the implications that methodological issues have on econometric modelling.

Theoretical issues of interest.

The economic performance of Greece during the years has been rather poor, characterised by macroeconomic indicators which underperform the corresponding EU ones. In fact, the period is mainly characterised by, on average, high inflation rates, slow growth relative to the EU and Greece's own post-war performance accompanied additionally by increases in unemployment and in the public sector deficit.

The beginning of the period coincides with a major change in the political regime, given that 1974 is the year when democracy in Greece is restored after the seven-year military dictatorship. It also means a number of changes in the economic policies pursued. The peg to the dollar was abandoned in favour of a crawling peg exchange rate and the macroeconomic policies became expansionary following the popular demand for income redistribution and a larger state role. Expansionary policies were followed by both conservative (in power for the 1974-1981 years) and socialist governments (in power for the 1981-1989 years) till the mid 80's, and despite Greece's entry into the EU in 1981, which changed the competition conditions for the economy.

In October 1985 a switch in policies was observed when a two-year stabilisation programme is put into practice in response to the sharp deterioration of macroeconomic conditions in that year. Policies were again relaxed for the pre-electoral 1988 year and the period up to 1990 which was characterised by relative political instability (short-lived governments) and resulted in another increase in inflation and worsening of the public deficit. The late 80's were also characterised by a number of institutional changes that took place gradually, such as the liberalisation of the Bank of Greece and the reduced role of the state. Finally, strict policies were implemented from 1990 on, first by the conservative government (1990-1993) which also introduced restructuring of the labour and financial markets and then by the socialist one (1993- present) in an effort to reach the EU Maastricht standards.

Methodological Issues

The analysis in all three studies follows the LSE tradition, in which the time series properties of the variables play an important role in modelling, and the "General to Specific" strategy is advocated as a trustworthy technique for model selection. Use of cointegration analysis leads to the estimation of possible long-run relationships of the series and allows modelling of the short-run dynamics while taking into account the long-run information.

Within this methodological framework, particular emphasis is also given to econometric modelling issues such as: characterisation of the seasonality of the series, cointegration at the zero frequency and at seasonal frequencies; exogeneity issues, weak exogeneity testing in cointegrating systems and its implications for econometric modelling; testing for reduction of systems of cointegrating variables; parameter constancy of econometric models and of the estimated cointegrating relationships; testing for the forecasting ability of econometric models.

1.2 Outline of the study

The studies deal with the aspects of the economy that have to do with price formation and the stagflationary Greek experience during the post 1974 years. The thesis is structured as follows:

Chapter 2 briefly presents the main elements of the econometric methodology adopted in the analysis.

Chapter 3 models the functioning of the labour market sector in an attempt to analyse the contemporaneous increase in inflation and unemployment that took place during the period. To this end, the behaviour and interdependences between wages, prices, productivity and unemployment are analysed in the context of a closed system. After a univariate analysis of the data series with emphasis given to their seasonal behaviour, the Johansen multivariate maximum likelihood technique is applied to test for cointegration. It leads to the identification of one long-run relationship among the series analysed: a real wage - productivity relationship, with positive unemployment effects. This long-run relation is then included in a vector error correction model which is used as a congruent general benchmark against which alternative models are evaluated. A theoretically reasonable simultaneous equations model (SEM) which encompasses the unrestricted general model is finally selected based on criteria such as parameter constancy, and provision of good forecasts.

The aim of chapter 4 is twofold: The first aim is to analyse in depth the foreign sector long-run effects on Greek prices, by testing for long-run purchasing power parity (PPP) with Greece's main trading partners, issue which also has important implications for the path of the Greek competitiveness during the recent years. Secondly, it also deals with methodological problems related with the testing of PPP. These are: the choice between a multilateral and a bilateral approach, the choice of the appropriate price index and the problem of simultaneous determination of prices and exchange rates. Long-run PPP is tested as an exchange rate-price cointegrating relationship by applying the Johansen procedure, using two alternative price measures. The analysis is carried out in a "general to specific" framework, which allows comparison between the multilateral and the bilateral approach and the econometric procedure adopted tests the endogeneity/exogeneity status of the variables rather than imposing it *a priori*. In contrast with previous studies, more positive evidence for the PPP hypothesis is found. The difference in findings can be attributed to the statistical technique used, which analyses the time dependence properties of the series on a multivariate framework, allowing for different short run dynamics and long run relationships and for adjustment for structural breaks.

Chapter 5 attempts to model price inflation in Greece by taking into account all possible sources suggested by economic theory. The aim is to build a data-coherent and empirically constant model which could thus clarify the relative importance of the factors determining consumer price inflation and make it easier to understand the role that the economic authorities can play in its determination. To this end, we use all alternative hypotheses of a small open economy that consider both monetary and cost-push causes. Moreover, we test for the existence and stability of any long-run relationships predicted by economic theory for price formation by applying cointegration analysis. We then go on by building a general overparameterised, error correction model in which the obtained long-run relationships play the role of error correction terms. According to it, inflation is assumed to come from the money market, labour market and exchange rate market. The general model is further reduced to a parsimonious theoretically interpretable model. Since our general model embeds various theoretical models, such as the Phillips curve, and closed and open economy monetarist models, we test for the empirical relevance of these in the process of obtaining the parsimonious model. Moreover, the significance of the parameters of the error correction terms indicate which variables drive inflation in the long run. The obtained model is also indicated to be parameter constant and to provide good forecasts.

Chapter 6 summarises the main conclusions.

Chapters 3 - 5 are self-contained and can be read in isolation. Therefore, a few repetitions were unavoidable.

Chapter 2

The methodology

2.1 Introduction

One of the most important developments in the field of applied econometrics in recent years has been the "LSE methodology". The components of this methodology are extensively discussed in Hendry (1995), Hendry and Mizon (1990), (1993), Hendry and Richard (1983), Mizon (1995) and Spanos (1986), (1990), *inter alia.*

In the present chapter just a brief presentation of the methodology is attempted: Section 2 briefly highlights its basic components whereas section 3 gives emphasis to the implications it has for system modelling.

2.2 The LSE methodology

The basic feature of the modelling methodology in hand is that it takes into account alternative sources of information. These sources include "...economic theory, the available sample of observations on the potentially relevant variables, knowledge of the economic history of the period under study, knowledge of the way in which the observed data are defined and measured, plus their relationship to the theory variables" (Mizon (1995)).

More analytically, the methodology advocates that the stochastic properties of the series of interest have to be accounted for, the measurement system (e.g. degree of aggregation) might influence the model specification, and that theoretical and observed variables may be two distinct concepts. In such a context, theories are treated as providing approximations to the observable phenomena without being exact copies of reality.

Consequently, observed data constitute a sample taken from an on-going real data generation process (DGP) with all its variability and "irrelevant" to the theory features, together with observational errors, whereas a theoretical model is simply a mathematical formulation of a theory based on simplifying assumptions.

The methodology advocates general-to-specific as a modelling strategy and congruence and encompassing for model evaluation. According to the general-to-specific strategy the first step in modelling is the specification of an unrestricted statistical model approximating the actual DGP.

Following Spanos (1986), the specification of a general statistical model is based on three sources of information: a) theory information; b) measurement information; c) sample information;

a) In the LSE methodology context theory information comes mainly in the form of the estimable model and the choice of the variables to be included.

b) The measurement information is related to the quantification and the measurement system properties of the variables involved. These include the units of measurement, the measurement system (nominal, ordinal, ratio), as well as exact relationships among the observed series such as accounting identities.

c) The sample information comes in the form of the observable variables involved and their structure (and can be divided into past, present and future information). Such information is useful in relation to concepts underlying the specification of the general model such as exogeneity, Granger-causality, structural invariance.

The above information sources together with the implementation (use) of a number of probabilistic assumptions concerning the way in which the data are supposed to, or did in fact originate, lead to the specification of the general statistical model. In other words, the general statistical model is a probabilistic formulation purporting to provide a generalised description of the actual DGP.

Then, the next step in the modelling procedure is to ensure that the estimated statistical model, is well-specified, (or statistically adequate, congruent), in the sense that the statistical (probabilistic) assumptions defining it are valid. This is of importance given that it is statistical arguments that will be used to define and to test any hypotheses related to the theoretical parameters of interest. Misspecification testing hence refers to the testing of the (testable) assumptions underlying the statistical model.

As far as the general statistical model is shown to be well-specified, it can be used as a valid basis against which alternative simplifications can be evaluated[1]. The advantage of doing so is that awkward circles of the kind arising in simple-to-general searches are avoided. Starting from a well-defined statistical model, we can proceed to test any theoretical restriction, the aim being the construction of an approximation of the actual DGP, in terms of the theoretical parameters of interest.

Following this procedure, a final econometric model can be chosen, which imposes a structure on the general statistical model to isolate relationships based on economic theory. The chosen model has to be shown an adequate characterisation of the available information (congruence). Where "necessary conditions for any model to be congruent include a) data coherency, b) constant parameters, c) valid weak exogeneity of any unmodelled variables for the parameters of interest and e) data admissibility. In addition, any model claiming to be structural must have invariant parameters and be able to parsimoniously encompass the unrestricted model" (Hendry and Mizon (1993)).

Finally, the methodology recognises the fact that numerous parameterisations are possible to satisfy the statistical assumptions, so, in practice, we need to choose one of such possible reparameterisations based on the above mentioned criteria of model selection.

Another recent development in applied econometrics which has become an indispensable stage of the LSE strategy given that it attributes to the statistical adequacy of the models, is the **cointegration analysis** (see Banerjee and Hendry (1992), Muscatelli and Hurn (1992) for brief reviews). This analysis begun in an effort to deal with the problems arising when regression methods developed to analyse stationary series are applied to non-stationary series. One such problem is the spurious regressions problem, that is, when two completely unrelated but integrated time series appear to produce significant relationships when regressed on each other. Not being aware of this feature, the estimation results might be subject to severe mis-interpretation.

One straightforward reaction for dealing with integrated series (as suggested by the traditional Box Jenkins (1970) time series analysis) is to difference them. However, although the use of differenced series clearly avoids the mentioned statistical problems, it neglects potential long-run relationships among the series.

A solution to these problems was finally given by the development of the notion of

[1]The need for a common statistical framework in the context of non-nested models and encompassing was emphasised by *inter alia* Mizon (1984), (1995), Mizon and Richard (1986).

cointegration (Granger (1981)) which states that non-stationary series are cointegrated if a linear combination of them is stationary, despite the fact that the series separately are nonstationary. In such a case, this linear combination which contains valuable long-run (level) information can be used in the modelling which makes use of the standard statistical inference techniques.

2.3 The "encompassing the VAR" framework

2.3.1 The general statistical model

In a **system context**, Hendry and Mizon (1993), Clements and Mizon (1991) propose the use of a congruent unrestricted vector autoregressive representation (UVAR) as the general framework against which alternative restricted simultaneous equations models (SEM) can be evaluated. A UVAR specified in levels can be considered as a valid representation of the actual DGP (general statistical model) allowing for non-stationarities in the variables analysed[2]. For the case of an $N \times 1$ vector of the time series of interest x_t, (perhaps after transformation to ensure that linearity is reasonable) the UVAR would be of the form:

$$A(L)x_t = \mu + \psi D_t + \nu_t \tag{2.1}$$

where $\nu_t \sim IN(0, \Omega)$, corresponding to:

$$x_t \mid \sigma(X_{t-1}^1) \sim N(-A^*(L)x_{t-1} + \mu + \psi D_t, \Omega) \tag{2.2}$$

for t=1,2,...T, where $\sigma(X_{t-1}^1)$ is the sigma field generated by:
$X_{t-1}^1 = \{x_1, x_2, ..., x_{t-1}\}$, μ is a constant and D_t contains conditioning variables such as seasonals, event dummy variables and relevant exogenous variables which influence only the short run behaviour of the process.

In model (2.1): $A(L) = \sum_{j=o}^{k} A_j L^j = I_N + A^*(L)L$, which is a k^{th} order matrix polynomial in the lag operator L with $A_0 = I_N$. Also, $\{A_j\}$ and Ω are unrestricted, except that the latter is a symmetric covariance matrix; the initial values $x_{1-k}, x_{2-k}, ..., x_0$ are fixed and k is finite, so that moving average components are excluded. These assumptions,

[2] Monfort and Rabemanjara (1990), propose a similar methodology for stationary series.

together with those about independence, normality and homoscedasticity, are not fundamental, while the assumption about constant parameters of interest $\{\mu, A_1, \ldots, A_k, \nu, \Omega\}$ is.

All of these assumptions can be tested: if they are accepted then the estimated UVAR can be said to be a congruent representation of the available information for the variables of interest, and can be used as the general benchmark model against which specific models implying particular behavioural patterns can be evaluated.

2.3.2 Cointegration analysis

As long as a UVAR of the form (2.1) is shown to be data congruent it can be used to test for the existence of cointegration among the series. In particular, the number of the possible long-run cointegrating relationships between the variables can be defined following the procedure suggested by Johansen (1988), Johansen and Juselius (1990), which is the conceptually most straightforward among the ones proposed in the literature. This procedure is discussed in more details below:

The UVAR of the form (2.1) can be reparameterised in a vector error correction form (VECM)[3] as follows:

$$\Delta x_t = -\sum_{i=1}^{k-1} \Pi_i \Delta x_{t-i} + \Pi x_{t-k} + \mu + \psi D_t + \nu \tag{2.3}$$

where:

$$\Pi_i = -(I_N + \Sigma_{j=1}^{i} A_j), \tag{2.4}$$

$$\Pi = -(I_N + \Sigma_{j=1}^{k} A_j) = -A(1) \tag{2.5}$$

and Π is the matrix of the long-run responses. Then, and in the case that the series are at most integrated of order one I(1), the maximum likelihood technique suggested by Johansen(1988), Johansen and Juselius (1990) (see also Johansen (1995)) can be used to test for the rank of the matrix Π, by computing two likelihood ratio test statistics, the "trace statistic" and the "maximal eigenvalue statistic".

[3]Clements and Hendry (1995) suggest that models of this form should be named as vector equilibrium correction models based on the observation that in such reparameterisations, the long run information terms known as "error corrections" first introduced by Davidson *et al* (1978) may play the opposite role when the equilibrium changes, so they should be called "equilibrium corrections".

Then, letting the Π rank be r and ignoring deterministic nonstationarities, we have the three cases:

if r=N, all the N variables in x_t are I(0);

if r=0, all the variables are integrated of order one, I(1) and do not cointegrate;

if 0< r <N, there are r cointegrating linear combinations of x_t.

In this last case, the matrix Π can be expressed as the product of two N×r matrices α and β', where β contains the r cointegrating vectors and α is the loadings or adjustment parameters matrix, which contains the loadings with which the cointegrating relationships enter the equations modelling Δx_t.

Estimation of the cointegration rank

More analytically, Johansen (1988), Johansen and Juselius (1990) suggest to first estimate a concentrated likelihood function in terms of the Π parameters alone: this can be done by partialling out all other variables of the system. The difficulty is that Π is of reduced rank and therefore cannot be estimated directly. So the concentrated likelihood function is maximised with respect to the $N \times r$ α parameters only, treating $\beta' x_t$ as a variable; solving for the β parameters then reduces to solving an eigenvalue problem where β is the matrix of the eigenvectors and the associated eigenvalues are: $0 \leq \lambda_N \leq ... \leq \lambda_2 \leq \lambda_1 \leq 1$.

When Π is unrestricted, all N eigenvalues are retained and the log-likelihood function depends on $-1/2\ T \sum^N ln(1-\lambda_i)$, whereas when Π has rank r, the loglikelihood is the same function summed over the r largest λ_i. Under the null of r cointegrating vectors, a sequential log-likelihood test procedure - the trace test - can be derived using twice the difference between the unrestricted and the restricted function. An alternative test of the null of $N-r$ unit roots, known as the maximum eigenvalue test is based on the idea that a small value of λ_i is less likely to reject the hypothesis that there is a unit root in the characteristic equation of $A(L)$.

The distributions of these two tests statistics are non-standard, and vary depending on whether a constant and a trend are included or not. Critical values have been tabulated by Osterwald-Lenum (1992).

Testing for theoretical restrictions on β's

The hypothesis of cointegration is given by:

$$H_{01} : \Pi = \alpha\beta' \tag{2.6}$$

Further, linear restrictions on either the parameters of the cointegrating vectors β_i or their loadings α_i can be tested (which form hypotheses against H_{01}). The importance of testing restrictions on α_i and β_i in part stems from the fact that the matrices α and β' are not unique: any linear transformation of, say, β' by a nonsingular r×r matrix Θ, leaves Π unchanged:

$$\Theta\beta' = \beta^{*} \rightarrow -\alpha\Theta^{-1}\Theta\beta' = \Pi \tag{2.7}$$

where $\Theta^{-1}\Theta = I_r$. In this framework, restrictions on the β_i 's which imply theoretical hypotheses for the long run behaviour of the series can be expressed as:

$$H_{02} : \beta = \Xi\phi, \tag{2.8}$$

In (2.8), the matrix $\Xi_{N\times s}$ defines known linear restrictions, while $\phi_{s\times r}$ incorporates the restrictions on the individual values of the cointegrating space. The hypothesis of the form (2.8) can be assessed by a likelihood ratio test statistic of the form:

$$T\sum_{i=1}^{r} log\{(1-\lambda_i^{*})/(1-\lambda_i)\} \tag{2.9}$$

where λ_i^{*}, λ_i are the r largest eigenvalues of the restricted and the unrestricted model, respectively. The statistic is asymptotically distributed as a χ^2 with $r(N-s)$ degrees of freedom when testing for H_{02}.

Testing for restrictions on the α's

Tests for the status of the variables and specification of some of them as weakly exogenous is of great help for the purposes of statistical inference, (estimation and hypothesis testing) in a conditional model. Simplistically, whether or not a variable is exogenous depends upon whether or not that variable can be taken as "given" without losing information for the estimation at hand (see *inter alia* the papers in Ericsson and Irons (1994)).

More analytically, the joint sequential density for all the modelled variables x_t can be factorised into the conditional density of the endogenous variables x_{1t} given the exogenous variables x_{2t} and the marginal density of the exogenous variables x_{2t}:

$$F_x(x;\theta) = F_{x_1|x_2}(x_{1t}|x_{2t};\theta_1).F_{x_2}(x_{2t};\theta_2) \tag{2.10}$$

where $F_v(.)$ denotes the density function for variable v. Thus, $F_x(x;\theta)$ is the joint density of x_t, $F_{x_1|x_2}(x_{1t}|x_{2t};\theta_1)$ is the conditional density of x_{1t} given x_{2t} and $F_{x_2}(x_{2t};\theta_2)$ is the marginal density of x_{2t}. The parameter vector θ is the full set of parameters in the joint process; θ_1 and θ_2 are the parameters of the conditional and marginal models respectively.

If we have weak exogeneity of the x_2 variables with respect to θ_1, it is valid to model x_{1t} using its conditional density $F_{x_1|x_2}$ alone. Such a requirement is violated if θ_1 and θ_2 are not *variation free*[4].

Within the cointegration analysis framework, in the case that the rank of the cointegration space r is $0 < r < N$, the information on the cointegrating vectors is retained in both the conditional and the marginal distributions via the error correction term. For the case of a VAR specified as in (2.3) for a vector of the form $x_t' = (x_{1t}, x_{2t})$, the Πx_t product matrix can be defined as:

$$\alpha\beta' x_t = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} \beta_{11}' & \beta_{12}' \\ \beta_{21}' & \beta_{22}' \end{bmatrix} \begin{bmatrix} x_{1t} \\ x_{2t} \end{bmatrix} =$$

$$= \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} \beta_{11}'x_{1t} + \beta_{12}'x_{2t} \\ \beta_{21}'x_{1t} + \beta_{22}'x_{2t} \end{bmatrix} =$$

$$= \begin{bmatrix} \alpha_{11}(\beta_{11}'x_{1t} + \beta_{12}'x_{2t}) + \alpha_{12}(\beta_{21}'x_{1t} + \beta_{22}'x_{2t}) \\ \alpha_{21}(\beta_{11}'x_{1t} + \beta_{12}'x_{2t}) + \alpha_{22}(\beta_{21}'x_{1t} + \beta_{22}'x_{2t}) \end{bmatrix} \tag{2.11}$$

The system as in (2.10) can be factorized into the conditional distribution of Δx_1 given Δx_2 and the marginal distribution of Δx_2. In that case, (2.11) becomes:

$$\begin{bmatrix} \Omega_{12}\Omega_{22}^{-1}\Delta x_2 + \delta_1(\beta_{11}'x_{1t} + \beta_{12}'x_{2t}) + \delta_2(\beta_{21}'x_{1t} + \beta_{22}'x_{2t}) \\ \alpha_{21}(\beta_{11}'x_{1t} + \beta_{12}'x_{2t}) + \alpha_{22}(\beta_{21}'x_{1t} + \beta_{22}'x_{2t}) \end{bmatrix}$$

Where $\delta_1 = (\alpha_{11} - \Omega_{12}\Omega_{22}^{-1}\alpha_{21})$ and $\delta_2 = (\alpha_{12} - \Omega_{12}\Omega_{22}^{-1}\alpha_{22})$. Then, necessary conditions for weak exogeneity of Δx_{2t} with respect to the parameters of interest β_{11} and β_{12} are:

[4]Intuitively, two parameters are *variation free* if knowledge about the value of one parameter provides no information on the other parameter's range of potential values.

$$\alpha_{21} = 0, \alpha_{12} - \Omega_{12}\Omega_{22}^{-1}\alpha_{22} = 0 \tag{2.12}$$

The first condition ensures that β_{11} and β_{12} do not enter in the Δx_{2t} equation. The second ensures that β_{21} and β_{22} do not enter in the Δx_{1t} equation.

Intuitevely, zero restrictions on α test whether or not the cointegrating vectors enter the equations modelling the determination of the series. Therefore, certain zero restrictions on α express necessary conditions for weak exogeneity of the variables for the long run parameters of interest while others (joint zero restrictions on the α's) test whether or not a reduction of the initial system (modelling of a conditional system) is valid in terms of the cointegration results.

Restrictions on α can be expressed as:

$$H_{03} : \alpha = A\psi \tag{2.13}$$

In (2.13) the matrix $A_{N\times m}$ defines known linear restrictions, while $\psi_{m\times r}$ incorporates the restrictions on the individual values of the cointegrating space. The hypothesis of the form (2.13) can be assessed by a likelihood ratio test statistic of the form (2.9) and is asymptotically distributed as a χ^2 with $r(N-m)$ degrees of freedom under H_{03}.

Testing jointly for restrictions on α's and β's.

Finally, joint restrictions on β and α can also be formed as:

$$H_{04} : (\alpha = A\psi) and (\beta = \Xi\phi) \tag{2.14}$$

In (2.14) the matrices $\Xi_{N\times s}$ and $A_{N\times m}$ are known and define linear restrictions. The restrictions reduce the parameters to $\phi_{s\times r}$ and $\psi_{m\times r}$ (see Johansen and Juselius (1990)). The hypothesis can be assessed by a likelihood ratio test statistic of the form (2.9), which is asymptotically distributed as a χ^2 with $r(N-s)+r(N-m)$ degrees of freedom under H_{04}.

2.3.3 From the unrestricted UVAR to the restricted SEM

The information obtained by the cointegration analysis can then be used in the modelling of the series. In particular, the accepted restricted cointegrating vectors can play the role of error correction terms in the equations of the endogenous variables in a parameterisation of the VECM of the form as given in (2.3). The point is that the imposition of restrictions on the cointegrating space will change the estimated short-run dynamics of (2.3) and the coefficients of the deterministic variables. These new coefficients are denoted by a tilde $\tilde{}$. The new parameterisation takes the form:

$$\Delta x_t = \sum_{i=1}^{p-1} \tilde{\Pi}_i \, \Delta x_{t-i} + \phi ECM_{t-1} + \tilde{\psi} \, D_t + \nu \tag{2.15}$$

(2.15) is a I(0) parameterisation which includes the long run information of the series behaviour; it has fewer parameters than the original VAR and so it can be referred to as a parsimonious VAR (PVAR). It can then be used as a benchmark within which alternative simultaneous equations models SEMs can be compared, the advantage of doing so being the use of models which are robust to changes in the sample information (see Mizon (1995), Clements and Mizon (1991)). Further reductions of the PVAR can be made based on statistical criteria (testing for exclusion (zero) restictions on the elements of the short-run dynamic matrices $\tilde{\Pi}_i$) and on economic considerations.

In the final SEM, each equation is fully specified in that it may have contemporaneous as well as lagged dynamic terms, and may contain long-run equilibria.

A key advantage of this strategy is that it results in a full system of equations, rather than a single reduced form; it thus allows for using the more powerful test of forecasting ability in which predicted values of all variables are used rather than actual values of key variables.

Bibliography

[1] Banerjee A. and Hendry D.F. (1992), "Testing Integration and Cointegration: an Overview", Oxford Bulletin of Economics and Statistics, 54, 3, 225-255.

[2] Box, G.E.P. and Jenkins, G.M (1970), "Time Series Analysis Forecasting and Control", San Francisco: Holden-Day.

[3] Clements, P. M. and Hendry D. F. (1995), "Macroeconomic Forecasting and Modelling", The Economic Journal, 105, 1001-1013.

[4] Clements, M. P. and Mizon, G.E. (1991), "Empirical Analysis of Macroeconomic Time Series: VAR and Structural Models", European Economic Review, 35, 887-932.

[5] Davidson, J.E.H., Hendry, D.F., Srba, F. and Yeo, J.S. (1978), "Econometric Modelling of the Aggregate time series Relationship between Consumer's Expenditure and Income in the United Kingdom", Economic Journal, 88, 661-692.

[6] Ericsson, N.R. and J.S. Irons (1994), "Testing Exogeneity", Oxford: Oxford University Press.

[7] Granger, C.W.J. (1981), "Some Properties of Time Series Data and their Use in Econometric Model Specification", Journal of Econometrics, 16, 121-150.

[8] Granger, C.W.J. (1990) (ed), "Modelling Economic Series: Readings in Econometric Methodology", Oxford: Oxford University Press.

[9] Hendry, D.F. (1995), "Dynamic Econometrics", Oxford: Oxford University Press.

[10] Hendry D.F. and Mizon, G.E. (1990), "Procrustean econometrics: Or stretching and Squeezing Data", chapter 17 in Modelling Economic Series: Readings in Econometric Methodology, edited by Granger, C.W.J. op cit.

[11] Hendry, D.F. and Mizon G.E. (1993), "Evaluating Dynamic Econometric Models by Encompassing the VAR", chapter 18 in Models, Methods and Applications of Econometrics, Essays in Honor of Rex Bergstom, Phillips, P.C.B. (ed.), Oxford: Basil Blackwell, 272-300.

[12] Hendry, D.F. and Richard, J-F. (1983), "The Econometric Analysis of Economic Time Series", International Statistical Review, 51, 111-163.

[13] Hendry, D.F. and Wallis, K.F. (1984), "Econometrics and Quantitative Economics", Oxford: Basil Blackwell.

[14] Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors", Journal of Economic Dynamics and Control, 12, 231-254.

[15] Johansen, S. (1995), "Likelihood-based Inference in Cointegrated Vector Autoregressive Models", Oxford: Oxford University Press.

[16] Johansen, S. and Juselius K., (1990), "Maximum Likelihood Estimation and Inference on Cointegration - with Applications to the Demand for Money", Oxford Bulletin of Economics and Statistics, 52, 169-210.

[17] Mizon, G.E. (1984), "The Encompassing Approach in Econometrics", Chapter 6 in D.F. Hendry and K.F. Wallis (eds) Econometrics and Quantitative Economics, op cit.

[18] Mizon, G.E. (1995), "Progressive Modelling of Macroeconomic Time-series: The LSE Methodology", in K. D. Hoover (ed), Macroeconometrics: Developments, Tensions and Prospects, Derdrecht: Kluwer.

[19] Mizon, G.E. and J.F. Richard (1986), "The Encompassing Principle and its Application to testing Non-nested Hypotheses", Econometrica, 54, 3, 657-678.

[20] Monfort A. and Rabemanjara, R. (1990), "From a VAR Model to a Structural Model: with an Application to the Wage-Price Spiral", Journal of Applied Econometrics, 5, 203-227.

[21] Muscatelli, A. and Hurn, S. (1992), "Cointegration and Dynamic Time Series Models", Journal of Economic Surveys, 6, 1-43.

[22] Osterwald-Lenum, M. (1992), "A Note with Quantiles of the Asymptotic Distribution of the ML Cointegration Rank Test Statistics", Oxford Bulletin of Economics and Statistics, 54, 461-472.

[23] Spanos, A.,(1986), "Statistical Foundations of Econometric Modelling", Cambridge: Cambridge University Press.

[24] Spanos, A. (1990), "Towards a Unifying Methodological Framework for Econometric Modelling" chapter 15 in Granger, C.W. (ed), Modelling Economic Series: Readings in Econometric Methodology, op. cit.

Chapter 3

Wages, Prices, Productivity and Unemployment in Greece: an application of the LSE methodology in systems of nonstationary variables

Abstract

The interdependence among wages, prices, productivity and unemployment in Greece is investigated empirically in the context of a closed system during the period 1975 - 1990, which is characterised by high inflation rates and covers different political regimes. The analysis adopts the "general to specific" methodology, in which the time dependence properties of the series play an important role. After a univariate analysis of the data series with emphasis given to their seasonal behaviour, a multivariate maximum likelihood technique is applied to test for cointegration. It leads to the identification of one long-run relationship among the series analysed: a real wage - productivity relationship, with positive unemployment effects. A theoretically reasonable simultaneous equation model (SEM) is finally established by testing for congruence and encompassing against a congruent vector autoregression (VAR) which incorporates the relevant long-run information and is shown to provide better forecasts than a VAR in differences model which constitutes a strong rival model.

3.1 Introduction.

The aim of the present chapter is to investigate empirically the wage - price spiral and its interdependence with unemployment and productivity in Greece over the post-1974 period, which is characterised by high inflation rates and an increase in unemployment. The modelling strategy adopted in the work follows recent developments in the econometric literature, in the spirit of the "LSE methodology".

The analysis is performed in the context of a closed system which includes hourly wages, consumer prices, hourly productivity and unemployment. Particular attention is paid on the time dependence properties of the series. In a first step, univariate data series analysis is done: it includes firstly examination of the seasonal pattern of the series by applying an ARIMA model-based adjustment technique and by testing for seasonal integration of the series and secondly, testing for integration at zero frequency. In a second step, cointegration at zero frequency is tested in a multivarate framework by using the Johansen (1988) maximum likelihood cointegration technique; the long-run relationships between the variables are identified with emphasis given in the parameter constancy of the relations and the exogeneity/ endogeneity status of the included variables with respect to the long-run parameters of interest.

Then, the "general to specific" methodology is applied in order to select a final simultaneous equation model (SEM) describing the dynamics of the system, while incorporating the long-run information. Its strength is evaluated by its ability to encompass a vector autoregression which includes the long-run information and can be considered a congruent representation of the joint distribution of the series of interest. It is also compared with a VAR in differences (DVAR), with special emphasis given to their forecasting ability.

The rest of the paper is organised as follows: The next section highlights some characteristics of the Greek labour market institutions and their implications for modelling the wage-price spiral; it also gives descriptive information on the data and defines the sample period for the study. Section 3.3 presents the univariate time dependence analysis of the series and gives the arguments for the choice of the variables to be used in the modelling. In Section 3.4 the multivariate cointegration analysis is performed: the long-run relationships are identified and the exogeneity status of the variables is assessed. Section 3.5 derives the SEM and evaluates its adequacy, while the last section summarises and concludes.

3.2 The variables set, Greek labour market institutions.

3.2.1 The variables set.

Empirical work on wage determination has been greatly influenced by the seminal work of Sargan (1964), where he provides one of the earliest forms of an error correction model. Recent work entails application of the notion of cointegration for the estimation and testing of wage long-run equilibrium relationships. (Among others, Hall (1989), Alogoskoufis and Smith (1991), Clements and Mizon (1991), Mizon (1995), test for cointegrating relationships among labour market variables for the case of the United Kingdom; Kouretas (1993) for the EFTA economies; Juselius (1992), Nymoen (1992) and Psaradakis (1991), for the Danish, the Finnish and the Greek economies respectively).

In the present analysis the set of variables modelled was chosen to be similar to that used by Hall (1989) and Clements and Mizon (1991). The data set covers the unemployment series (U), the hourly earnings in manufacturing (W), the consumer prices (P) and the hourly productivity in manufacturing (HPROD) derived as the rate of the hourly industrial production in manufacturing (defined as the rate Y/H), over the employment (E) in that sector. All data series are quarterly and not seasonally adjusted. Detailed definitions of the series as well as data sources can be found in the Appendix 3.A. The natural logs of the series are used. Throughout the paper, lower-case letters which refer to the variables signify logarithms of capitals, and D denotes the first difference operator.

The choice of variables is rather restricted: the purpose of the paper is to model the functioning of the labour market focusing on the determination of the unemployment and the wage-price spiral. Therefore, other possible determinants of e.g. the price inflation are not included in the analysis. This is also done in order to keep the system manageable, given that inclusion of many variables would mean too few degrees of freedom for statistical inference, unless if this was done at the expense of introducing a range of exogeneity assumptions. The analysis is here constrained to be done on the context of a closed system involving the variables mentioned above.

3.2.2 Changes in regime, labour market institutions.

The plots of the series used are given in Figures 3.1 and 3.2. The series presented in Figure 3.1 are the quarterly consumer price inflation Dp, the annual consumer price inflation $D4p$, the quarterly real wage inflation Drw, the annual real wage inflation $D4rw$, the real wage rw, and the unemployment series U. The wage variables refer to the manufacturing sector, and the graphs of a number of variables characterising the performance of that sector are given in Figure 3.2[1]. These variables are: production Y, employment E, weekly hours worked H, productivity $PROD$ and hourly productivity $HPROD$.

The present work is of interest, given that the post-1974 period has been characterised by high inflation rates and an increase in unemployment as also shown in the Dp, $D4p$, U graphs. In particular, while lower than the OECD average for the fifteen years before 1974, the inflation rate rose sharply after the first oil price shock and has remained among the highest positions in the OECD and EU areas from then on. 1974 is also the year when the military regime fell, resulting in a number of changes in the labour market institutions.

The analysis is extended up to 1990.2. This is done so, because during this quarter, a number of restrictive policies taken by the newly elected conservative government (in an effort to converge the Greek macroeconomic variables with the Maastricht standards), resulted in radical but overestimated changes in the behaviour of basic variables characterising the manufacturing sector performance. More analytically, in 1990.2 the automatic wage indexation scheme was abolished, policies for subsidysing loss making companies were stopped and privatisations were started. As shown in the graphs of the relevant series in Figure 3.2, the measures resulted in a considerable fall in the employment in manufacturing which is not, however, accompanied by the same fall in production: this results in an impressive rise in labour productivity. However, this productivity swing is overestimated, given that it reflects the closure or restructuring of a number of low productivity "problematic" enterprises. In addition, in the 90's manufacturing accounts for only 17% of the GDP share compared to the 25% at the 70's, while emphasis is now given by the authorities to the development of service sectors, principally tourism[2].

Analysis of the wage and price inflation determination during the 1975 - 1990 period is

[1] Even though the manufacturing sector share of GDP is quite low, it is considered to be indicative of the labour market developments and important for the wage formation for the years under consideration.

[2] Attempts to model the whole 1975 - 1995 period resulted in models and cointegrating relationships with non-constant parameters. An alternative would be modelling the price-wage spiral in the whole period using a reduced system including wages, prices and unemployment (see Chapter 5).

of interest given that it covers two different political regimes with different weights placed on inflation control: the conservative government episode until 1981.3 was succeeded by an episode during which the socialist party was in power, even though this second episode is characterised by a shift towards more restrictive policies in 1985.4, when a stabilisation program was put into practice. 1975 - 1990 also covers a number of events and institutional changes that affected the performance of the Greek economy. From March 1975, the drachma was not linked to the dollar but followed a managed exchange rate regime. In 1979, the econony had to deal with the second oil price shock. In January 1981, Greece became a EU member country. In January 1982, the socialist government introduced a formal (but not full) automatic wage indexation scheme, which remained in practice until 1990, excluding the 1986 - 1987 stabilization program period. Finally, in October 1985, a stabilisation program (including devaluation of the drachma by 15% in order to raise Greek competitiveness) was put into effect.

3.2.3 Descriptive analysis.

The effects of these shifts are evident in the graphs of the series. The inflation rate rises considerably in 1980 and remains high for the following three years as a result of the expansionary policies that were followed during this period. First, by the conservative government in order to accomodate the second oil price shock in 1979 and in the pre-election 1981 year and then by the social government elected in October 1981 for the first two years they were in power. It reaches its highest observed point in 1986.1 because of the drachma devaluation in the previous quarter, while relatively low rates are observed during the stabilisation program period 1986 - 1987.

Hourly real wages show an upward trend for the period until 1985.4, decrease during the 1986 - 1987 stabilisation scheme period, and remain relatively stable from then on, indicating the shift to more restrictive policies. The unemployment rate is characterised by an upward trend especially for the period until 1986; the seasonal pattern is also very strong and this can be attributed to the fact that employment in Greece is highly related to the developed touristic service sector.

Production, employment and productivity in manufacturing show an upward trend up to 1981.1 and remain relatively constant for the rest of the period, despite the on average expansionary policies of the 80's; the evidence makes more apparent the structural inefficiencies of the productive sector which could not respond to demand increases. This probably indicates that this sector which operated in an environment of protectionism for years could not adjust promptly in the EU competitive environment. Average weekly hours worked show a downward trend from the beginning of the examined period till the mid 80's when they reach quite low levels; they follow a stable path after 1988, reflecting a stabilisation in the labour market conditions. Reflecting the pattern of the above series, hourly productivity remains also relatively stable during the 80's.

As described above, the behaviour of the series of interest has been strongly influenced by particular policy shift events that took place in certain time points and thus may support inclusion of dummy variables. As advocated by Clements and Mizon (1991), inclusion of dummies is preferable to the enlargement of the number of explanatory variables, given that the sample size is relatively small. This should be kept in mind while extending the analysis in Section 3.4, where a UVAR is formed.

In Figure 3.3, the graphs of more than one series of interest adjusted for mean and variance are given together, in an attempt to investigate visually possible relationships among them. A seasonally adjusted series for unemployment, su, (obtained by an ARIMA model based techique as described in Section 3.3) is used instead of the seasonally unadjusted one in order to make the changes of the pattern of unemployment more evident. The first phenomenon that could be naively observed in graph (a) which depicts the annual inflation-unemployment relation is a Phillips curve relationship for the years 1980 - 1985. This, however, would be wrong: the modest decrease in inflation and the rise in unemployment are not the results of restrictive policies (which were quite expansionary during this period). In addition, as it is also shown by graph (b) this period is characterised by simultaneous increase in real wages and unemployment. The evidence can probably be explained by the insiders - outsiders theories that claim stronger interest of the powerful insiders (who care for the welfare of their employed members) for increase in real wages than decrease in unemployment, and the assumption of real wage rigidity. The argument is strengthened by graph (c) where employment in manufacturing remains stable, despite the increase in unemployment. This indicates mainly changes in the structure of unemployment but it also reflects the fact that the manufacturing sector could not absorbe new entrances in the labour force; the explanation being twofold: i) it could not respond to positive demand shocks as functioning in the new competitive EU environment, and ii) the rise in real wages did not allow for new working places. Finally, graph (d) shows that real hourly wage was increased on top of the increase in hourly productivity in the periods 1975 - 1977 and 1982 - 1985.

Summarising, we argue that analysis of the wage-price spiral during the 1975 - 1990 period is of interest, given that the period is characterised by high inflation rates and covers different policy regimes, while, as also evidenced by the graphs of the series, an important policy change takes place in 1985.4 signaling a shift towards more restrictive policies.

3.3 Univariate analysis of the time properties of the series.

3.3.1 Characterisation of the seasonal pattern.

The univariate analysis of the series entails initially thorough investigation of their seasonal pattern. Issues such as the significance of the seasonal component on the evolution of a series, whether seasonality follows a constant pattern or not, or to what extend the series are integrated at seasonal frequencies are of importance for the modelling of the closed system (see *inter alia* Ericsson, Hendry and Tran (1993), Hendry (1995) for similar arguments). As shown by the graphs of the series, the presence of seasonality is evident for at least the series of productivity and unemployment. In the present application, we therefore first use an ARIMA-model-based method in order to estimate the seasonal component of the series and then test for integration of the series at a seasonal frequency.

Estimation of the seasonal component.

Estimation of the seasonal components of the series is performed by applying the SEATS (Signal Extraction in ARIMA Time Series) (Maravall and Gomez (1994a)) programme. Given that it assumes a linear time series model with Gaussian innovations, it was used in companion with TRAMO (Time series Regression with ARIMA noise, Missing observations and Outliers) (Maravall and Gomez (1994b)) which played the role of a preadjustment program[3].

[3]TRAMO was used in order to identify and correct for outliers in the series; it actually detected outliers at 1985.4 and 1986.1 for the price series. The corrected series was therefore used for the seasonal adjustment of the price variable; for the rest of the cases, the original raw series are used for estimation of the seasonal components. However, analytical results for the TRAMO preadjustment procedure are not given for space reasons.

Table 3.1: **Estimation of the seasonal component with SEATS.**

AIRLINE model							
	coeff.		Missp.	Tests			
Variable	δ_1	δ_4	st. err.[1]	DW	skewn.	kurt.	$N(\chi^2(2))$
p	0.219	-0.257	0.905	1.878	0.311	2.656	1.475
w	0.151	-0.746	0.211	1.999	0.241	3.255	0.916
hprod	-0.604	-0.613	0.288	1.903	-0.054	3.741	1.709
u	0.243	-0.240	0.104	2.086	-0.306	3.848	3.831

[1] Standard error in 10^{-1}

SEATS is an ARIMA-model-based method for decomposing a series into its unobserved time components: trend, seasonal, cyclical and irregular components and it is used for seasonal adjustment of economic time series. The programme is fitting by default the so-called airline model (see Box and Jenkins (1970)) which provides a decent fit to the series according to Gomez and Maravall (1994). The airline model is given by:

$$(1 - L)(1 - L^4)X_T = (1 - \delta_1 L)(1 - \delta_4 L^4)\epsilon_t + \mu \tag{3.1}$$

where ϵ is a white noise innovation and μ is a constant. SEATS uses a model based technique and therefore provides with diagnostics that allow for evaluation for the fit of the model. It also provides an estimate of the seasonal pattern, and the weights by which it contributes to the estimate of the series. In Table 3.1, the diagnostics of the fitted models are reported, together with estimates of the parameters δ_1, which is related to the stability of the trend component, and δ_4 which is related to the stability of the seasonal component.

In Figure 3.4, the estimated trends, seasonal components and seasonally adjusted series are presented, whereas Figure 3.5 presents the weights by which the seasonal pattern is contributed to the estimated series. The seasonal component is quite unstable for the cases of the unemployment and price series. Finally, as shown in Figure 3.5, the seasonal pattern plays a very important role for the evolution of the unemployment series, while it has minor impacts for the evolution of the rest of the series. The evidence advocates the use of a seasonally adjusted series (as suggested by *inter alia* Hendry (1995)) instead of the raw series for the unemployment variable when going on with the modelling of the system. Nevertheless, further investigation of the seasonal pattern of the whole group of series by testing for seasonal integration is attempted before proceeding with the multivariate cointegration analysis.

Testing for seasonal integration.

The stochastic process X_t is integrated of order (n, s), or $I(n, s)$, if the series is stationary after first period differencing n times and seasonal differencing s times (for brief presentations of the concepts of integration and cointegration on zero and seasonal frequencies see *inter alia* Banerjee and Hendry (1992), Muscatelli and Hurn (1992)). The most used test for seasonal integration is the Hylleberg, Engle, Granger and Yoo (1990) (HEGY) test, which considers all the possible seasonal roots of the generating process. It essentially allows the null hypothesis of $I(1,1)$ to be tested against the alternatives of $I(0,1)$ and $I(0,0)$ by making use of the following regression equation:

$$A(L)Y_{4t} = \gamma_1 Y_{1t-1} + \gamma_2 Y_{2t-1} + \gamma_3 Y_{3t-2} + \gamma_4 Y_{3t-1} + \epsilon_t \tag{3.2}$$

where Y_{it} are transformations of the time series X_t:

$$Y_{1t} = (1 + L + L^2 + L^3)X_t \tag{3.3}$$

$$Y_{2t} = -(1 - L + L^2 - L^3)X_t \tag{3.4}$$

$$Y_{3t} = -(1 - L^2)X_t \tag{3.5}$$

$$Y_{4t} = (1 - L^4)X_t \tag{3.6}$$

The order of the $A(L)$ polynomial is obtained through augmenting the basic regression parsimoniously by lags of Y_{4t} to ascertain an *iid* error process ϵ_t. Deterministic terms such as an intercept (I), an intercept and a trend (I, Tr), an intercept and seasonal dummies (I, SD), or an intercept, a trend and seasonal dummies (I, Tr, SD) can be added to the regression.

Table 3.2: **HEGY tests.**

Variable	Sample	Det	γ_1	γ_2	γ_3	γ_4
p	76.1-90.2	I, SD	-0.566	-4.131*	-3.209	-2.404*
		I, Tr, SD	-2.649	-3.913*	-3.127	-2.011*
w	76.1-90.2	I, SD	-1.869	-3.726*	-4.031*	-1.579
		I, Tr, SD	-0.721	-3.653*	-4.021*	-1.583
hprod	76.1-90.2	I, SD	-1.983	-3.101*	-1.034	-4.455*
		I, Tr, SD	-2.477	-3.321*	-0.857	-4.283*
u	76.1-90.2	I, Tr	-3.061	-1.308	-0.563	-1.018
		I, Tr, SD	-2.876	-1.640	-1.067	-0.403
su	76.1-90.2	I, SD	-0.273	-3.190*	-4.988*	-2.919*
		I, Tr, SD	-2.712	-3.397*	-4.137*	-3.408*

Stationarity of X_t requires that γ_1, γ_2, and either γ_3 or γ_4 are non-zero. If $\gamma_1 = 0$, whilst γ_2, and either γ_3, or γ_4 are non-zero, $I(1,0)$ behaviour is implied. If $\gamma_2 = 0$, X_t has a unit root at the biannual frequency, whilst $\gamma_3 = 0$, and/or $\gamma_4 = 0$, imply a unit root at an annual frequency. This last hypothesis can be tested by either an F test for $\gamma_3 = \gamma_4 = 0$, or a two-sided $t - test$ for $\gamma_4 = 0$, followed by a one-sided $t - test$ for $\gamma_3 = 0$, if $\gamma_4 = 0$, is not rejected. The finite sample distributions of the test statistics testing the above hypotheses are tabulated in Hylleberg *et al* (1990).

The results of the HEGY test are reported in Table 2. The I(1) property at zero frequency for every series is stated by the t_{γ_1}, statistic. Then, for the series p, w, and *hprod*, the assumptions $\gamma_2 = 0$, and either $\gamma_3 = 0$, or $\gamma_4 = 0$, are rejected at a 5% level, implying a $I(1,0)$ behaviour: the series are not seasonally integrated. However, for the case of the unemployment series, the presence of seasonal unit roots cannot be rejected; in particular, the HEGY tests strongly indicate unit roots at both the annual and the biannual frequency. (Given that no other series turns out to be an integrated seasonal process, there is no ground for testing for seasonal cointegration).

Finally, as Hylleberg *et al* (1990) suggest, it would make sense to use a filtered series in place of the seasonally integrated u, when testing further for cointegration at zero frequency with the rest of the series. Therefore, the seasonally adjusted series su estimated by the SEATS technique as described in the previous subsection, is going to be used for

Table 3.3: **Augmented Dickey-Fuller Tests.**

Variables	t(ADF)	lag length
p	-0.768	4
w	-2.321	4
hprod	-1.595	4
su	-0.720	4
u	-1.752	4
Dp	-2.655	4
Dw	-2.971*	4
Dhprod	-5.073**	4
Dsu	-3.704**	4
Du	-4.579**	4

* significant at 5% level
** significant at 1% level

the multivariate analysis[4].

The graph of *su* is already shown in Figure 3.3. As expected, the HEGY tests performed for the *su* series which are reported at the low part of the Table 3.2 do not indicate the presence of seasonal unit roots.

3.3.2 Testing for integration at zero frequency

The by now well known univariate augmented Dickey and Fuller (1981) (ADF) tests are applied to check for the presence of unit roots at zero frequency. These tests rely on the rejection of the hypothesis that a process is driven by a random walk against the alternative of stationarity. The results are reported in Table 3.3[5]. The regressions include a constant. The data clearly reject the first order integration hypothesis in favour of a stochastically stationary alternative in the case of *Dhprod*, *Dsu* and *Du* using a 1 % significance level and the case of *Dw* using a 5 % significance level, whereas for the levels of all four variables, show no evidence against the I(1) representation. However, the

[4]Note that Ericsson, Hendry and Tran (1993) suggest that use of either adjusted or unadjusted series leads to similar results in terms of the estimated cointegrating vectors; in the present paper, though, it was decided not to use the non adjusted unemployment series given that it was found to entail seasonal unit roots and to contain a very strong and unstable seasonal pattern.

[5]The results reported are obtained using the PC-GIVE module of the PC-GIVE version 8.1, system of computer programs (see Doornik and Hendry (1994)).

presence of unit root is rejected for the case of the Dp series only at a 10 % significance level, giving evidence that it may be integrated of order 2.

However, the D-F unit root tests are low power tests; in particular, their power is likely to be very low for values of the autoregressive parameter less than, but close to unity. In addition, unit roots are not invariant to changes in the information set relative to which they are defined. (see Spanos (1990b)). Hence, a multivariate analysis of the time dependence properties of the series seems to be more appropriate.

3.4 Multivariate cointegration analysis.

3.4.1 The unrestricted VAR.

An unrestricted fifth order autoregressive system (UVAR) for the vector:

$x'_t = (p, w, hprod, su)$

containing also a constant term and centred seasonal dummies, was initially estimated for the period 1975.1 to 1990.2 using multivariate least squares. Lower order UVAR systems were evaluated against it by using likelihood ratio tests, provided there were no autocorrelated residuals in the specifications. A fourth lag system was finally found to adequately capture the dynamics.

However, there remained evidence (shown by Chow tests for parameter constancy) of two substantial but explainable outliers: in 1975.2 for the switch to a managed exchange rate regime and in 1985.4 for the change in the economic policy which included a drachma devaluation. The effect of the two outliers was eliminated by the use of the dummies D75.2 which takes the value 1 in 1975.2 and 0 elsewhere and D85.4 which takes the value 1 in 1985.4 and 0 elsewhere. Since the two dummy variables should not have a long-run effect on any of the modelled variables, they are entered unrestricted in the VAR. They both turned out to be significant at a 5% level with obtained t-values 2.8323 (0.0381*) for D85.4, and 4.4626 (0.0045**) for D75.2; in addition, their absence would mean nonnormality for the residuals[6].

[6] A number of other impulse dummies to account for events that have possibly influenced the behaviour of the series (for the periods 1979.1, 1981.1 and 1983.1 to account for the oil price shock, Greece becoming an EEC member and a first drachma devaluation), were also included for the specification of the system, but they turned out to be statistically insignificant and therefore they were not kept in the final specification of the unrestricted VAR.

The descriptive statistics of the unconstrained fourth order VAR system are presented in Table 3.4. First, single equation diagnostics are reported: the AR Lagrange multiplier (LM) statistic for residual serial independence across five lags of the autocorrelation function, the $ARCH$ LM test statistic testing the null of no autoregressive conditional heteroscedasticity and the N statistic testing the null of normal skewness and kurtosis. Second, test statistics for vector autoregressive residuals $vecAR$ and vector normality $vecN$ (see Doornik and Hendry (1994), for definition of these test statistics). There is no evidence for misspecification of the residuals of the estimated VAR.

Furthermore, the parameter constancy assumption was assesed by the sequence of forecast Chow tests against the end point of the sample (not shown here in order to save space): the tests imply that the parameters remain constant over the examined period. Similar evidence is also borne out by the tests for predictive failure F_1, F_2, F_3 for the last eight observations (for details for the tests see Doornik and Hendry (1994)): according to these tests, the estimated parameters remain reasonably constant over the period 1988.3 - 1990.2 (it is only F_1 (32,33) that rejects parameter constancy). Finally, inspection of the residual correlations suggests that there is a modest correlation between *hprod* and *w* and *hprod* and *su* but the correlations between the residuals of the rest of the equations are negligible.

3.4.2 Cointegration analysis.

Identification of the cointegration space rank.

Having established a VAR system which provides an adequate characterisation of the data structure, and fulfills the required assumptions (residuals which are serially uncorrelated, homoscedastic, and normally distributed and has relatively constant parameters), we can go on by examining the time dependence of the data series within a multivariate framework. The Johansen maximum likelihood technique (Johansen (1988), Johansen and Juselius (1990), (1992)) in which the order of cointegration of the system is examined conditional upon the short-run dynamics of the Δx_t process and the seasonal dummies, is therefore applied.

The estimated eigenvalues and the results of the two rank tests, are given in the upper part of Table 3.5. The largest eigenvalue which is involved in the maximisation of the loglikelihood function with respect to β is quite large (0.33) and turned out to be clearly

Table 3.4: **UVAR Diagnostic Statistics.**

Equation standard deviations

w	p	su	hprod
0.02612	0.01141	0.04075	0.01913

Equation tests

Variable	Statistic	Value	p-value
w :	AR 1- 4F(4, 36) =	0.6392	[0.6379]
p :	AR 1- 4F(4, 36) =	0.6460	[0.6333]
su :	AR 1- 4F(4, 36) =	1.9937	[0.1163]
hprod :	AR 1- 4F(4, 36) =	1.0104	[0.4150]
w :	Normality $\chi^2(2)$=	1.8138	[0.4038]
p :	Normality $\chi^2(2)$=	1.6403	[0.4404]
su :	Normality $\chi^2(2)$=	0.2362	[0.8886]
hprod :	Normality $\chi^2(2)$=	0.0359	[0.9822]
w :	ARCH 4 F(4, 32) =	0.5589	[0.6940]
p :	ARCH 4 F(4, 32) =	1.9461	[0.1268]
su :	ARCH 4 F(4, 32) =	0.9505	[0.4478]
hprod :	ARCH 4 F(4, 32) =	0.4821	[0.7486]

Vector tests

VecAR	1-4 F(64, 84) =	1.3204	[0.1157]
VecN	$\chi^2(8)$=	3.9949	[0.8576]

Parameter constancy forecast tests: sample 1988.3 to 1990.2

F_1	F(32,33)=	3.1140	[0.0008]**
F_2	F(32,33)=	1.4782	[0.1346]
F_3	F(32,33)=	1.5084	[0.1227]

Table 3.4 (continued):

Correlation of residuals

	w	p	su	hprod
w	1			
p	0.104	1		
su	-0.095	0.037	1	
hprod	0.195	0.041	-0.161	1

Table 3.5: **Cointegration Results.**

Cointegration analysis 1975 (1) to 1990 (2).

eigenvalue	loglik	rank
	961.569	0
0.333639	974.153	1
0.237604	982.563	2
0.149370	987.578	3
0.030014	988.523	4

H_0:rank=p	Max Eigen.	95%	Trace	95%
$p = 0$	25.17	27.1	53.91**	47.2
$p \leq 1$	16.82	21.0	28.74	29.7
$p \leq 2$	10.03	14.1	11.92	15.4
$p \leq 3$	1.889	3.8	1.889	3.8

Standardised eigenvectors β_i':

w	p	su	hprod
1.000	-0.651	-0.166	-5.951
-2.297	1.000	1.545	8.969
4.109	-4.683	1.000	-10.13
0.123	-0.355	0.172	1.000

Standardized adjustment coefficients α_i:

w	0.059741	-0.023563	-0.048449	0.008061
p	-0.019646	-0.010165	-0.0019498	0.028493
su	-0.080264	-0.107540	0.0023654	-0.033459
hprod	0.067108	-0.018053	0.017363	0.009066

significantly different from zero (at a 1% level of significance) on the basis of the trace statistic, while its significance is just marginally rejected by the maximum eigenvalue statistic at a 5% level of significance[7]. It was then decided to proceed based on the assumption of one cointegrating vector in the system[8].

The graphs of the cointegrating vectors and the recursive estimated eigenvalues are given in Figure 3.6. The eigenvalue corresponding to the first cointegrating vector takes a large value and is essentially constant.

Identification of the long-run structure.

The low part of Table 3.5 records estimates of the standardised eigenvectors and their corresponding loadings of the four variable VAR. An examination of the (first) cointegrating vector reported, shows that a direct interpretation is not straightforward. An interesting outcome is that w and p come out with coefficients which are quite close in size to each other and have opposite signs, probably implying a long run relationship between real wage, productivity and unemployment. Nevertheless, further investigation on the identification of the cointegrating vector by testing for possible theoretical assumptions seems to be necessary. A number of theoretical assumptions and their test outcomes are given in Table 3.6: the likelihood ratio tests reported are asymptotically distributed as χ^2 with the appropriate degrees of freedom given in parentheses.

The first four hypotheses imply stationarity of the individual series. They are all rejected by the given data set, a result which is in line with the univariate testing. The fifth hypothesis H_5 tests for equal in size and opposite in sign w and p coefficients: it implies cointegration between real wage, unemployment and productivity. The relevant likelihood ratio test is assymptotically distributed as $\chi^2(1)$ and H_5 is accepted by the data.

H_6 tests for cointegration between real wage and productivity. H_7 tests for cointegra-

[7]Critical values of the distributions of the test statistics used are reported in Osterwald-Lenum (1992).

[8]Actually, the second eigenvalue takes a relatively high value and is significant different from zero at a 10% level of significance on the basis of the trace statistic. In addition, as Kostial (1994) indicates, in the case of systems with small eigenvalues of the signal-noise ratio matrix, the Johansen tests tend to underestimate the rank of the cointegrating space in small samples. Therefore, initial analysis was performed based on the assumption of two cointegrating vectors. However, testing for a number of alternative structural restrictions in order to identify two long-run relations among the variables, turned out meaningless: no pair of reasonable economic relationships was accepted by the data set. The analysis was concequently decided to be continued based on the assumption of one cointegrating vector.

Table 3.6: **Testing for structural restrictions.**

Hypothesis	(w	p	hprod	su)	$\chi^2(dof)$	p-value
	(w	p	hprod	su)		
H_1:	(1	0	0	0)	10.142 (3)	[0.0174] *
H_2:	(0	1	0	0)	11.565 (3)	[0.0090] **
H_3:	(0	0	1	0)	10.301 (3)	[0.0162] *
H_4:	(0	0	0	1)	12.308 (3)	[0.0064] **
H_5:	(1	-1	a	b)	0.6452 (1)	[0.4218]
H_6:	(1	-1	a	0)	3.5469 (2)	[0.1698]
H_7:	(1	-1	0	b)	3.0202 (2)	[0.2109]
H_8:	(1	-1	-1	b)	3.4631 (2)	[0.1770]
H_9:	(0	0	a	1)	3.5542 (2)	[0.1691]
H_{10}:	(1	-1	-1	0)	4.6116 (3)	[0.2025]

tion between real wage and unemployment. H_8 is concerned with the question whether real wage around the productivity trend cointegrates with unemployment, while H_9 implies a long-run relationship between unemployment and productivity. Finally, H_{10} tests for a one to one real wage-productivity relationship. Hypotheses H_6 - H_9 are evaluated by $\chi^2(2)$ tests while H_{10} by a $\chi^2(3)$ test. All hypotheses H_6 - H_{10} are accepted by the data set for p-values which are close to each other. However, theoretical considerations led to the choice of H_8 (which is accepted for the second high p-value among the hypotheses which are assymptotically distibuted as $\chi^2(2)$) as possibly expressing best the underlying relationship. It is of the form:

$$\beta_1 : w_t - p_t - hprod - 0.11 su_t \tag{3.7}$$

It expresses a reasonable positive relationship between real wage and productivity, implying that the wage earners get the share of the productivity growth, with positive unemployment level effects. The positive sign in the unemployment coefficient reflects the fact that the period examined is characterised by quite expansionary policies which included wage increases, but did not result in rises in employment. Such a phenomenon can be due to insiders - outsiders effects, real wage rigidities and inability of the productive sector to react to positive shocks because of labour market rigidities (firing, hiring costs)

Table 3.7: **Tests for weak exogeneity restrictions.**

Hypothesis	$\chi^2(4)$	p-value
H_{21}: $\alpha_{11} = 0$: w. exogeneity for w:	7.8332	0.0979
H_{22}: $\alpha_{21} = 0$: w. exogeneity for p:	9.6448	0.0469*
H_{23}: $\alpha_{31} = 0$: w. exogeneity for $hprod$:	7.1848	0.1264
H_{24}: $\alpha_{41} = 0$: w. exogeneity for su:	20.074	0.0005**

and the fact that it had to function in the new competitive EU environment[9].

Tests for weak exogeneity.

Having identified the structure of the cointegrating vector, the analysis can proceed by investigating the exogeneity/endogeneity status of the variables involved (for a presentation of the concept of exogeneity see *inter alia* the papers in Ericsson and Irons (1994)). The outcomes of a number of weak exogeneity tests as formed in a multivariate cointegrating framework are reported in Table 3.7.

Hypotheses H_{21}, H_{22}, H_{23} and H_{24} test respectively for weak exogeneity of wage, price, productivity and unemployment, with respect to the long-run parameters of interest. H_{22} and H_{24} are rejected, implying that prices and unemployment are possibly the endogenous variables in the long-run relationship. The result makes sense, if we take into consideration that during the period, wages were effected to a large extend by trade unions - government negotiations, while productivity is also determined by factors outside the wage determination process.

[9] See Demekas and Kontolemis (1996) for similar arguments in a detailed analysis of unemployment formation and persistence in Greece during the same period.

3.5 The final model

In the present section, the analysis follows closely the steps proposed by the so called "LSE methodology" (see *inter alia* Spanos (1986), Hendry and Mizon (1990), Spanos (1990a), Hendry (1995)), which is also known as the "encompassing the VAR" methodology (see Hendry and Mizon (1993), Clements and Mizon (1991)) when applied in VAR systems (see *inter alia* Canova (1993) for a review on the VAR literature).

Initially, a VAR which models the short run dynamics including the long run information (which is known as parsimonious VAR, (PVAR)) is estimated. It constitutes the general model within which two nested models can be evaluated: a SEM which simplifies the dynamics of the general formulation and a VAR in differences of the series (DVAR) popular in time series analysis of non stationary series. The two models are compared by considering:

i) their congruency,

ii) their ability to encompass the PVAR,

iii) the constancy of their parameters,

and iv) their forecasting power.

3.5.1 Encompassing the PVAR

The PVAR

On the basis of the information about the long-run solution to the system, obtained through the cointegration analysis described above, a transformation of the initial system was further decided. The original VAR is transformed into a simplified, yet congruent I(0) representation, by differencing and using the cointegration information. Accordingly, a VAR for the series *Dp*, *Dw*, *Dhprod* and *Dsu* was estimated, using 4 lags of the series and the cointegrating vector β_1 included as lagged endogenous variable denoted as ecm_{t-1}; in the model no dummies were kept given that they did not turn out to be significant or to improve its diagnostics.

The transformed I(0) system has 4 fewer parameters than the original system and so can be referred to as a parsimonious VAR (PVAR) (see Clements and Mizon (1991), Mizon (1995b)).

Table 3.8: **PVAR Diagnostic Statistics.**

Equation residual standard deviations

Dw	Dp	Dsu	Dhprod
0.02841	0.01160	0.04058	0.02629

Equation tests

Variable	Statistic	Value	p-value	
Dw :	AR 1- 4F(4, 36) =	0.6215	[0.6501]	
Dp :	AR 1- 4F(4, 36) =	0.6531	[0.6284]	
Dsu :	AR 1- 4F(4, 36) =	3.2881	[0.0214]	*
Dhprod:	AR 1- 4F(4, 36) =	0.5136	[0.7261]	
Dw :	Normality $\chi^2(2)$=	3.6722	[0.1594]	
Dp :	Normality $\chi^2(2)$=	0.6262	[0.7312]	
Dsu:	Normality $\chi^2(2)$=	0.0092	[0.9954]	
Dhprod:	Normality $\chi^2(2)$=	5.1941	[0.0745]	
Dw :	ARCH 4 F(4, 32) =	0.3053	[0.8722]	
Dp :	ARCH 4 F(4, 32) =	2.0878	[0.1055]	
Dsu:	ARCH 4 F(4, 32) =	0.5305	[0.7141]	
Dhprod:	ARCH 4 F(4, 32) =	0.6247	[0.6483]	

Vector tests

VecAR	AR 1-4 F(64, 84) =	1.2926	[0.1345]
VecN	$\chi^2(8)$=	7.8759	[0.4457]

Table 3.8 (continued):

Correlation of residuals

	Dw	Dp	Dsu	Dhprod
Dw	1			
Dp	0.116	1		
Dsu	0.088	0.178	1	
Dhprod	0.208	0.159	0.080	1

Table 3.9: **DVAR Diagnostic Statistics.**

Equation residual standard deviations

Dw	Dp	Dsu	DLhprod
0.02811	0.01206	0.04214	0.02624

Equation tests

Variable	Statistic	Value	p-value
Dw :	AR 1- 4F(4, 37) =	0.65957	[0.6240]
Dp :	AR 1- 4F(4, 37) =	0.61438	[0.6550]
Dsu:	AR 1- 4F(4, 37) =	0.95578	[0.4431]
Dhprod :	AR 1- 4F(4, 37) =	0.77913	[0.5459]
Dw :	Normality $\chi^2(2)$=	3.8706	[0.1444]
Dp :	Normality $\chi^2(2)$=	2.3159	[0.3141]
Dsu:	Normality $\chi^2(2)$=	0.53982	[0.7634]
Dhprod :	Normality $\chi^2(2)$=	4.8056	[0.0905]
Dw :	ARCH 4 F(4, 33) =	0.3987	[0.8081]
Dp :	ARCH 4 F(4, 33) =	2.2399	[0.0859]
Dsu:	ARCH 4 F(4, 33) =	0.59138	[0.6712]
Dhprod :	ARCH 4 F(4, 33) =	0.88429	[0.4840]

Vector tests

VecAR	AR 1-4 F(64, 88) =	1.1196	[0.3092]
VecN	$\chi^2(8)$=	10.108	[0.2575]

It can be still considered as a congruent parameterisation of the data process as can be seen by the misspecification test outcomes reported in Table 3.8. The only evidence of noncongruence comes from the autocorrelation statistic for the *Dsu* equation, which rejects non-autocorrelation but only marginally (p=0.0214); in addition, recursive break-point Chow tests (not shown for economy of space), reveal that the estimated parameters remain reasonably constant over the estimation period. Even though there is scope for simplifying the PVAR specification given that not all the variables included are significantly different from zero, we decided to keep it in this form, so that alternative specifications can be evaluated according to their ability to encompass it.

The DVAR.

Table 3.9 (continued):

Correlation of residuals				
	Dw	Dp	Dsu	Dhprod
Dp	0.102	1		
Dsu	0.065	0.211	1	
Dhprod	0.272	0.104	0.031	1

The DVAR model corresponds to a model of the form (2.15) with $\phi = 0$. It is a popular model within the time series analysis tradition (see Box and Jenkins (1970)) and it provides with good forecasts. The diagnostic statistics for the DVAR are presented in Table 3.9, and indicate that it is well specified.

A LR statistic testing for the overidentifying restrictions implied by the DVAR, which is asymptotically distributed as $\chi^2(4)$ takes the value of 12.128 (p=0.0164*), which rejects the assumption that it parsimoniously encompasses the PVAR. Hence, within sample the PVAR is preferred to the DVAR.

The SEM

Then, alternative simultaneous equation models have been compared by their ability to parsimoniously encompass the PVAR. Among them, the one presented below has been chosen based on simple economic theory considerations, the results of previous relevant studies (for recent works, see Alogoskoufis (1986), (1992), Psaradakis (1991)) and statistical criteria[10]. The model is estimated for the period 1975.2 - 1990.2 using full information maximum likelihood (FIML). It is presented in Table 3.10.

Wage inflation appears to be influenced mainly by its past values, while price inflation also has a reasonable positive and significant impact on it. Unemployment growth has an overall negative impact on it, implying probably that in the short-run a rise in unemployment has negative effects on nominal wage claims.

The second equation of the SEM shows consumer price inflation to be significantly positively influenced by the history of the process, together with the wage inflation which has a lower but positive and significant impact. The error correction term has a low but

[10]The "second" powerful simultaneous equation model has similar specification with the one chosen for all but the wage inflation equation. Theoretical considerations, together with the fact that it had lower predictive power, (even though it is wellspecified), led us to choose the one reported.

Table 3.10: **Simultaneous equation model FIML estimates.**

Variable	Coefficient	t-value	t-prob
Equation for Dw			
Dw_{t-1}	0.25269	2.344	0.0229
Dw_{t-4}	0.32032	2.918	0.0052
Dp_{t-2}	0.38424	2.474	0.0166
Dsu_{t-1}	-0.17936	-2.711	0.0090
Dsu_{t-2}	0.16303	2.309	0.0248
Dsu_{t-3}	-0.19147	-2.772	0.0077
Dsu_{t-4}	0.06843	1.052	0.2976
$Seas_t$	0.03023	3.152	0.0027
Equation for Dp			
Dp_{t-1}	0.20314	2.210	0.0315
Dp_{t-3}	0.30286	3.375	0.0014
Dw_{t-3}	0.11756	2.345	0.0228
ecm_{t-1}	0.04339	2.166	0.0348
$Seas_t$	-0.02627	-4.575	0.0000
$Seas_{t-2}$	-0.05388	-9.976	0.0000
Constant	-0.10055	-1.637	0.1075
Equation for Dsu			
Dsu_{t-2}	0.27307	2.503	0.0154
Dsu_{t-4}	-0.26954	-2.660	0.0103
$Dhprod_{t-2}$	-0.62959	-3.401	0.0013
$Dhprod_{t-4}$	-0.52295	-2.768	0.0077
Dw_{t-1}	0.31497	1.826	0.0735
Dw_{t-4}	0.42025	2.402	0.0198
ecm_{t-1}	0.21837	3.138	0.0028
$Seas_t$	-0.05955	-2.473	0.0167
$Seas_{t-2}$	-0.06416	-2.765	0.0078
Constant	-0.65933	-3.027	0.0038

Table 3.10 (continued):

Equation for Dhprod			
$Dhprod_{t-1}$	-0.46372	-3.728	0.0005
$Dhprod_{t-2}$	-0.45514	-3.558	0.0008
$Dhprod_{t-3}$	-0.29770	-2.683	0.0097
Dw_{t-1}	0.19335	1.574	0.1215
Dw_{t-2}	0.24734	2.396	0.0201
Dw_{t-4}	0.28111	2.619	0.0115
$Seas_{t}$	-0.06179	-4.603	0.0000
$Seas_{t-1}$	-0.01465	-1.288	0.2034
$Seas_{t-2}$	-0.03981	-2.836	0.0065

significant effect and it enters with a sign that rules out disequilibrium in the long-run - in line with the interpretation given by Davidson *et al* (1978).

Unemployment growth is greatly influenced by the history of the process; it is also positively related to wage inflation, result which supports again the long-run cointegrating relationship. It implies that increases in nominal wages would often take place at the expence of decreases in employment, as suggested by micro-based labour market models. Growth in productivity has negative effects, indicating that a rise in hourly productivity works as a motivation for further increase in employment. Finally, the error correction term has a strong significant positive effect.

An important feature of the equation is that it implies a high degree of persistence for unemployment. In fact, the equation reparameterised in levels, suggests that unemployment depends on its first lag with a coefficient of 0.975. Such high degree of persistence reflects insider-outsider effects, real wage rigidities and labour market rigidities such as high firing and hiring costs.

Growth in hourly productivity is mainly determined by its past history. The nominal wage inflation has also a positive effect which probably implies that, in the short-run, rises in the nominal wage inflation motivate rises in productivity growth.

The misspecification statistic results of the system are given in Table 3.11. The system can still be considered well specified even though there is evidence of increased serial correlation in the residuals for *Dsu*. Finally, in order to test if the chosen congruent simultaneous equations model parsimoniously encompasses the VAR (see Mizon (1984), Mizon

Table 3.11: **SEM Diagnostic Statistics.**

Equation residual standard deviations

Dw	Dp	Dsu	Dhprod
0.02620	0.01119	0.03953	0.02593

Equation tests

Variable	Statistic	Value	p-value
Dw :	AR 1- 4F(4, 36) =	1.9455	[0.1240]
Dp :	AR 1- 4F(4, 36) =	2.5047	[0.0592]
Dsu :	AR 1- 4F(4, 36) =	3.8965	[0.0101]*
Dhprod :	AR 1- 4F(4, 36) =	2.5376	[0.0567]
Dw :	Normality $\chi^2(2)$=	2.4793	[0.2895]
Dp :	Normality $\chi^2(2)$=	3.7557	[0.1529]
Dsu :	Normality $\chi^2(2)$=	2.3434	[0.3098]
Dhprod :	Normality $\chi^2(2)$=	4.5972	[0.1004]
Dw :	ARCH 4 F(4, 32) =	0.1024	[0.9808]
Dp :	ARCH 4 F(4, 32) =	0.8933	[0.4793]
Dsu :	ARCH 4 F(4, 32) =	0.2499	[0.9076]
Dhprod :	ARCH 4 F(4, 32) =	0.2455	[0.9102]

Vector tests

VecAR	AR 1-4 F(64,135) =	0.7143	[0.9337]
VecN	$\chi^2(8)$=	12.214	[0.1419]

and Richard (1986) for a presentation of the encompassing principle), we performed a LR test for the overidentifying restrictions. The statistic which is asymptotically distributed as χ^2 (50), took the value of 44.287 (p-value: 0.7010) which provides evidence to accept the imposed restrictions.

Table 3.11 (continued):

Correlation of residuals				
	Dw	Dp	Dsu	Dhprod
Dp	0.119	1		
Dsu	0.093	0.192	1	
Dhprod	0.238	0.098	0.068	1

3.5.2 Parameter constancy and forecasting

•

Parameter constancy

All four specifications (UVAR, PVAR, DVAR and SEM) obtain relatively constant parameters as evidenced by Chow tests (not shown for space reasons). However, they can also be compared according to the constancy of their parameters by making use of three forecast test statistics (see Doornik and Hendry (1994)).

The break point for the sample period is decided to be 1985.4. As shown by the graphs of the series at this period there was a shift to more restrictive economic policies which influenced seriously the behaviour of the series. In addition, the policy regime change had to be taken into account for the modelling of the system, by inclusion of a dummy for that period. Thus, the four alternative specifications were first estimated for the period until 1985.3 and then their dynamic forecasts over the period 1985.4 - 1990.2 were used for model comparison. The results of the one-step ahead forecast test statistics together with the means and standard deviations of the forecast errors are reported in Table 3.12. On the basis of these results the best overall performance is found in the SEM.

The SEM is the only model for which the parameter constancy assumption is not rejected by any of the obtained tests. Actual and forecast values for the PVAR, SEM and DVAR models are given respectively in Figures 3.7, 3.8 and 3.9.

Parameter constancy of the cointegrating relationship.

The SEM and PVAR models perform better than the DVAR one, in terms of parameter constancy. However, this may happen because of the way the models are specified. As

Table 3.12: **Testing for parameter constancy using forecast statistics**

UVAR: Period 1985 (4) to 1990 (2)	
F_1 using Ω	F(76,23)= 12.278 [0.0000]**
F_2 using V[e]	F(76,23)= 3.8368 [0.0003]**
F_3 using V[E]	F(76,23)= 2.4140 [0.0099]**

PVAR: Period 1985 (4) to 1990 (2)	
F_1 using Ω	F(76,21)= 2.9898 [0.0032]**
F_2 using V[e]	F(76,21)= 1.5351 [0.1345]
F_3 using V[E]	F(76,21)= 1.3046 [0.2506]

DVAR: Period 1985 (4) to 1990 (2)	
F_1 using Ω	F(76,22)= 2.6334 [0.0063]**
F_2 using V[e]	F(76,22)= 1.4129 [0.1819]
F_3 using V[E]	F(76,22)= 1.2903 [0.2549]

SEM: Period 1985 (4) to 1990 (2)	
F_1 using Ω	F(76,34)= 1.5700 [0.0731]
F_2 using V[e]	F(76,34)= 1.2738 [0.2192]

Table 3.12 (continued):

Descriptive statistics of forecast errors.

	Dw	Dp	Dsu	Dhprod
UVAR				
Mean	-0.0618	0.0138	-0.0591	0.0116
SD	0.0306	0.0243	0.0908	0.0280
PVAR				
Mean	-0.0407	-0.0003	0.0011	-0.0192
SD	0.0423	0.0181	0.0523	0.0353
DVAR				
Mean	-0.0293	-0.0028	-0.0103	-0.0106
SD	0.0408	0.0187	0.0567	0.0355
SEM				
Mean	-0.0075	0.0024	0.0162	0.0059
SD	0.0228	0.0132	0.0528	0.0301

Table 3.13: **Reduced sample weak exogeneity tests.**

1975.1 - 1985.3		
Hypothesis	$\chi^2(1)$	p-value
$\alpha_{11} = 0$: w. exogeneity for w:	3.047	0.0809
$\alpha_{21} = 0$: w. exogeneity for p:	10.61	0.0011**
$\alpha_{31} = 0$: w. exogeneity for $hprod$:	3.472	0.0624
$\alpha_{41} = 0$: w. exogeneity for su:	5.321	0.0211*

Mizon (1995) notices, this may be due to the fact that, even though possible regime shifts are not taken into account explicitly by any of the three specifications (there is no dummy included in any of the models), the PVAR and SEM models include a full sample estimate of the ecm_t, which thus reflects the regime shift and keeps the forecasts on track. This would not happen, though, when comparing *ex ante* forecasts in case that a regime shift (which affects the long-run equilibrium mean) takes place in a time point after the analysed period.

Actually, as Clements and Hendry (1995), Hendry and Clements (1994) and Mizon (1995) notice, the forecasts of the difference models remain unbiased when the long-run equilibrium mean has changed prior to forecasting due to an important regime shift. The models, though, which include the error correction terms (VECM, PVAR, SEM) will produce biased forecasts: the error correction terms tend to pull the forecasts towards the now inapropriate "equilibrium" [11].

It seems therefore necessary to perform cointegration analysis using the data sample before the break in 1985.4 and reestimate the PVAR and SEM models using the short sample long-run information in order to evaluate their *ex ante* forecasting performance.

Cointegration analysis performed for the period 1975.1 - 1985.3, gives evidence for two possible cointegrating relationships, one of which takes the form of a long-run relationship between real wage, unemployment and productivity:

$$w - 0.8455p + 0.0046su - 5.190hprod$$

The obtained cointegrating relationship is very close to the unrestricted cointegrating vector obtained by making use of the whole sample period, given in Table 3.5. The hypo-

[11] Hendry argues in his co-breaking theory (1996), that a solution to this problem could be the exploration of whether and how the regime shifts that occur in a number of variables, are related.

thesis of cointegration between real hourly wage, hourly productivity and unemployment is accepted for a LR $\chi^2(1)$ test value of 2.8913 (p-value = 0.0891) and gives a relationship of the form:

$$w - p - hprod - 0.1673su$$

which can be used as an error correction term, *ecm*1. In the reduced sample cointegrating vector, it is just the magnitude of the coefficient of *su* that changes, with no change in the sign. In addition, tests for weak exogeneity of the variables with respect to the long-run parameters reveal no change in their status when the reduced sample is used. The results reported in Table 3.13 indicate that unemployment and prices remain the endogenous variables of the relationship.

In addition, the assumption that b takes the value -0.11 obtained by the whole sample analysis, is accepted when tested for the period 1975.1 - 1985.3: The relevant LR test distributed as a $\chi^2(2)$ takes the value = 4.516 (p-value= 0.1045).

In Figure 3.7 the graphs of the two cointegrating vectors obtained for the different periods can be compared visually. All evidence support that the policy change did not have a very strong effect in the long-run behaviour of the variables.

Forecasting comparison.

In a final step, the short sample cointegrating vector *ecm*1 replaces *ecm* in the PVAR, forming PVAR1 and in SEM specification forming SEM1, and the *ex ante* forecasts are compared with those of the DVAR. The forecast test results and the means and standard deviations of the forecast errors are reported in Table 3.14. The new model SEM1 again has the best forecasting performance among the three models DVAR, PVAR1 and SEM1. Actual and forecast values for SEM1 are given in Figure 3.11.

3.6 Conclusions

Price, wage, productivity and unemployment determination in Greece was investigated using labour market theories describing wage setting and the relationship between wage and price inflation. The sample period included different political regimes with different weights on inflation control, the effects of two devaluations of the national currency at 1983 and 1985 and the beginning of the EU membership at 1981. The analysis was done

Table 3.14: **Forecasting tests.**

PVAR1 forecasting: Period 1985 (4) to 1990 (2)

F_1 using Ω	F(76,21)=	3.3188	[0.0015]**
F_2 using V[e]	F(76,21)=	1.6064	[0.1106]
F_3 using V[E]	F(76,21)=	1.3329	[0.2325]

SEM1 forecasting: Period 1985 (4) to 1990 (2)

F_1 using Ω	F(76,34)=	1.7018	[0.0437]*
F_2 using V[e]	F(76,34)=	1.3365	[0.1755]

Descriptive statistics of forecast errors.

	Dw	Dp	Dsu	Dhprod
PVAR1				
Mean	-0.04334	0.00146	0.00688	-0.02360
SD	0.04109	0.01809	0.05367	0.03438
SEM1				
Mean	-0.00744	0.00453	0.03149	0.00587
SD	0.02287	0.01314	0.05330	0.03002

in a closed system framework including the variables prices, hourly wages and hourly productivity in manufacturing and unemployment.

A thorough investigation of the time dependence properties of the series on a univariate level, indicated that the unemployment series contains a strong and unstable seasonal component and is seasonally integrated. These properties led to the use of a seasonally adjusted series of unemployment for the modelling of the system. The empirical analysis followed the "encompassing the VAR" methodology, according to which simultaneous equations models are evaluated by their congruence and their ability to encompass the VAR congruent representation of the data generation process. In addition, the Johansen cointegration analysis which takes into account the nonstationarities of the series on a multivariate level, and provides a framework for the joint analysis of long-run and short-run behaviour was used.

A long run positive real wage - productivity relation with positive unemployment effects, in which price and unemployment are the endogenous variables, was established. The positive unemployment impact probably reflects insiders - outsiders effects, real wage rigidities and inability of the productive sector to react to positive shocks. The result came out from the long-run analysis of the labour market, where alternative theoretical hypotheses, including stationarity for the individual series, were tested. Then, the long-run information was incorporated in a reduced, yet congruent parameterisation of the initial system, (the PVAR), which has been used as the benchmark within which alternative models were evaluated. The finally chosen simplified model, SEM is shown to be congruent and able to encompass the PVAR. It has been given reasonable theoretical interpretation and has constant parameters. In addition, it gives better forecasts than the DVAR model (which can be considered a powerful rival model within the time series analysis tradition) even when it is estimated by using the cointegrating relation obtained for the period before the policy change regime characterising the whole period, took place.

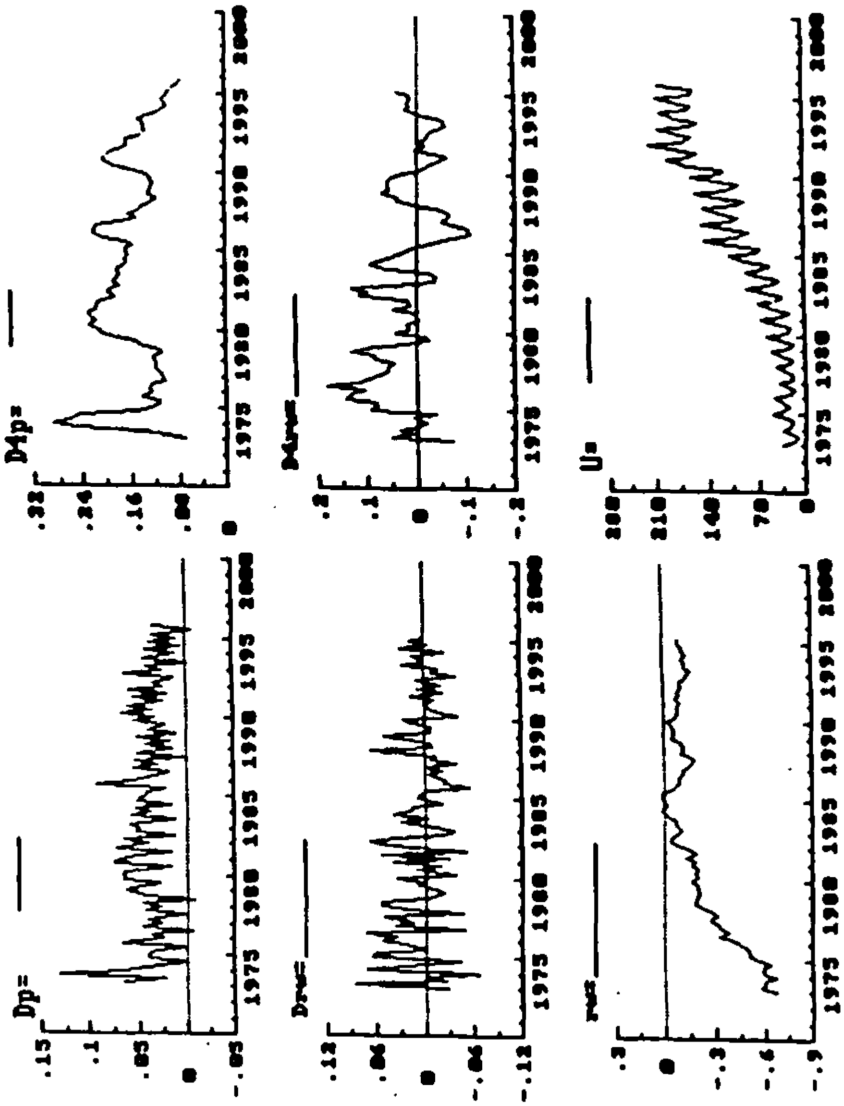

Figure 3.1: The overall activity series

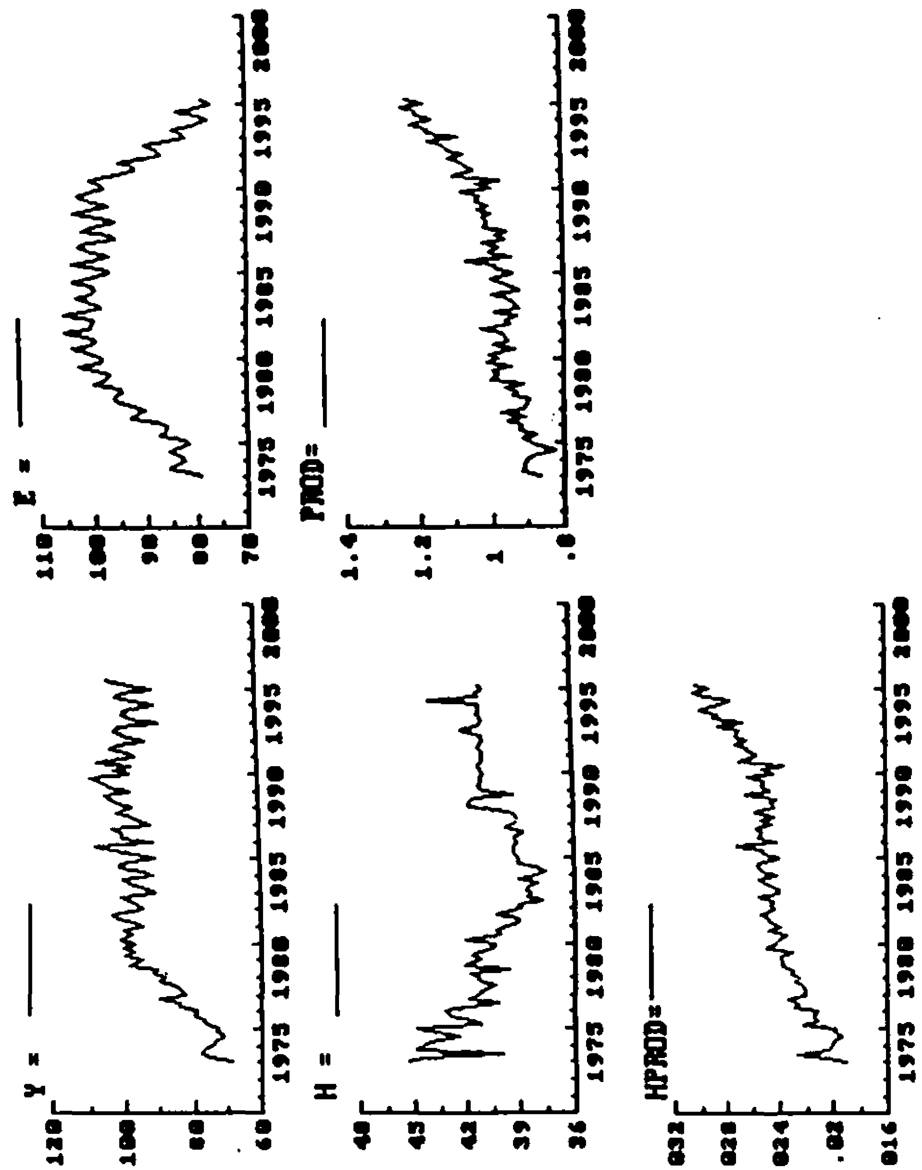

Figure 3.2: Manufacturing sector series

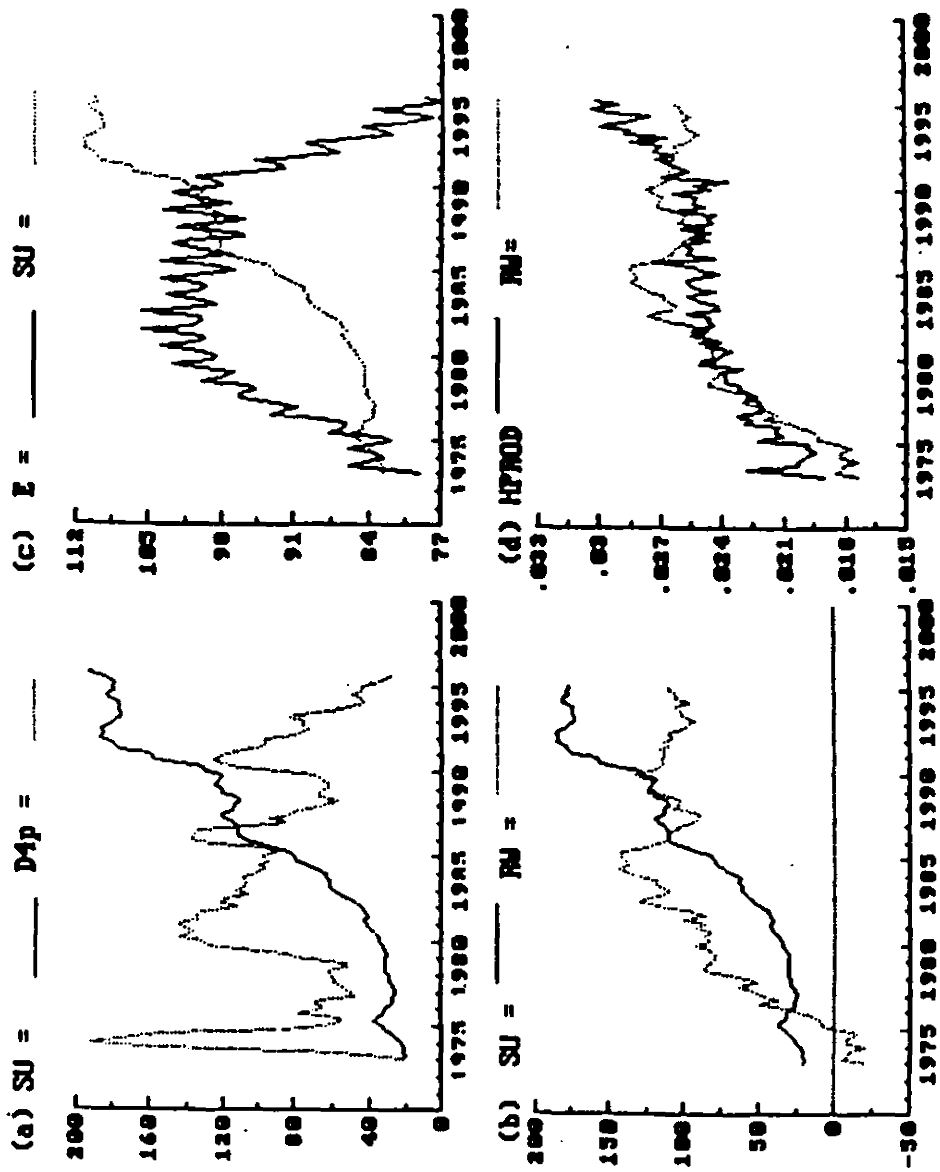

Figure 3.3: Mean and variance adjusted series

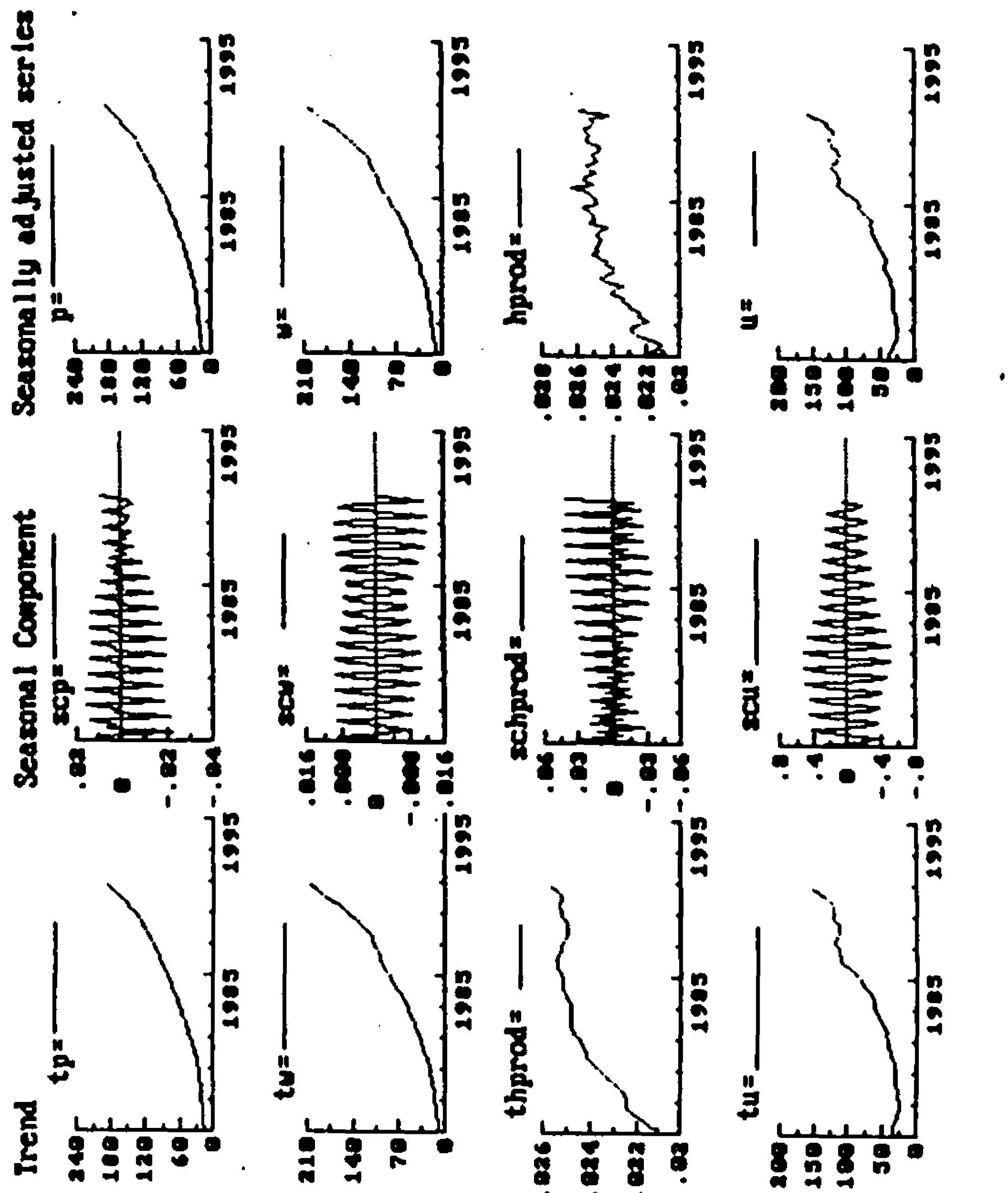

Figure 3.4: Trend, seasonal component and SA series

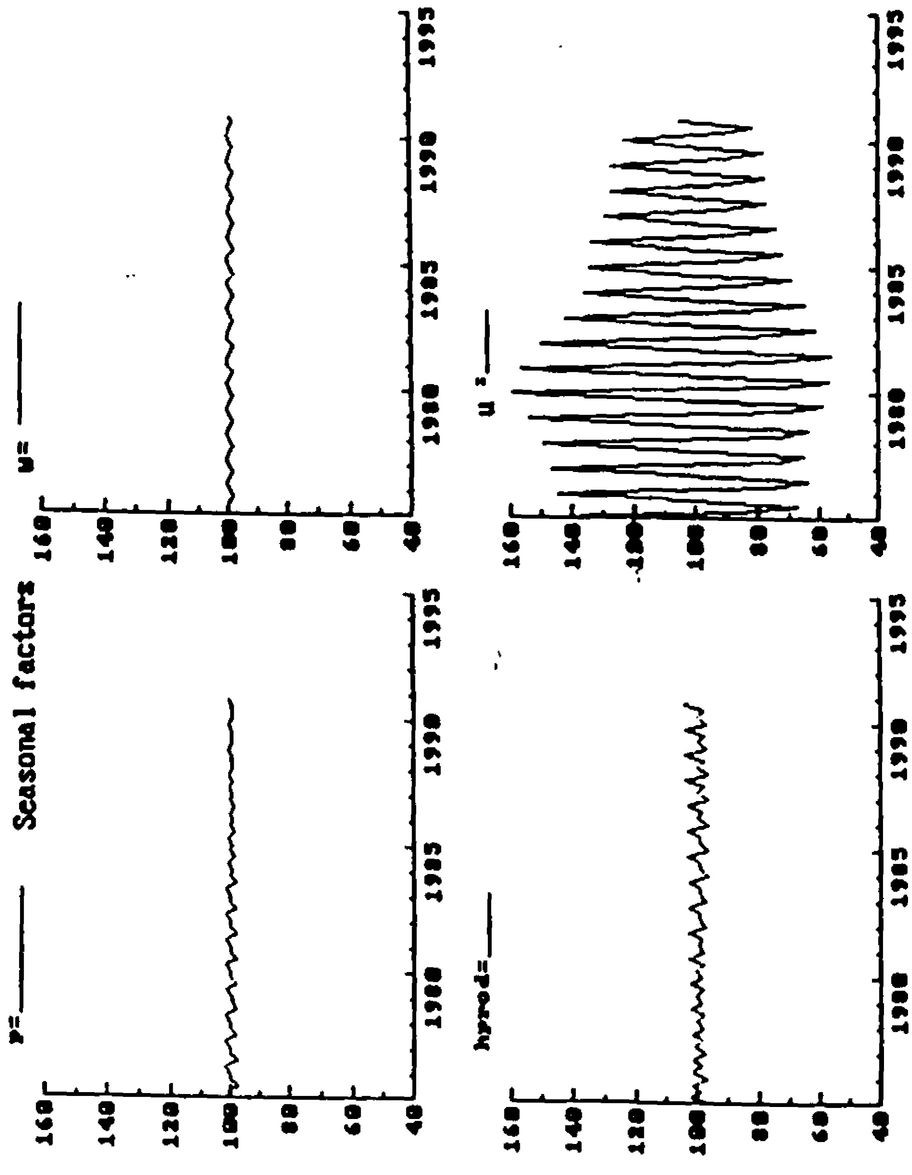

Figure 3.5: Seasonal factors of the series

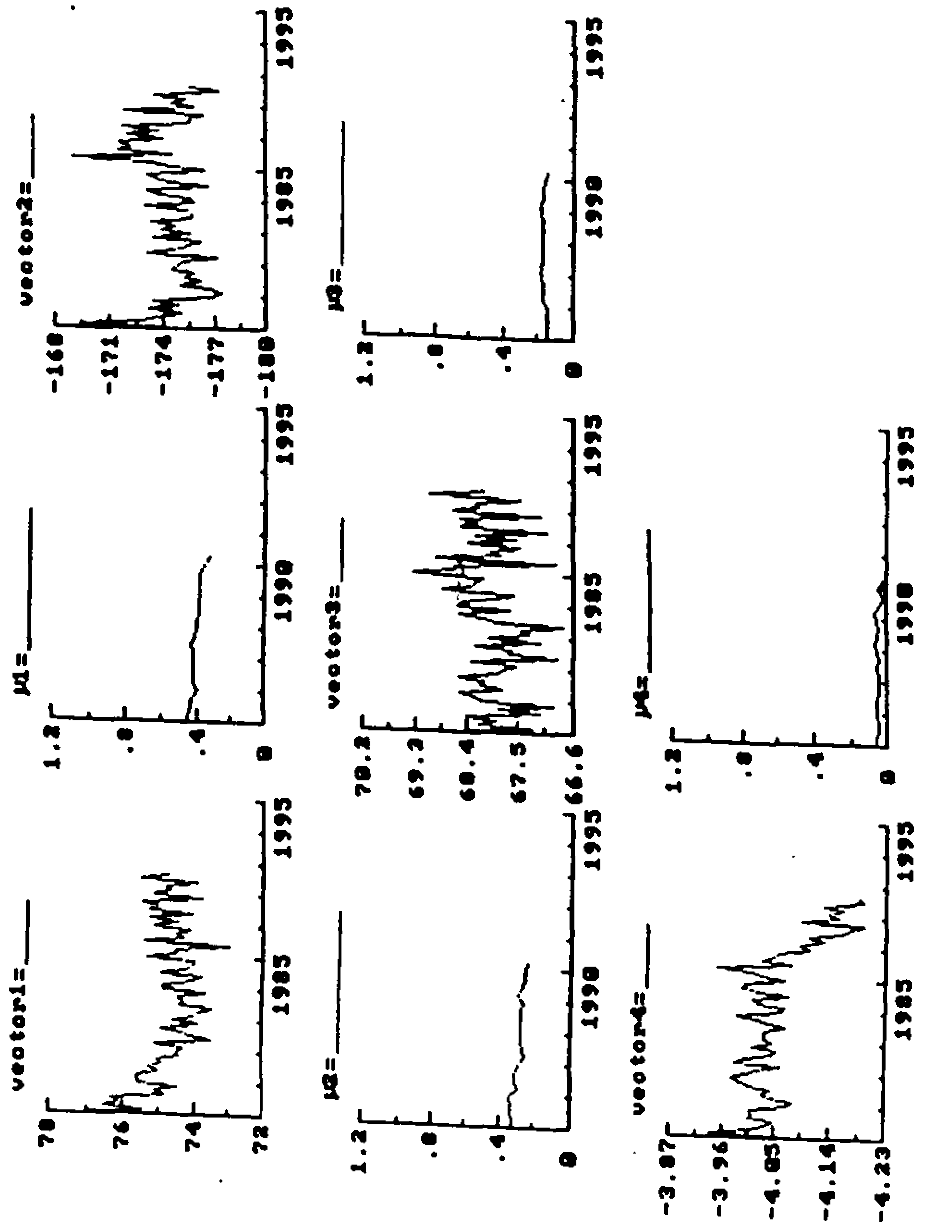

Figure 3.6: Cointegrating vectors and recursive eigenvalues

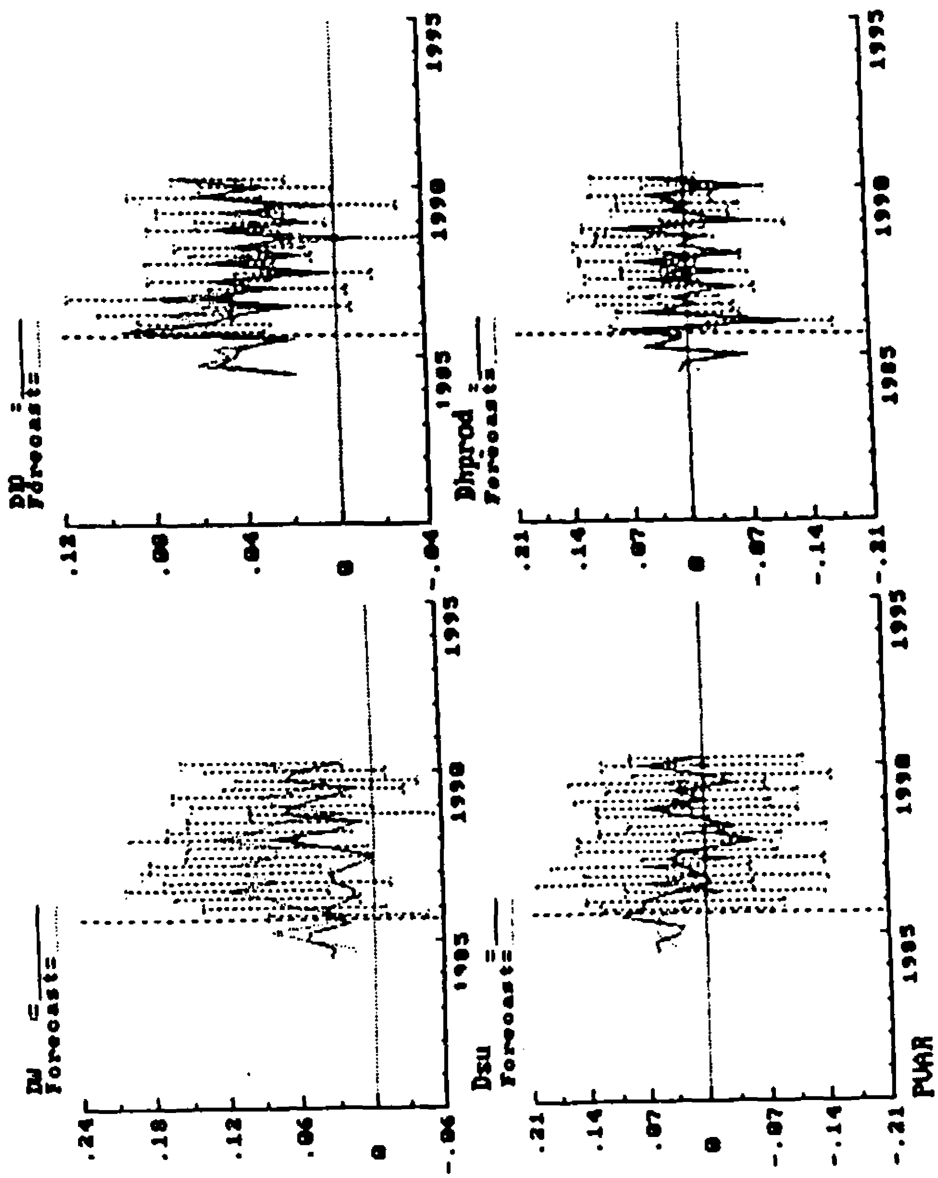

Figure 3.7: PVAR forecasts

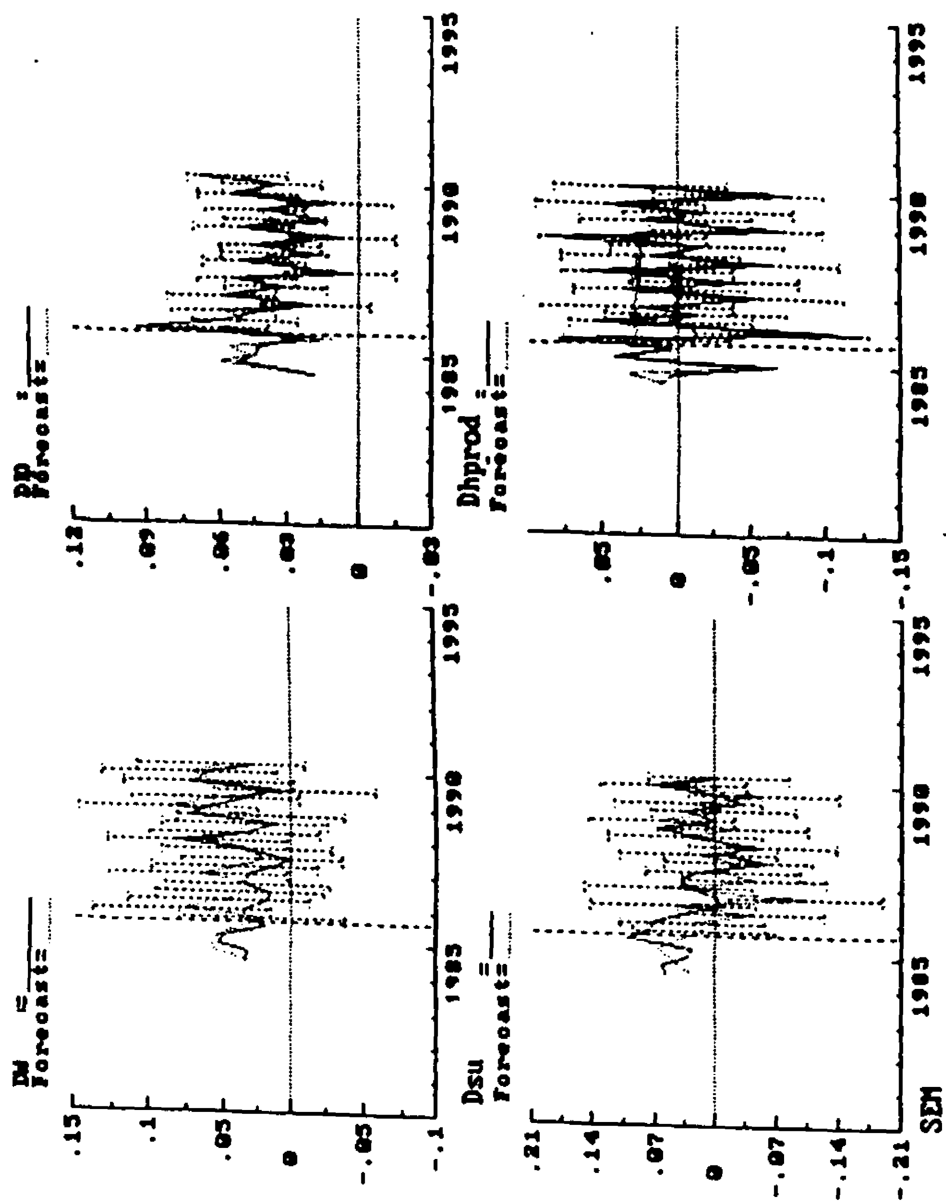

Figure 3.8: SEM forecasts

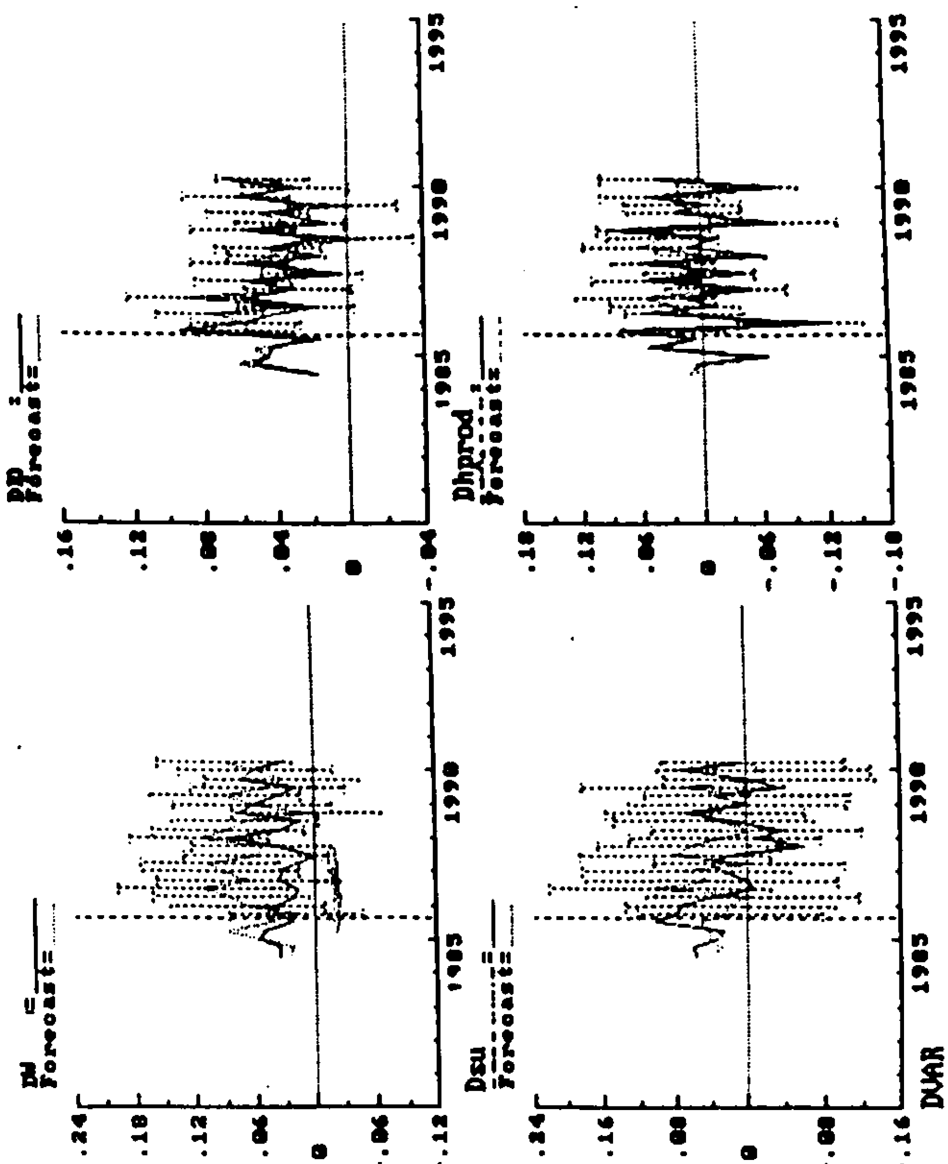

Figure 3.9: DVAR forecasts

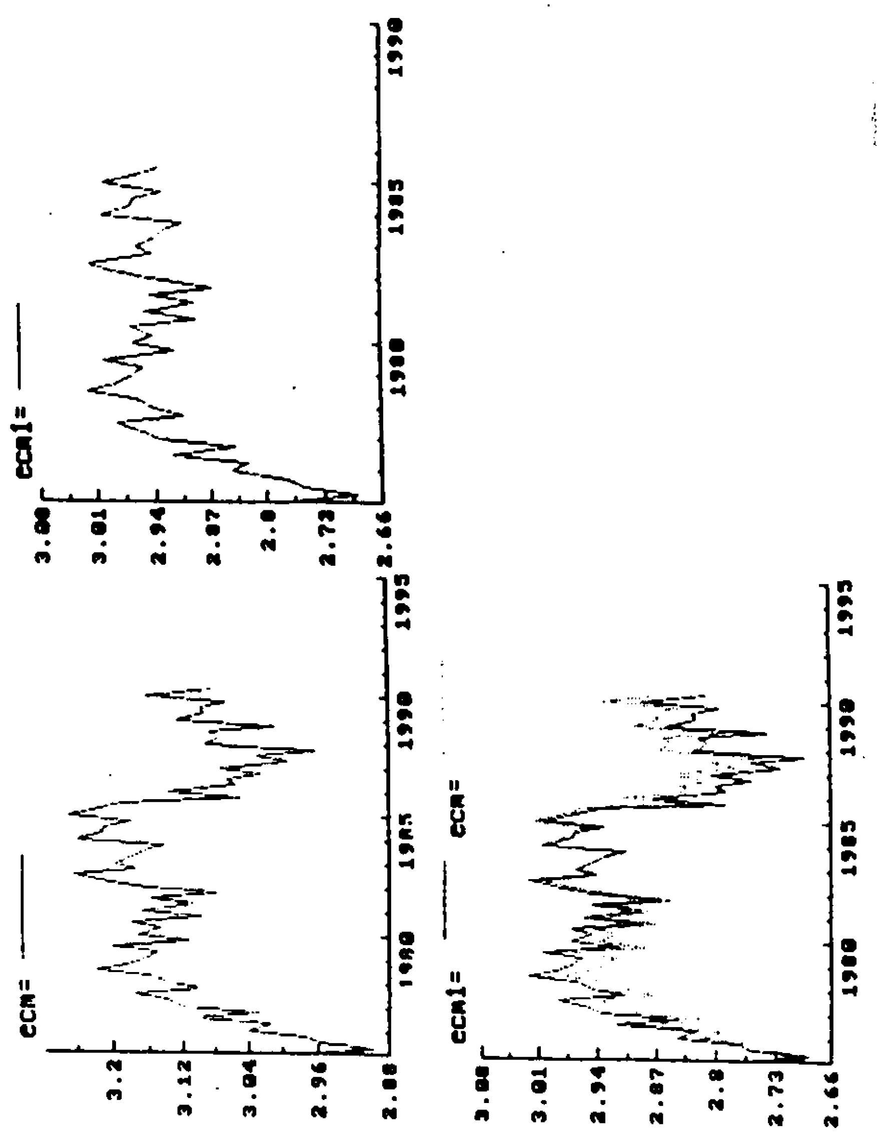

Figure 3.10: ecm, ecm1

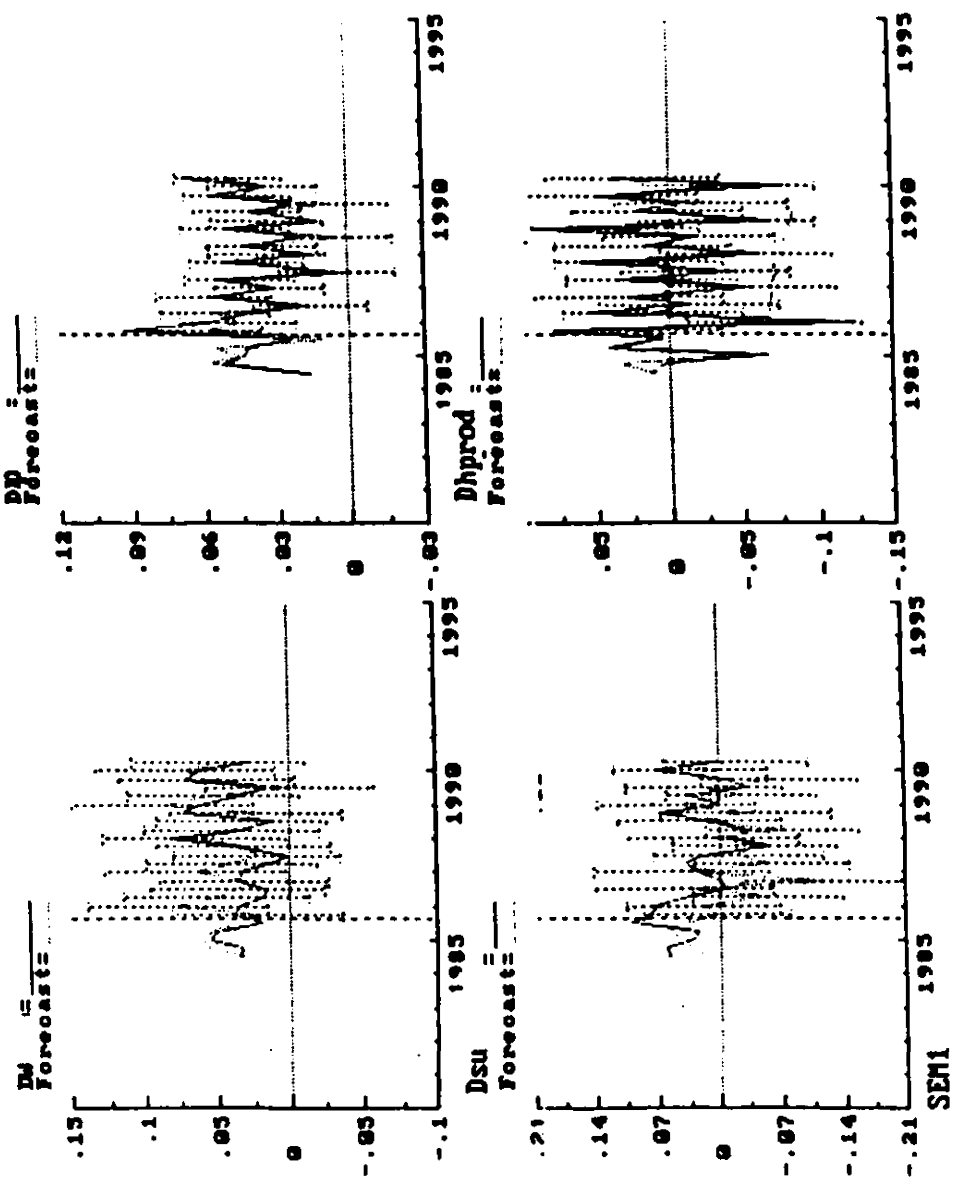

Figure 3.11: SEM1 forecasts

Appendix 3.A: Data definitions and sources

- Y = Index of industrial production in manufacturing. Source: OECD Main Economic Indicators, various issues (OECD).
- E = Employment in manufacturing. Source: OECD.
- W = Nominal hourly earnings in manufacturing. Source: OECD.
- P = Consumer price index. Source: International Financial Statistics, International Monetary Fund (IMF).
- H = Weekly hours of work in manufacturing industry. Source: OECD.
- U = Number of registered unemployed. Source: OECD.

Bibliography

[1] Alogoskoufis, G. (1986), "On the Determinants of Consumer Price Inflation in Greece", Greek Economic Review, 245-266.

[2] Alogoskoufis, G. (1990), "Competitiveness, Wage adjustment and Macroeconomic Policy in the Dependent Economy: the case of Greece", Greek Economic Review, 12, 15-57.

[3] Alogoskoufis G. and Smith R. (1991), "On Error Correction Models: Specification, Interpretation, Estimation", Journal of Economic Surveys, 5, 97-127.

[4] Banerjee A. and Hendry D.F. (1992), "Testing Integration and Cointegration: an Overview", Oxford Bulletin of Economics and Statistics, 54, 3, 225-255.

[5] Box, G.E.P. and Jenkins, G.M (1970), "Time Series Analysis Forecasting and Control", San Francisco: Holden-Day.

[6] Bruno, M. and Sachs, J. (1985), "Economics of Worldwide Stagflation", Harvard University Press, Cambridge, Massachusetts.

[7] Canova, F. (1993), "Vector Autoregressions", in K.D. Hoover (ed.), Macroeconometrics: Developments, Tensions and Prospects, Kluwer Academic Publishers.

[8] Clements, P. M. and Hendry D. F. (1995), "Macroeconomic Forecasting and Modelling", The Economic Journal, 105, 1001-1013.

[9] Clements, M. P. and Mizon, G.E. (1991), "Empirical Analysis of Macroeconomic Time Series: VAR and Structural Models", European Economic Review, 35, 887-932.

[10] Davidson, J.E.H., Hendry, D.F., Srba, F. and Yeo, J.S. (1978), "Econometric Modelling of the Aggregate time seies Relationship between Consumer's Expenditure and Income in the United Kingdom", Economic Journal, 88, 661-692.

[11] Demekas, D. and Kontolemis, Z. (1996), "Unemployment in Greece: A Survey of the Issues", mimeo, International Monetary Fund, March.

[12] Dickey, D. and Fuller, W. (1981), "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", Econometrica, 49, 1657-1672.

[13] Doornik, J.A. and Hendry, D.F. (1994), "PC_GIVE and PC_FIML Professional, Version 8: An Interactive Econometric Modelling System", London: International Thomson.

[14] Ericsson, N.R. and J.S. Irons (1994), "Testing Exogeneity", Oxford: Oxford University Press.

[15] Ericsson, N.R., Hendry D. F. and Tran H. (1993), "Cointegration, Seasonality, Encompassing and the Demand for Money in the United Kingdom", International Finance Discussion Papers, no 457.

[16] Granger, C.W.J. (1990) (ed), "Modelling Economic Series: Readings in Econometric Methodology", Oxford: Oxford University Press.

[17] Gomez, V. and Maravall, A. (1994),"Estimation, Prediction and Interpolation for Nonstationary Series with the Kalman Filter", Journal of the American Statistical Association, 89, 611-624.

[18] Hall, S.G. (1989), "Maximum Likelihood Estimation of Cointegrating Vectors", Oxford Bulletin of Economics and Statistics, 51, 213-218.

[19] Hendry, D.F. (1995), "Dynamic Econometrics", Oxford: Oxford University Press.

[20] Hendry D.F. (1996), "A Theory of Co-breaking", mimeo, Institute of Economics and Statistics, Oxford, February.

[21] Hendry D.F. and Clements, M.P. (1994), "Can Econometrics Improve Economic Forecasting?", Swiss Journal of Economics and Statistics, 130, 267-298.

[22] Hendry D.F. and Mizon, G.E. (1990), "Procrustean econometrics: Or stretching and Squeezing Data", chapter 17 in Modelling Economic Series: Readings in Econometric Methodology, edited by Granger, C.W.J. op cit.

[23] Hendry, D.F. and Mizon G.E. (1993), "Evaluating Dynamic Econometric Models by Encompassing the VAR", chapter 18 in Models, Methods and Applications of Econometrics, Essays in Honor of Rex Bergstom, Phillips, P.C.B. (ed.), Oxford: Basil Blackwell, 272-300.

[24] Hendry, D.F. and Wallis, K.F. (1984), "Econometrics and Quantitative Economics", Oxford: Basil Blackwell.

[25] Hylleberg, S., Engle, R.F., Granger, C.W.J. and Yoo, B.S. (1990), "Seasonal Integration and Co-integration", Journal of Econometrics, 44, 215-238.

[26] Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors", Journal of Economic Dynamics and Control, 12, 231-254.

[27] Johansen, S. (1995), "Likelihood-based Inference in Cointegrated Vector Autoregressive Models", Oxford: Oxford University Press.

[28] Johansen, S. and Juselius K., (1990), "Maximum Likelihood Estimation and Inference on Cointegration - with Applications to the Demand for Money", Oxford Bulletin of Economics and Statistics, 52, 169-210.

[29] Johansen, S. and Juselius K., (1992), "Identification of the Long-run and the Short-run Structure: An Application to the ISLM Model", mimeo, University of Copenhagen (May).

[30] Juselius, K. (1992), "Domestic and Foreign Effects on Prices in an Open Economy: The Case of Denmark", Journal of Policy Modeling, 14, 401-428.

[31] Kouretas, G. (1993), "Wage Indexation in EFTA Economies: An Application of Co-Integration Techniques", Jahrbucher fur Nationalokonomie und Statistik, 212/3-4, 278-291.

[32] Kostial, K. (1994), "The Role of the Signal-Noise ratio in Cointegrating Systems", European University Institute Working Paper ECO, no 94/27.

[33] Maravall, A. and Gomez, V. (1994a),"Program SEATS, Signal Extraction in ARIMA Time Series: Instructions for the User", European University Institute Working Paper ECO, no 94/28.

[34] Maravall, A. and Gomez, V. (1994b),"Program TRAMO, Time Series Regression with ARIMA Noise, Missing Observations and Outliers: Instructions for the User", European University Institute Working Paper ECO, no 94/31.

[35] Mizon, G.E. (1984), "The Encompassing Approach in Econometrics", Chapter 6 in D.F. Hendry and K.F. Wallis (eds) Econometrics and Quantitative Economics, op cit.

[36] Mizon, G.E. (1995), "Progressive Modelling of Macroeconomic Time-series: The LSE Methodology", in K. D. Hoover (ed), Macroeconometrics: Developments, Tensions and Prospects, Derdrecht: Kluwer.

[37] Mizon, G.E. and J.F. Richard (1986), "The Encompassing Principle and its Application to testing Non-nested Hypotheses", Econometrica, 54, 3, 657-678.

[38] Monfort A. and Rabemanjara, R. (1990), "From a VAR Model to a Structural Model: with an Application to the Wage-Price Spiral", Journal of Applied Econometrics, 5, 203-227.

[39] Muscatelli, A. and Hurn, S. (1992), "Cointegration and Dynamic Time Series Models", Journal of Economic Surveys, 6, 1-43.

[40] Nymoen, R. (1992), "Finish Manufacturing Wages 1960-1987: Real-Wage Flexibility and Hysteresis", Journal of Policy Modelling, 14, 429-452.

[41] Osterwald-Lenum, M. (1992), "A Note with Quantiles of the Asymptotic Distribution of the ML Cointegration Rank Test Statistics", Oxford Bulletin of Economics and Statistics, 54, 461-472.

[42] Psaradakis, Z. (1991), "Modelling the Structure of Wage and Price Determination in Greece", University of Southampton, Department of Economics, Discussion Paper No 9102.

[43] Sargan, J.D. (1964) "Wages and Prices in the United Kingdom: A Study in Econometric Methodology" in Hart, P.E. Mills, G. and Whitaker, J.K.(eds), Econometric

Analysis for National Economic Planning. Butterworths. London. Reprinted in Hendry and Wallis (1984) op.cit.

[44] Spanos, A.,(1986), "Statistical Foundations of Econometric Modelling", Cambridge: Cambridge University Press.

[45] Spanos, A. (1990a), "Towards a Unifying Methodological Framework for Econometric Modelling" chapter 15 in Granger, C.W. (ed), Modelling Economic Series: Readings in Econometric Methodology, op. cit.

[46] Spanos, A. (1990b), "Unit Roots and their Dependence on the Conditioning Information set", pp.271-292 in Fomby, T.B., and Rhodes G.F. (eds), Advances in Econometrics, Volume 8: Cointegration, Spurious Regression and Unit Roots, JAI Press Inc., Greenwich, Connecticat.

Chapter 4

Multilateral versus bilateral testing for long run Purchasing Power Parity: A cointegration analysis for the Greek drachma.

Abstract

Problems faced by empirical studies of the purchasing power parity (PPP) hypothesis are: the choice between a multilateral and a bilateral approach, the choice of the appropriate price index and the problem of simultaneous determination of prices and exchange rates. In the present paper, we analyse the implications that these problems have, while testing for the PPP doctrine between Greece and its three major trading partners during the recent floating exchange rate period. Long-run PPP is tested as an exchange rate-price cointegrating relationship by applying the Johansen procedure, using two alternative price measures. The analysis is carried out in the "general to specific" framework, which allows comparison between the multilateral and the bilateral approach and the econometric technique adopted tests the endogeneity/ exogeneity status of key variables rather than imposing it *a priori*.

4.1 Introduction

Purchasing power parity (PPP) states that the exchange rate between two currencies is determined by the change in the two countries' relative prices. The notion underlying this is that deviations from the parity represent profitable commodity arbitrage opportunities which, if exploited, will tend to force the exchange rate towards the parity. Since the return to a floating exchange rate regime in the early 70's, PPP has been used as at least a long run relationship in most of the international economic models as much as it has been the focal point of exchange rate policy (see *inter alia* Dornbusch (1988), MacDonald and Taylor (1992)). As a consequence, its empirical verification as either a short run or a long run relationship has been the purpose of a large number of applied papers, with cointegration analysis (introduced by Engle and Granger (1987)), used in the most recent ones as an important tool to test for its existence in the long run. In general, the empirical evidence in favour of the PPP condition has been rather weak (see Dornbush (1989)). In addition, most of the empirical works of the PPP hypothesis present a few common problems which are essentially the choice between a multilateral and a bilateral approach, the choice of the price index and the problem of the simultaneous determination of prices and exchange rates.

The two most recent studies which analyse PPP using Greek data during the recent floating exchange rate period are Karfakis and Moschos (1989) and Dockery and Georgellis (1994)[1]. In both papers the authors use the Engle and Granger (1987) two step technique and adopt the bilateral approach for testing for PPP. Karfakis and Moschos (1989) use quarterly unadjusted series for the exchange rates and two alternative price measures of Greece and its six major trading partners for the period 1975(1)-1987(1); they find no evidence of long run PPP. Dockery and Georgellis use monthly unadjusted series for nine European trade partners of Greece for the post EEC period 1980(4)-1992(8); they use consumer prices and again they find no evidence of long run PPP in most cases[2].

The present chapter extends the existing literature on long run PPP for the Greek drachma by giving particular emphasis to the methodological problems presented in the literature. Long run PPP between Greece and its three major trading partners is tested as

[1]Whereas Georgoutsos and Kouretas (1992) test for long run PPP between Greece and main economies for the floating exchange rate regime period of the 20's. Moschos and Stournaras (1991) also test for PPP between Greece and an approximation of the rest of the world and they find no such evidence.

[2]In particular, they find no evidence for PPP for the countries Germany, France, Italy, Belgium, Holland and Denmark, while they find PPP evidence for the countries UK, Spain and Portugal.

a cointegrated equilibrium relationship, by making use of two alternative price measures, the consumer price index p^c and the wholesale price index p^w. The analysis is initially made in a multilateral framework in an effort to capture the bilateral bias (the fact that the bilateral analysis does not take into account the correlation between exchange rate movements). In a second step, the strength of the bilateral specifications is evaluated by formal testing against the general multicountry models. Finally, PPP is tested in bilateral systems and the results obtained are compared with the multilateral ones.

Both multilateral and bilateral analyses are performed in a multivariate framework which is consistent with the "general to specific" tradition, briefly presented in Chapter 2. Initially vector autoregressive (VAR) models in levels are considered, which describe the statistical properties of the data. Then, the Johansen (1988), Johansen and Juselius (1990) cointegration technique is applied, which leads to the determination of the number of the cointegrating long run relationships and allows testing for the hypotheses of interest expressed as linear restrictions on the cointegrating parameters. In particular, certain linear restrictions on the cointegrating parameters β's imply long run PPP, whereas restrictions on the loading parameters α's imply necessary conditions for weak exogeneity for the variables involved[3].

The basic advantage of the methodology compared in particular with the Engle and Granger's (1987) residual based technique used in the aboved mentioned studies of the Greek experience, is that it allows for possible interactions in the determination of the variables and no variable has to be considered *a priori* exogenous. In addition, the model specification used for cointegration allows for different long run relations and short run dynamics and for adjustment for specific regime shifts which may have occurred during the examined period; this is important since such shifts can distort statistical tests that do not account for them. Finally, it allows for more than one cointegrating vector.

The rest of the chapter is organised as follows: Section 4.2 describes briefly the theory underlying the PPP doctrine and outlines the problems related to the empirical PPP literature. In Section 4.3 the data set is presented. Sections 4.4 and 4.5 analyse the applied work done in a multilateral and a bilateral framework respectively, and interpret the results. The final section summarises and concludes.

[3]Testing for PPP for main exchange rates using the Johansen methodology has provided new results (see *inter alia* Johansen and Juselius(1992), Hunter (1992), Cheung and Lai (1993a), Juselius (1994), Chen (1995), McDonald and Marsh (1995)).

4.2 The existing literature.

4.2.1 The economic background

PPP states a theory of exchange rate determination. Letting p, p_f indicate the logs of the price levels of the domestic and the foreign economy respectively, and e be the log of the exchange rate denominated in the currency of the domestic economy. the **"strong" PPP** version states that:

$$e = p - p_f \tag{4.1}$$

implying that, whatever the monetary or real disturbances in an economy, under the assumption of instantaneous costless arbitrage, the prices of a common basket of goods in the two countries measured in a common currency will be the same.

However, even though there cannot be any objection to (4.1) as a theoretical statement, it cannot be expected to hold always as an empirical proposition. The prices of a given commodity will not necessarily be equal in different locations, because of transportation costs, possible tariff barriers and information costs. Moreover, measurement error problems, arising from published price indices not coinciding with the theoretical prices, should also be taken into account when PPP is tested empirically[4].

Therefore, the relationship is more likely to take the following **"weak" PPP** form:

$$e = \gamma(p - p_f) \tag{4.2}$$

with γ being a constant factor which accounts for assumed constant transportation, information costs and measurement errors. In (4.2), γ is allowed to differ from unity, implying that long run proportionality between the exchange rate and relative prices may not be exactly one-to-one (see Taylor (1988), for the derivation of (4.2) in a model allowing for transportation costs and measurement errors).

However, even in its weak form (4.2), PPP does not necessarily hold in the long run, given that changes in tastes cause shifts in exports demand, the different relevant importance of the tradeable to the nontradeable sectors, as well as the difference in more

[4]An implicit assumption for PPP to hold when tested using aggregate price indices is that each good is equally weighted in the indices of the different economies. International differences in consumption patterns, variations in product qualities and differences between listed and transaction prices are some of the reasons for different weighting of the price indices.

fundamental factors such as productivity, government spending and stategic pricing decisions by firms would cause exchange rate movements beyond the PPP level (see Froot and Rogoff (1995) for a survey of the structural models that explain deviations from PPP).

Finally, exchange rates are also determined through transactions in the asset markets, related to the interest rate differentials between different countries. (For that reason, Johansen and Juselius (1992), McDonald and Marsh (1995) suggest testing for PPP in a framework which includes interest rates, in an attempt to capture any special financial market effects). Therefore, temporary departures from PPP can be explained by asset markets clearing faster than commodity markets, thus leading to exchange rates being temporarily influenced by "news" effects.

4.2.2 Empirical problems.

The main problems of the empirical PPP literature (see *inter alia* Giovannetti (1992)) are:

1. A bilateral versus a multilateral approach: Bilateral testing for PPP has often been criticised for ignoring the correlation between exchange rate movements. Dealing with this problem by using trade weighted series has also been criticised for being arbitrary in terms of the choice of weights. In addition, it has the drawback that it implies that the relative importance of different countries' prices in determining domestic prices changes if and only if, the trade pattern changes.

In the present application, a multi-country analysis in systems which account for the interractions of exchange rates and prices between more than two countries simultaneously is first attempted. Then, (in line with the "general to specific" methodology) reduced two-country systems are formally tested against the more general ones in terms of the robustness of the cointegration results. Finally, a bilateral analysis is performed in an attempt to test whether the results obtained confirm the multilateral analysis results.

2. The choice of the price index: Empirical studies considering PPP as an arbitrage relationship advocate the use of traded good indices such as export prices or the wholesale price index. Studies taking into account the different pricing behaviour in goods and asset markets on the other hand, support the use of more general price measures such as the consumer price index, or the GDP deflator. In the present work, both approaches are followed, by using both consumer and wholesale price indices and the results are interpreted accordingly.

From a theoretical point of view, the p^w is the adequate price measure to be used in the present work, given that the Greek asset market was relatively closed during the period under study. However, examination of the way in which the indices are computed reveals differences between the methodologies used to compile the p^ws in Greece and in the other countries, while this is not so for the p^cs. Similar household expenditure measures, rent and product prices are included for the p^c compilation for all countries under study (see OECD (1994a) supplement); the p^c indices also cover similar geographical area and population (see IFS (1986) supplement, p. 217-219). On the contrary, the methodologies in which the p^w s are compiled differ from country to country: The various p^ws include different groups of industry commodities weighted in a quite judgmental way by the compilers of the national statistical institutions. The Greek w^p for example, includes exported domestic goods, while this is not so for the indices of the rest of the countries (see OECD (1994b) supplement). As a consequence, the p^c index is a better comparable measure to test for PPP than the p^w, in terms of measurement precision.

3. **Endogeneity/ exogeneity status of the variables:** The question is whether the price or the exchange rate series is the endogenous variable in the PPP relationship. The arbitrage based theory advocates exogenous prices (so it could be expected that this would hold in traded good price systems), while exogeneity for the exchange rates could only be supported by models taking into account the asset - good market forces interactions (therefore, more likely to be found in general price measure models). Contrary to most of the previous PPP empirical studies, including most of those using the Engle and Granger technique, application of the Johansen maximum likelihood technique allows the endogeneity/ exogeneity status to be evaluated statistically, rather than imposed *a priori.*

4.3 The data set.

PPP is tested for Greece and its three major trading partners for the period examined: Germany (G), France (FR) and Italy (IT). As shown in Table 4.1, more than one third of Greece's trade is with these three countries. Almost two thirds of the Greek imports are received from European countries, more than half of them from the EU members. Germany is the most important trading partner, accounting for approximately 18% of

Greek total imports and 20% of Greek total exports, followed by Italy (11% of imports, 10% of exports) and France (7% of imports, 6.5% of exports)[5].

Quarterly seasonally unadjusted data for the post Bretton-Woods period 1975(1) to 1993(4) are used. The price series are IMF series; they were all obtained using the DATASTREAM data bank. The drachma exchange rate and the Greek trade series were taken from the *Greek Monthly Statistical Bulletin* of the *Bank of Greece*, various issues. The sample is shorter in a number of cases due to non availability of data[6], and effective estimation periods are reduced so as to accomodate the lag structure of the estimated models.

Table 4.1: **Trade with major trading partners (1975 - 1993)[1].**

Country	Imports (%)	Exports (%)
Germany	18	20
Italy	11	10
France	7	6.5
All three countries	36	36.5
EEC countries	52	48
EEC & OECD Europe	66	59

[1]The percentages are calculated using averages for the period 1975(1)-1993(4). Data are taken from the *Greek Monthly Statistical Bulletin* of the *Bank of Greece* , various issues.

The variables used are the logs of the exchange rates of the drachma against the Deutsch mark e_G , the Italian lira e_{IT} and the French franc e_{FR} and two alternative price measures, the consumer price index and the wholesale price index in Greece p^c_{GR} and p^w_{GR} respectively, and in the three countries p^c_f, p^w_f, where f denotes foreign country and takes the values G, IT, and FR for the countries Germany, Italy and France, respectively. The graphs of the series are presented in Figure 4.1.

[5]Those countries are followed by the US (6% of imports, 7% of exports) and the UK (5% of imports, 6% of exports), but extension of the analysis to test for PPP between Greece and the UK and the US is not attempted in the present work. It is done, though, in a bilateral framework in Sideris (1994).

[6]For France, the wholesale price index is not available before 1980(2), and the Greek drachma/Italian lira exchange rate series is not available before 1978(1).

4.4 Testing for PPP in a multilateral framework.

4.4.1 Specification of the VAR models.

In this first stage, the bilateral bias in PPP testing is dealt with by the specification of multicountry systems which model the price and exchange rate interractions among more than two countries simultaneously. In addition, in multilateral models the domestic prices are regressed against the prices of the domestic country's major trade partners, allowing the relative importance of the different countries prices in determining domestic prices to be directly determined from the data.

The initial aim was to test for PPP simultaneously between Greece and its three major competitors Germany, Italy and France, in four-country systems (seven-dimensional VARs) using the two alternative price index specifications. However, given the available sample period, analysis of seven dimensional VARs would mean loss of valuable degrees of freedom. It was therefore decided to do the analysis in five-dimensional VARs allowing for possible interrelations between Greece and two of its major partners at a time.

Four three-country VAR systems are estimated: (A) and (B) model simultaneously the price-exchange rates interrelations between Greece and: (a) Germany and France, and (b) Germany and Italy repectively, using p^c's; (C) and (D) model the price- exchange rate movements between Greece and: (c) Germany and France, and (d) Germany and Italy, using p^w's. Estimation is done by application of the multivariate least squares technique using five lags for the variables, with a constant and centred seasonals included in the deterministic variables set D_t[7].

Likelihood ratio tests (provided there were non autocorrelated residuals in the reduced systems) indicated the number of lags to be four in system (D) and five in the rest of the systems. All initial VARs rejected the null of normal residuals, possibly due to non-constant parameters as indicated by the plots of one-step Chow tests against the end point of the samples (not shown to save space). These features supported the inclusion of impulse dummy variables to account for the regime shifts/ structural breaks observed in the examined period, which (as advocated by Clements and Mizon (1991)) is preferable to an enlargement of the system.

[7] All results reported in the paper are obtained using the PC-GIVE and PC-FIML modules of the PC-GIVE.8 system of computer programs (see Hendry (1989), Doornik and Hendry (1994)).

In fact, two severe regime shifts in the form of two drachma devaluations took place during this period: the first one in January 1983, and the second one in October 1985. The second initially caused sharp rises in Greek prices, with inflation reaching its highest point in the first quarter of 1986. The shift dummies D831 and D854 accounting for the first and second devaluations turned out to be significant in all systems, while their absence would have meant non normal residuals for the exchange rate and Greek price equations of them[8]. The dummy D924 which accounts for the withdrawal of major European currencies (including the Italian lira) from the ERM in September 1992, also had to be included in the Greek-German-Italian systems. Finally, a number of other specific dummies related to the performance of Greece's trading partners were included in the relevant VARs; a description of the structural breaks which they account for is given in Appendix 4.A.

Tables 1 and 2 in Appendix 4.B summarise the properties of the preferred VARs residuals. The number of lags of the endogenous variables used and the variables contained in the D_t set for each VAR are given in the first lines of the tables.

First, single equation diagnostics are reported: The AR Lagrange multiplier (LM) statistic for residual serial independence across the mentioned lags of the autocorrelation function and the N statistic testing the null of normal skewness and kurtosis. Second, test statistics for vector autoregressive residuals $VecAR$ and vector normality $VecN$ which make use of auxiliary systems to assess serial correlation and non normality in the VAR as a whole are reported (for definition of the tests, see Doornik and Hendry (1994)). The diagnostics do not indicate serious autocorrelation and non-normality problems for the VARs residuals. In a couple of equations, the hypothesis of either non autocorrelation or nonnormality of the residuals was marginally rejected. In addition, (with respect to the non normality evidence) since the Johansen technique has been demonstrated to be robust to nonnormality by Cheung and Lai (1993b) and Gonzalo (1994), it was decided to continue the analysis without altering the VAR specification.

[8]While the shift dummies D832 and D861 which account also for the same effects turned out to be significant in a number of cases.

4.4.2 Cointegration Analysis.

The Long-Run structure of the VAR system A.

The cointegration space rank.

Model (2.1) as specified in Chapter 2 for a vector of the form:

$x_t = (e_{FR}, e_G, p^c_G, p^c_{GR}, p^c_{FR})$

with the required assumptions fulfilled as described previously provides the framework to perform the Johansen (Johansen (1988)) multivariate cointegration analysis. Inspection of the graphs of the series shown in Figure 4.1, indicate that the series have an approximate linear trend: therefore, model (2.1) is estimated without imposing the linear restriction of the constant to be included only in the cointegrating space. The outcomes of the maximum eigenvalue and trace statistics, the estimated eigenvectors and their loadings are reported in Table 4.2. Both likelihood ratio tests support the cointegrating space rank to be three, so we continue the analysis based on this assumption.

Finally, the robustness of the three cointegrating vectors is assessed by visual examination of the graphs of the recursive estimates of the eigenvalues, given that they can be used as a valuable check for parameter constancy (see Mizon (1995)). Their graphs given in Figure 4.2 indicate parameter constancy of the cointegrating relations.

Identification of the Long Run structure.

The three estimated unrestricted cointegrating vectors seem to imply theoretically interpretable relations. In the first one, the exchange rates e_G and e_{FR} have coefficients which are almost equal in size, and have opposite signs: the two variables together could be given the interpretation of the Deutsch mark/French frank exchange rate; in addition, the p^c_{GR} coefficient is quite small in size, while the signs of the coefficients of the variables p^c_G and p^c_{FR} are the ones that could support a PPP relation between Germany and France. The second cointegrating vector could imply a PPP relation between Greece and Germany with coefficients quite close to unity. Finally, the third vector cannot be given a theoretical interpretation at the present stage, even though the signs of the e_{FR}, p^c_{FR}, p^c_{GR} variables could support a PPP link between Greece and France. Nevertheless, formal testing for possible theoretical assumptions is needed.

Table 4.3 presents the outcomes of a number of likelihood ratio statistics testing for

Table 4.2: **Cointegration analysis of system (A).**

Testing for the Π rank.

Eigenvalues	H_0	Max. Eigen.	95%	Trace	95%
0.660	$r = 0$	76.75**	33.5	146.8**	68.5
0.360	$r \leq 1$	31.74*	27.1	70.07**	47.2
0.261	$r \leq 2$	21.49*	21.0	38.33**	29.7
0.195	$r \leq 3$	14.05	14.1	15.31	15.4
0.003	$r \leq 4$	0.267	3.8	0.267	3.8

Standardised eigenvectors.

e_{FR}	e_G	p^c_G	p^c_{GR}	p^c_{FR}
1	-0.924	0.064	-0.131	0.553
-0.478	1	1.438	-0.731	-0.283
-1.052	0.219	1	1.664	-3.211
-1.094	-0.697	2.405	1	-1.256
-2.380	-1.021	-13.63	4.036	1

Adjustment coefficients.

e_{FR}	-0.458	0.077	0.034	0.028	0.001
e_G	-0.064	0.041	0.009	0.066	0.001
p^c_G	-0.000	-0.007	0.014	-0.004	0.000
p^c_{GR}	-0.051	-0.022	-0.012	-0.011	0.004
p^c_{FR}	0.035	0.067	0.005	-0.002	0.005

alternative theoretical hypotheses concerning the specification of the three dimensional cointegrating space.

Hypotheses on a single cointegrating vector framework are initially considered. H_{A1} assumes a "weak" PPP relation between Greece and Germany for the specification of the second vector: it is accepted by the given data set. H_{A2} assumes "weak" PPP between Greece and France for the specification of the third vector: it is marginally rejected by the data. H_{A3} which expresses a cointegrating long run relation between the Deutsch mark/ French frank exchange rate and the German and French prices for the first vector does not form a constraint. "Strong" PPP between Germany and Greece implied by H_{A4} is accepted for the specification of the second vector. H_{A5} testing for "strong" PPP between Greece and France for the specification of the third vector is accepted. Finally, H_{A6}, which tests for "weak" PPP between Germany and France, even though accepted by the data set, does not provide a relation with the theoretically expected signs for the coefficients.

H_{A7} tests jointly for H_{A1}, H_{A2} and H_{A3}: it is accepted by the given data sample.

H_{A8} tests jointly for H_{A4}, H_{A2} and H_{A3}: it is accepted.

H_{A9} tests jointly for H_{A4}, H_{A2} and H_{A6}: it is strongly rejected by the data.

H_{A10} tests jointly for H_{A4}, H_{A5} and H_{A3}: even though it is accepted, it does not provide a theoretically reasonable relation for the specification of the first vector, as the obtained signs of the coefficients are not the expected ones.

H_{A11} tests jointly for H_{A4}, H_{A5} and H_{A6}: it is marginally rejected by the data.

As a consequence, the analysis was continued by assuming that the structure of the cointegrating space can be trustfully given by the specification implied by H_{A8}. The three cointegrating vectors are of the form (standard errors in parenthesis):

$$\beta_{A1} : (e_{FR} - e_G) + 0.787(0.033)p^c_{FR} - 0.852(0.080)p^c_G$$

$$\beta_{A2} : e_G + p^c_G - p^c_{GR}$$

$$\beta_{A3} : e_{FR} - 0.962(0.017)(p^c_{GR} - p^c_{FR})$$

β_{A2} expresses a "strong" PPP relation between Greece and Germany, while β_{A3} a "weak" PPP relation between Greece and France, with coefficients very close to unity. Finally, the first vector β_{A1} expresses a relation between the Deutsch mark/ French franc exchange rate and the French and German price indices, which is very close to a "weak" PPP relation between the two countries.

Table 4.3: **Testing system (A) for structural and exogeneity restrictions.**

Testing restrictions on single vector specification.

		e_{FR}	e_G	p^c_G	p^c_{GR}	p^c_{FR}	$\chi^2(dof)$	p-value
H_{A1}:	β_{A2}:	0	1	a	-a	0	3.414 (1)	0.064
H_{A2}:	β_{A3}:	1	0	0	-b	b	5.354 (1)*	0.020
H_{A3}:	β_{A1}:	1	-1		0		n a c	
H_{A4}:	β_{A2}:	0	1	1	-1	0	4.584 (2)	0.101
H_{A5}:	β_{A3}:	1	0	1	-1	0	4.652 (2)	0.097
H_{A6}:	β_{A1}:	1	-1	-c	0	c	3.364 (1)	0.066

Testing for joint restrictions.

		$\chi^2(dof)$	p-value
H_{A7}:	$H_{A1} \cap H_{A2} \cap H_{A3}$:	5.956 (2)	0.050
H_{A8}:	$H_{A4} \cap H_{A2} \cap H_{A3}$:	6.713 (3)	0.081
H_{A9}:	$H_{A4} \cap H_{A2} \cap H_{A6}$:	13.21 (4)**	0.010
H_{A10}:	$H_{A4} \cap H_{A5} \cap H_{A3}$:	7.942 (5)	0.159
H_{A11}:	$H_{A4} \cap H_{A5} \cap H_{A6}$:	14.77 (6)*	0.022

Testing for weak exogeneity restrictions.

		$\chi^2(dof)$	p-value
H_{A12}:	$H_{A8} \cap$ w. exog. of p^c_{GR} wrt β_{A2}:	9.532 (4)*	0.049
H_{A13}:	$H_{A8} \cap$ w. exog. of p^c_G wrt β_{A2}:	7.170 (4)	0.127
H_{A14}:	$H_{A8} \cap$ w. exog. of e_G wrt β_{A2}:	9.571 (4)*	0.048
H_{A15}:	$H_{A8} \cap$ w. exog. of p^c_{GR} wrt β_{A3}:	9.981 (4)*	0.040
H_{A16}:	$H_{A8} \cap$ w. exog. of p^c_{FR} wrt β_{A3}:	7.456 (4)	0.113
H_{A17}:	$H_{A8} \cap$ w. exog. of e_{FR} wrt β_{A3}:	7.098 (4)	0.130

Testing for reduction to bi-lateral systems.

H_{A18}:	$H_{A8} \cap$ w. ex. of p^c_{FR}, e_{FR} wrt β_{A2}:	21.91 (5)**	0.000
H_{A19}:	$H_{A8} \cap$ w. ex. of p^c_G, e_G wrt β_{A3}:	10.326 (5)	0.066
H_{A20}:	$H_{A8} \cap$ w. ex. of p^c_G wrt coint. space:	7.685 (6)	0.248

Weak exogeneity tests.

As shown in Johansen (1992), a necessary condition for Δx_{it} for some i, to be weakly exogenous for α and β is that $\alpha_i = 0$. In that case, Δx_{it} is weakly exogenous for α and β in the sense that the conditional distribution of Δx_t given Δx_{it} as well as the lagged values of x_t contains the parameters α and β, whereas the distribution of Δx_{it} given the lagged x_{it} does not contain the parameters α and β.

Weak exogeneity tests are reported in the lower part of Table 4.3. H_{A12}, H_{A13} and H_{A14} test for the necessary condition for weak exogeneity of p^c_{GR}, p^c_G and e_G respectively, with respect to the parameters of the long run Greek-German strong PPP: the condition is rejected for e_G and p^c_{GR}. The results imply that while p_G's are determined independently of the long run relationship that characterises the determination of the mark/drachma exchange rate, e_G and p_{GR} do not. H_{A15}, H_{A16} and H_{A17} test for weak exogeneity of p^c_{GR}, p^c_{FR} and e_{FR} respectively, with respect to the vector expressing the "weak" French-Greek PPP relationship: weak exogeneity of p^c_{GR} is only rejected.

Testing for reduction to bilateral systems.

Finally, a number of joint weak exogeneity assumptions that can be considered as necessary conditions for reduction to bi-lateral systems' cointegration analysis are performed. H_{A19} tests whether the German variables are weakly exogenous with respect to the Greek-French PPP relationship and is accepted by the data set. However, H_{A18} which tests whether the French variables are weakly exogenous with respect to the Greek-German PPP relationship is not accepted by the data set.

The results suggest that determination of the e_{FR} is highly influenced by the long run movement of the e_G rate. From a statistical point of view, they imply that while reduction to a bi-lateral German-Greek system is allowed, the cointegrating relationship of the variables p^c_{GR}, p^c_{FR} and e_{FR} necessitates modelling of the joint distribution of the complete system of the five variables. Finally H_{A20} which tests for weak exogeneity of the German prices for the whole cointegration space is accepted by the given data set.

The data support PPP relationships between Greece and Germany and Greece and France. Between the two relationships, though, the Greek-German PPP seems to be the most robust one (implying that p^c_{GR} and e_G move in a way to keep constant the competitiveness between the two countries). The Greek-French PPP seems to be a "secondary" relationship explained probably by the EMS performance of the French currency (the fact that the French franc was linked to the mark for most of the period examined): the necessary condition for e_{FR} to be weakly exogenous with respect to the Greek-German PPP parameters is rejected; in addition, the Greek-French PPP is shown to be obtained only by analysis of the joint distribution of the series.

The Long-Run structure of the VAR system B.

Determination of the cointegration space rank.

Application of the multivarate cointegration technique on the Greek-German-Italian system as specified in the previous subsection 4.4.1 gave us the results presented in Table 4.4. The estimation was done again without imposing the restriction of the constant to lie in the cointegrating space, given that the series have a linear trend. Both likelihood ratio tests give evidence of two cointegrating relations. The two recursively estimated eigenvalues shown in Figure 4.3 are constant. Interpretation of the two long run relations is again not straightforward.

Identification of the long-run structure.

A number of theoretical hypotheses concerning the specification of the cointegrating space were tested formally. The outcomes of the likelihood ratio tests are given in the upper part of Table 4.5.

First, hypotheses on a single vector framework were tested. Hypothesis H_{B1} tests for "weak" PPP between Greece and Germany and it is accepted by the given data set. Hypothesis H_{B2} tests for unity coefficient for the drachma/lira rate and equal and opposite coefficients for the Greek and Italian prices, restrictions which could imply "weak" PPP between the two countries. Even though it is accepted by the given data set, the relation obtained is of the form $e_{IT} = 19.61(p^c_{GR}/p^c_{IT})$ which is not a plausible "weak" PPP relation. H_{B3} tests for cointegration between the lira/mark rate and the German and Italian price indices (if accepted, it would motivate further investigation for "weak" PPP between Germany and Italy): it is strongly rejected by the data. H_{B4}, which tests for PPP between Greece and a weighted average of the German and Italian price indices expressed in drachma terms, is also rejected by the given set. H_{B5} tests for cointegration

Table 4.4: **Cointegration analysis of system (B).**

Testing for the Π rank.					
Eigenvalues	H_0	Max. Eigen.	95%	Trace	95%
0.673	r = 0	68.28**	33.5	124.6**	68.5
0.404	r ≤ 1	31.62*	27.1	56.27**	47.2
0.216	r ≤ 2	14.87	21.0	24.85	29.7
0.147	r ≤ 3	9.703	14.1	9.783	15.4
0.001	r ≤ 4	0.080	3.8	0.080	3.8
Standardised eigenvectors.					
e_{IT}	p^c_{GR}	e_G	p^c_G	p^c_{IT}	
1	-4.946	2.400	7.106	2.171	
-1.350	1	0.315	-1.771	-0.622	
-3.509	2.856	1	-0.579	-2.776	
0.464	-0.256	-0.280	1	0.054	
1.016	0.175	-1.156	-1.824	1	
Adjustment coefficients.					
e_{IT}	0.033	0.181	0.055	0.278	-0.0112
p^c_{GR}	-0.019	-0.017	-0.022	-0.259	-0.0114
e_G	0.022	0.210	0.034	0.413	-0.0134
p^c_G	-0.022	-0.005	0.001	-0.030	-0.0001
p^c_{IT}	-0.009	0.076	-0.010	-0.012	0.0004

between the price indices of the three countries and is accepted by the data. Finally, both H_{B6} and H_{B7}, which test for strong PPP between Greece and Germany, and Greece and Italy respectively, are strongly rejected.

Secondly, a few hypotheses concerning the structure of the two-dimensional cointegrating space were tested. H_{B8} tests jointly for H_{B1} and H_{B2}; H_{B9} tests jointly for H_{B1} and H_{B3}; H_{B10} tests jointly for H_{B1} and H_{B4}; H_{B11} tests jointly for H_{B1} and H_{B5}; finally, H_{B12} tests jointly for H_{B2} and H_{B5}; all but H_{B11} were strongly rejected by the given data set. As a consequence, it was decided to continue the analysis assuming that H_{B11} characterises the given data set. The two cointegrating vectors take the form (standard errors in parentheses):

$$\beta_{B1} : e_G - 0.752(0.091)(p^c_{GR} - p^c_G)$$

$$\beta_{B2} : p^c_{IT} + 2.811(0.290)p^c_G - 1.728(0.165)p^c_{GR}$$

Table 4.5: **Testing system (B) for structural and exogeneity restrictions.**

Testing restrictions on single vectors specification.

		e_{IT}	p^c_G	e_G	p^c_{GR}	p^c_{IT}	$\chi^2(dof)$	p-value
H_{B1}:	β_{B1}:	0	a	1	-a	0	5.948 (2)	0.051
H_{B2}:	β_{B1}:	1	0	0	-b	b	3.903 (2)	0.142
H_{B3}:	β_{B2}:	1		-1	0		12.21 (1)**	0.000
H_{B4}:	β_{B2}:	c	d	d	1	c	4.820 (1)*	0.028
H_{B5}:	β_{B2}:	0	1	0	a	b	3.952 (1)	0.052
H_{B6}:	β_{B2}:	0	1	1	-1	0	18.66 (3)**	0.000
H_{B7}:	β_{B1}:	1	0	0	-1	1	18.12 (3)**	0.000

Testing for joint restrictions.

		$\chi^2(dof)$	p-value
H_{B8}:	$H_{B1} \cap H_{B2}$:	14.91 (3)**	0.001
H_{B9}:	$H_{B1} \cap H_{B3}$:	14.24 (3)**	0.002
H_{B10}:	$H_{B1} \cap H_{B4}$:	23.53 (3)**	0.000
H_{B11}:	$H_{B1} \cap H_{B5}$:	7.001 (3)	0.071
H_{B12}:	$H_{B2} \cap H_{B5}$:	13.80 (3)**	0.003

Testing for weak exogeneity restrictions.

		$\chi^2(dof)$	p-value
H_{B13}:	$H_{B11} \cap$ weak exogeneity of p^c_G wrt β_{B1}:	12.021 (4)*	0.017
H_{B14}:	$H_{B11} \cap$ weak exogeneity of e_G wrt β_{B1}:	13.872 (4)**	0.007
H_{B15}:	$H_{B11} \cap$ weak exogeneity of p^c_{GR} wrt β_{B1}:	10.286 (4)*	0.035

In the accepted structure, β_{B1} expresses "weak" Greek-German PPP and β_{B2} a cointegration relationship among the price indices.

Tests for weak exogeneity.

The outcome of the weak exogeneity testing assuming the long run structure as specified by H_{B11}, is given at the lower part of the Table 5.4. H_{B13}, H_{B15} and H_{B14} test for a necessary condition for weak exogeneity of the German prices, the Greek prices and the drachma/mark exchange rate respectively, with respect to the parameters of the first cointegrating vector: they are all rejected by the given data set (for the cases of p_{GR} and p_G at the margin).

Concluding, we would say that there is evidence for "weak" PPP between Greece and Germany, while there is no evidence for "weak" PPP between neither Greece and Italy nor Germany and Italy[9], results which probably reflect the EMS performance of the countries. The estimated magnitude of the coefficients of the Greek-German weak PPP relation are, though, lower than the ones obtained in the system (A) and "strong" PPP is rejected. However, it should be remembered that in the present stage we identified a long run relationship between p_{GR}, p_G and e_G, using a shorter sample period, than in the system (A) due to lack of Italian lira/drachma exchange rate series data.

The Long-Run structure of the VAR system C.

The cointegration space rank.

Model (2.1) as specified in Chapter 2 for a vector of the form:

$x_t = (e_{FR}, e_G, p^w_G, p^w_{GR}, p^w_{FR})$ provides the framework to perform the multivariate cointegration analysis. The outcomes of the maximum eigenvalue and trace statistics, the estimated eigenvectors and their loadings are reported in Table 4.6. Both two likelihood ratio tests support the cointegrating space rank to be three, so we continue the analysis based on this assumption. In addition, visual examination of the graph of the three re-

[9] The fact that there is evidence for a cointegrating relation which is very close to "weak" PPP between France and Germany, while such a relation cannot be supported between Italy and Germany is in accordance with the results obtained by Chen (1995), where he tests for PPP between EMS countries by testing for stationarity of a number of real exchange rates using producer price indices for the period 1974(4) -1990(12).

cursively calculated eigenvalues given in Figure 4.4 provides evidence for the parameter constancy of the cointegrating relations.

Table 4.6: **Cointegration analysis of system (C).**

Testing for the Π rank.					
Eigenvalues	H_0	Max. Eigen.	95%	Trace	95%
0.736	r = 0	68.03**	33.5	148.8**	68.5
0.533	r ≤ 1	38.87**	27.1	80.79**	47.2
0.404	r ≤ 2	26.40**	21.0	41.91**	29.7
0.239	r ≤ 3	13.98	14.1	15.30	15.4
0.029	r ≤ 4	1.532	3.8	1.532	3.8
Standardised eigenvectors.					
e_G	e_{FR}	p_G^w	p_{GR}^w	p_{FR}^w	
1	1.201	4.585	-2.620	-0.090	
-1.321	1	-1.427	0.495	0.611	
0.322	0.012	1	-0.391	-0.148	
-0.499	-0.434	-2.485	1	-0.013	
-1.070	0.037	-3.938	1.107	1	
Adjustment coefficients.					
e_G	0.565	0.240	-2.023	0.178	0.009
e_{FR}	0.529	-0.202	-2.716	0.224	0.021
p_G^w	-0.097	0.003	-0.060	0.032	0.007
p_{GR}^w	0.153	-0.053	-0.298	-0.038	0.051
p_{FR}^w	-0.064	-0.146	0.913	0.160	0.008

Identification of the Long Run structure.

Even though some of the unconstrained eigenvectors seem to imply reasonable relations, formal testing is performed. Table 4.7 presents the outcomes of a number of likelihood ratio statistics testing for alternative theoretical assumptions concerning the specification of the three cointegrating vectors.

Assumptions on a single cointegrating vector framework are followed by assumptions concerning the joint structure of the cointegrating space. Main assumptions tested are "weak" PPP between Greece and Germany, Greece and France, Germany and France. The assumptions implied by H_{C7} are finally shown to specify the structure of the three-dimensional cointegration space.

Table 4.7: **Testing system (C) for structural and exogeneity restrictions.**

Testing restrictions on single vectors specification.

		e_{FR}	e_G	p^w_G	p^w_{GR}	p^w_{FR}	$\chi^2(dof)$	p-value
H_{C1}:	β_{C1}:	0	1	a	-a	0	4.700 (1)*	0.030
H_{C2}:	β_{C3}:	1	0	0	-b	b	5.205 (1)*	0.022
H_{C3}:	β_{C2}:	1			0		n a c	
H_{C4}:	β_{C2}:	1	-1	-c	0	c	5.192 (1)*	0.022

Testing for joint restrictions.

		$\chi^2(dof)$	p-value
H_{C5}:	$H_{C1} \cap H_{C4}$:	12.211 (2)**	0.002
H_{C6}:	$H_{C2} \cap H_{C4}$:	11.452 (2)**	0.003
H_{C7}:	$H_{C1} \cap H_{C2} \cap H_{C3}$:	5.208 (2)	0.074
H_{C8}:	$H_{C1} \cap H_{C2} \cap H_{C4}$:	37.353 (3)**	0.000

Testing for weak exogeneity restrictions.

		$\chi^2(dof)$	p-value
H_{C9}:	$H_{C7} \cap$ w. exogeneity of p^w_{GR} wrt β_{C1}:	10.382 (4)*	0.034
H_{C11}:	$H_{C7} \cap$ w. exogeneity of p^w_G wrt β_{C1}:	9.485 (4)	0.050
H_{C12}:	$H_{C7} \cap$ w. exogeneity of e_G wrt β_{C1}:	14.50 (4)**	0.005
H_{C13}:	$H_{C7} \cap$ w. exogeneity of p^w_{GR} wrt β_{C3}:	14.68 (4)**	0.005
H_{C14}:	$H_{C7} \cap$ w. exogeneity of p^w_{FR} wrt β_{C3}:	9.467 (4)	0.052
H_{C15}:	$H_{C7} \cap$ w. exogeneity of e_{FR} wrt β_{C3}:	32.19 (4)**	0.000

Testing for reduction to bi-lateral systems.

H_{C16}:	$H_{C7} \cap$ w. ex. of p^w_{FR}, e_{FR} wrt β_{C1}:	24.45 (8)**	0.001
H_{C17}:	$H_{C7} \cap$ w. ex. of p^w_G, e_G wrt β_{C3}:	16.11 (8)*	0.043

The three cointegrating vectors are of the form:

$\beta_{C1} : e_G - 0.871(0.032)(p^w_{GR} - p^w_G)$

$\beta_{C2} : e_{FR} - 0.836(0.089)e_G + 0.588(0.078)p^w_{FR} - 0.239(0.067)p^w_G$

$\beta_{C3} : e_{FR} - 0.651(0.027)(p^w_{GR} - p^w_{FR})$

β_{C1} expresses a "weak" PPP relation between Greece and Germany, while β_{C3} a "weak" PPP relation between Greece and France. Finally, β_{C2} expresses a relation between the Deutsch mark/ French frank exchange rate and the French and German price indices, which could imply a "weak" PPP relation between the two countries. The results reinforce the findings obtained in the system (A) analysis.

Weak exogeneity tests.

Weak exogeneity tests are reported in the lower part of Table 4.7. Consistent with the system (A) results, the necessary condition for weak exogeneity with respect to the Greek-German PPP relation is not rejected just for the case of p_G. Weak exogeneity of the variables with respect to the "weak" French-Greek PPP parameters is not rejected just for the case of p^c_{FR}.

Testing for reduction to bi-lateral systems.

Finally, testing for reduction to bi-lateral systems conditional on changes on the weakly exogenous variables demonstrates that, even though this is feasible for the Greek-German system (in the margin though), this is not so for the Greek-French relationship.

The Long-Run structure of the VAR system D.

The cointegration space rank.

Cointegration analysis is performed on a wellspecified VAR for the vector of the form: $x_t = (e_G, e_{FR}, p^w_{GR}, p^w_G, p^w_{FR})$. The outcomes of the maximum eigenvalue and trace statistics, the estimated eigenvectors and their loadings are given in Table 4.8. There is evidence of two cointegrating relationship as supported by the trace likelihood ratio statistic, which are also relatively constant as indicated by the recursively calculated eigenvalues shown in Figure 4.5.

Table 4.8: **Cointegration analysis of system (D).**

Testing for the Π rank.					
Eigenvalues	H_0	Max. Eigen.	95%	Trace	95%
0.5491	r = 0	48.59**	33.5	112.5**	68.5
0.4801	r ≤ 1	39.90**	27.1	63.87**	47.2
0.2496	r ≤ 2	17.52	21.0	23.96	29.7
0.0957	r ≤ 3	6.143	14.1	6.443	15.4
0.0049	r ≤ 4	0.300	3.8	0.300	3.8
Standardised eigenvectors.					
e_G	e_{IT}	p^w_G	p^w_{GR}	p^w_{IT}	
1	-0.236	3.981	-0.644	-1.379	
8.400	1	42.37	-8.049	-11.28	
-0.223	0.169	1	0.226	-0.561	
-0.108	-0.864	-1.933	1	-0.251	
-0.222	0.194	-1.406	-0.219	1	
Adjustment coefficients.					
e_G	-0.022	0.015	0.581	0.021	0.034
e_{IT}	-0.019	0.029	0.054	0.065	0.081
p^w_G	-0.005	-0.013	-0.040	0.006	0.008
p^w_{GR}	0.117	-0.002	-0.038	-0.136	0.038
p^w_{IT}	0.246	-0.019	-0.026	0.012	0.014

Identification of the Long Run structure.

Hypothesis testing results concerning the structure of the two cointegrating vectors are reported in the upper part of Table 4.9. H_{D8} assumes jointly a "weak" PPP relation between Greece and Germany for β_{D1} and a non-specified cointegrating relationship between e_G, e^w_{IT}, p^w_G and p^w_{IT} for β_{D2}. It is accepted with the highest *p-value* by the given data set and, therefore, the analysis is continued based on this specification.

Weak exogeneity tests.

Weak exogeneity tests are reported in the lower part of Table 4.9: H_{D9}, H_{D10}, H_{D11}, test for the necessary condition for weak exogeneity of e_G, p^w_{GR}, p^w_G respectively, with respect to the parameters of the "weak" Greek-German PPP. Consistent with the analysis of the previous systems, weak exogeneity is not rejected just for the case of p^w_G.

Table 4.9: **Testing system (D) for structural and exogeneity restrictions.**

Testing for structural restrictions.

		e_G	e_{IT}	p^w_{GR}	p^w_G	p_{IT}	$\chi^2(dof)$	p-value
H_{D1}:	β_{D1}:	1	0	-a	a	0	3.422 (2)	0.180
H_{D2}:	β_{D1}:	0	1	-b	0	b	12.09 (2)**	0.002
H_{D3}:	β_{D2}:	0	0	1	-c	-d	2.546 (1)	0.110
H_{D4}:	β_{D2}:	1	-1	0	a	b	0.012 (1)	0.912
H_{D5}:	β_{D2}:	1	a	0	b	c	n a c	
H_{D6}:	β_{D1}:	1	0	-1	1	0	29.69 (3)**	0.000

Testing for joint restrictions.

		$\chi^2(dof)$	p-value
H_{D7}:	$H_{D1} \cap H_{D3}$:	6.616 (3)	0.085
H_{D8}:	$H_{D1} \cap H_{D5}$:	2.972 (3)	0.396

Testing for weak exogeneity restrictions.

		$\chi^2(dof)$	p-value
H_{D9}:	$H_{D1} \cap$ w. exogeneity of e_G wrt β_{D1}:	7.396 (2)*	0.024
H_{D10}:	$H_{D1} \cap$ w. exogeneity of p^w_{GR} wrt β_{D1}:	7.716 (2)*	0.021
H_{D11}:	$H_{D1} \cap$ w. exogeneity of p^w_G wrt β_{D1}:	2.957 (2)	0.227

4.4.3 Interpretation of the results.

The results obtained in the first stage of testing for PPP in a multilateral framework are indicative of the way Greek exchange rates and prices were determined during the period examined. First of all, there is evidence for cointegrating relationships of the form $\gamma_1 e - \gamma_2 p + \gamma_3 p_f$ related with the long run behaviour of all three exchange rates e_G, e_{FR} and e_{IT} in most of the systems. This is consistent with these European countries being the three main trading partners of Greece with special trading agreements, especially after Greece became an EU member in January 1981. Moreover, from March 1979, the EMS mechanism existed, according to which the participating countries had to maintain the market exchange rates of their currencies against the ECU (essentially the Deutsch mark) within particular bands, for mainly antiinflationary reasons[10].

However, joint testing of the hypotheses revealed that:

a) The strongest relationship is the one implying "weak" PPP between Greece and Germany. Such a relationship is supported by all three-country systems using the two alternative price indices[11]. The result is easily interpreted given that Germany has been the largest trading partner of Greece for the period under consideration, with the Deutsch Mark being the most powerful European currency. In the relationship, Greek prices and the e_G are the endogenous variables with respect to the long run parameters. The status of the variables indicates that, during the period, the exchange rate moved in a way to keep Greece's competitiveness against Germany relatively constant, while influencing Greek price formation. The strength of the relationship is also verified by the fact that it can be identified in reduced two-country systems as shown by relevant tests. Finally, as indicated by the recursively estimated eigenvalues, the relationship has constant parameters.

b) A constant parameter "weak" PPP is also accepted between Greece and France in the two relevant systems, in which, though, there is also evidence for a cointegrating long run relationship very close to "weak" PPP between Germany and France. In addition, in both systems (systems (A) and (C)), the French variables are not weakly exogenous with respect to the parameters of the estimated weak Greek-German PPP; in other words, the Greek-French PPP is identified only when analysis of the joint distribution of the variables

[10]Greece did not participate in the EMS, even though the drachma was added to the ECU basket in September 1984.

[11]The "weak" PPP hypothesis is accepted obtaining different coefficient values in different systems, and in system (A) even "strong" PPP is accepted, but this can be due to the different data samples.

is performed. The results indicate that the "weak" PPP between Greece and France is a "secondary" relation caused by the fact that both countries tried to keep relatively constant competitiveness against Germany, and that the franc was strongly linked to the Deutsch mark.

c) There is no evidence for "weak" PPP between Greece and Italy, a result which at first seems strange, given that Italy is more important a trading partner of Greece than France. The result, however, reinforces the interpretation given above for the French case. This interpretation seems reasonable if, in addition, we take into account that there is no evidence for weak PPP between Germany and Italy[12], and the fact that the French franc was for the whole EMS period participating in the ERM mechanism within lower bands (2.25% on each side of the central parity against ECU) than the Italian currency (6% on each side of the central parity).

The multilateral analysis gave evidence for two weak PPP relationships, revealing at the same time relationships between the variables of the system which were out of the initial scope of the analysis. In addition, it indicated that testing for PPP in a bilateral framework would not produce similar results in any but the Greek-German case. Nevertheless, it was decided to continue the analysis in bi-lateral systems for the sake of curiosity.

[12]Finding consistent with the work by Chen (1995).

4.5 Testing for PPP in a bilateral framework.

4.5.1 Specification of the VAR models.

In a second stage, PPP is tested between Greece and each of its three major trading partners, in a two country system framework. To this end, six three-dimensional VAR systems for the three exchange rates using the two alternative price indices which analyse vector processes of the form $z_t = (e, p, p_f)$ are formulated. The estimated VARs allow for a set of conditioning variables, D_t: a constant and seasonal dummies for all VARs and different impulse dummy variables, to account for different regime shifts that characterise the performance of the different economies. Once the VARs are shown to be congruent, the Johansen technique estimates the number of the stationary linear combinations of the variables of the form:

$$\gamma_1 e + \gamma_2 p + \gamma_3 p_f \tag{4.3}$$

In the case that there is evidence of one stationary relationship (one cointegrating vector) among the variables, the theoretical restrictions of interest can be assessed. The first theoretical assumption H_1 to be tested for, is that expressed by the "weak" PPP version allowing for transportation costs/ measurement errors as formalised in (4.2). This implies jointly the restrictions:

$$H_1 : \gamma_1 = 1, -\gamma_2 = \gamma_3 (= \gamma) \tag{4.4}$$

Finally, and in the case that the assumption H_1 has not been rejected, the "strong" PPP version as expressed by (4.1) can be assessed by testing for H_2 which implies jointly the restrictions:

$$H_2 : \gamma_1 = 1, \gamma_2 = -1, \gamma_3 = 1. \tag{4.5}$$

All six VARs were initially estimated by applying multivariate least squares using five lags of the variables (k=5). First of all, none of the initial 5th order systems presented autocorrelated residuals. However, the final number of lags of the endogenous variables used for each estimated VAR was specified by sequential testing of the initial systems against specifications of lag length k-1 by means of the likelihood test, until the shorter

Table 4.10: **Bilateral systems' eigenvalues.**

VARs using p^w's.			
$z_t = (e, p^w_f, p^w_{GR})$			
Germany	0.261	0.122	0.016
Italy	0.481	0.167	0.009
France	0.486	0.138	0.006

VARs using p^c's			
$z_t = (e, p^c_f, p^c_{GR})$			
Germany	0.230	0.068	0.000
Italy	0.296	0.049	0.016
France	0.257	0.163	0.012

lag length k-1 was rejected against some value of k, provided there were non autocorrelated residuals in the estimated reductions. Therefore, the number of lags used finally for each VAR system was: five lags for the France using p^c's VAR and the Germany using p^w's VAR; three lags for the German VAR using p^c's; four lags for the rest of the systems. Normality problems indicated a number of dummies to be included in D_t to account for specific regime shifts that characterise the examined period, shown (also) by Chow tests for parameter constancy. The events that the dummies account for are described in Appendix 4.A.

Tables 3 and 4 in Appendix 4.B summarise the properties of the final systems' residuals obtained by the VARs using p^w's, and the VARs using p^c's, respectively. The number of lags of the variables used and the variables contained in the D_t set for each system are mentioned in the first lines of the tables. Single equation diagnostics are first reported, followed by the diagnostics for the VARs residuals. They do not indicate serious autocorrelation, and non-normality problems for any of the cases.

4.5.2 The long run structure. Testing for PPP as a cointegrating relationship.

The cointegration rank.

Model (2.1) for a vector of the form $z_t = (e, p, p_f)$ is the starting point of the cointegration

Table 4.11: **Two-country VARs Cointegration Analysis.**

	Maxim.	eigenv.		Trace		
	$r = 0$	$r \leq 1$	$r \leq 2$	$r = 0$	$r \leq 1$	$r \leq 2$
95%	21.0	14.1	3.8	29.7	15.4	3.8
VARs using p^w's						
Germany	21.49*	9.25	1.20	31.95*	10.46	1.20
Italy	31.49**	8.82	0.04	40.36**	8.870	0.04
France	34.02**	7.57	0.31	41.91**	7.880	0.31
VARs using p^c's						
Germany	21.14*	5.25	0.02	26.82	5.280	0.02
Italy	21.83*	3.11	1.00	25.95	4.110	1.00
France	21.11*	12.7	0.91	34.71*	13.61	0.91

analysis. Given that the exchange rate and price series have an approximate linear trend, evidence consistent with the assumption of constant nominal price growth, the analysis is again continued without imposing the constant to lie in the cointegrating space in all VARs. Table 4.10 presents the obtained eigenvalues while Table 4.11 reports the outcomes of the two likelihood ratio tests testing for the cointegration rank r of the matrix Π for the six systems.

There is evidence of one cointegrating relationship for all systems. Table 4.12 reports the unrestricted form of the eigenvectors accepted to express stationary relationships, normalized with the value corresponding to the nominal exchange rate and the adjustment coefficients for each accepted eigenvector. The eigenvectors of all but the French system using p^w's emerge as having coefficients with the theoretically expected sign and magnitudes which could support a PPP relation.

Testing for PPP as a structural restriction.

The next step is to test for the restrictions implied by the "weak" PPP version as expressed by the hypothesis H_1, by applying the likelihood ratio test given by (2.9). The results are reported in the first column of table 4.13. The restrictions that H_1 implies are accepted for the following VAR systems:

Table 4.12: **Two-country VARs cointegrating vectors and adjustment coefficients.**

	Coint. Vector				Adjust. Coeff.		
VARs using p^w's.							
	e	p^w_f	p^w_{GR}	const	e	p^w_f	p^w_{GR}
Germany	1	1.830	-1.091		-0.07	0.22	-0.84
Italy	1	1.880	-1.560		0.02	0.05	-0.00
France	1	-0.602	-0.671		-0.16	0.00	0.00
VARs using p^c's							
	e	p^c_f	p^c_{GR}		e	p^c_f	p^c_{GR}
Germany	1	2.098	-1.136		-0.12	-0.02	0.02
Italy	1	3.362	-1.143		-0.00	0.06	0.01
France	1	0.737	-0.840		-0.20	0.02	0.01

Table 4.13: **Tests for structural restrictions on the cointegrating vectors of the two-country systems.**

Hypothesis Test Statistic	H_1 [1] $\chi^2(1)$	Restricted coint. vector	H_2 [2] $\chi^2(2)$
VARs using p^w's			
		(e, p^w_f, p^w_{GR})	
Germany	2.76	(1, 0.857, -0.857)	10.945**
Italy	23.42**		
France	19.15**		
VARs using p^c's			
		(e, p^c_f, p^c_{GR})	
Germany	5.97*	(1, 0.924, -0.924)	15.79**
Italy	8.71**		
France	0.73	(1, 0.867, -0.867)	6.142*

[1] H_1 tests for "weak" PPP

[2] H_2 tests for "strong" PPP

Both VARs modelling the determination of the Deutsch mark/ drachma exchange rate e_G using p^w's and p^c's; the restriction is, though, just marginally accepted with a p: 0.0145 (rejected at a 5% but not at a 1% level of significance) for the system using p^c's. The accepted relationships are of the form (with standard errors given in parentheses):

$$e_G = 0.857(0.037)(p^w_{GR} - p^w_G)$$

$$e_G = 0.924(0.021)(p^c_{GR} - p^c_G)$$

The system modelling the French franc exchange rate using p^c's, with accepted "weak" PPP relationship of the form:

$$e_{FR} = 0.867(0.039)(p^c_{GR} - p^c_{FR})$$

For all accepted cointegrating relationships the magnitude of γ is close to unity, which evidence implies that they possibly express PPP relationships. For the rest of the VAR systems the "weak" PPP restriction of equal coefficients and opposite signs for the price variables was strongly rejected.

The next step is to test for the restrictions of the "strong" PPP implied by hypothesis H_2, in the cases where the proportionality assumption is not rejected. The results are given in the third column of Table 4.13. The restrictions were rejected for all cases.

Finally, the robustness of the three obtained weak PPP relations is assessed by visual examination of the graphs of the recursive estimates of the eigenvalues of the three systems. They are presented in figure 4.6. They are constant for all but the French system thus casting doubt on the validity of its results. The Greek-German using both indices PPP relations are, therefore, the two most robust relations that come out of the bi-lateral analysis.

Weak exogeneity tests.

The weak exogeneity status of the variables with respect to the long run parameters of interest is tested for the cases where the "weak" PPP hypothesis is not rejected by the given data sets. The results are reported in table 4.14.

In the Greek-German system using p^c's, weak exogeneity for the exchange rate variable is rejected, while weak exogeneity for Greek prices is accepted (even though marginally), in contrast to the multilateral systems (A) and (B). Rejection of the weak exogeneity for the e_{FR} with respect to the Greek-French PPP parameters is also in contrast with the

Table 4.14: **Testing for weak exogeneity restrictions.**

Hypothesis	$\chi^2(dof)$	p-value
a. Testing the Greek - German p^w system		
H_{a1}: w. exogeneity for p^w_G:	6.365 (3)	0.095
H_{a2}: w. exogeneity for p^w_{GR}:	9.908* (3)	0.019
H_{a3}: w. exogeneity for e_G:	9.186* (3)	0.026
b. Testing the Greek - German p^c system		
H_{b1}: w. exogeneity for p^c_G:	7.437 (3)	0.059
H_{b2}: w. exogeneity for p^c_{GR}:	7.508 (3)	0.057
H_{b3}: w. exogeneity for e_G:	15.054** (3)	0.001
c. Testing the Greek - French p^c system		
H_{c1}: w. exogeneity for p^c_{FR}:	4.452 (3)	0.216
H_{c2}: w. exogeneity for p^c_{GR}:	7.884 (3)*	0.048
H_{c3}: w. exogeneity for e_{FR}:	17.522 (3)**	0.000

result obtained in (A); however, the result of the particular bi-lateral system is not of great importance given that the cointegrating vector does not seem to have constant parameters. Finally, in the Greek-German system using p^w's the assumptions for weak exogeneity for the Greek prices and the exchange rate are rejected, which result is consistent with both multilateral systems (C) and (D).

4.5.3 Interpretation of the results.

The findings obtained at this second stage verified the implications made based on the results obtained in the multi-lateral analysis: The "weak" PPP doctrine is accepted for both VARs modelling Greek-German trade interrelations. "Weak" Greek-French PPP is accepted in the system using p^c's. However, given that the p^c's cointegrating relationship does not have constant parameters as indicated by the recursive eigenvalues graph and that "weak" PPP is not accepted in the p^w's system, the result is quite inconclusive. "Weak" PPP is not accepted for the drachma/ Italian systems using both price indices. Finally, the "strong" PPP version is rejected for all cases tested. Summarising, even though there is evidence for a cointegrating relation between prices and exchange rates between Greece and its three main trading partners, the robust "weak" PPP relationships have been identified in the Greek-German systems using both price indices.

The bi-lateral analysis findings confirm mainly the ones obtained in the multi-lateral one, leaving though a number of questions (Greek-French PPP, exogeneity status of variables in the two Greek-German PPP relations) unanswered. In addition, no possible explanations for the behaviour of the series are implied.

4.6 Conclusions

In the present paper, the PPP hypothesis between Greece and its three major trading partners was tested using the Johansen multivariate cointegration technique, which tests for cointegration allowing for a distinction between the long run relations and short run dynamics and for adjustment for structural breaks. A basic aim of the work was also to investigate the implications that problems related with the empirical PPP literature have for the analysis. Therefore, the PPP hypothesis was tested in a multi-lateral and a bi-lateral framework, using two alternative price indices and without imposing *a priori* any endogenous/exogenous status for the variables.

The basic theoretical results are:

There is evidence for long-run weak PPP between Greece and Germany and between Greece and France. PPP with Germany is supported by all systems (multi-lateral as well as bi-lateral), using the two alternative indices and can, therefore, be considered as a robust relationship. However, PPP with France can be seen as a "secondary" relationship supported mainly by the multi-lateral systems in which PPP between Germany and France is also indicated. The results imply that Greece tried to preserve constant competitiveness mainly with Germany which is its most important trade partner with a currency that dominated the European countries (which also account for almost the two thirds of the Greek trade). On the other hand, the Greek-French PPP can be seen as a result of the fact that France tried also to preserve constant competitiveness with Germany, and that the French franc was strongly linked to the Deutsch mark through the ERM mechanism for most of the period.

With respect to the empirical PPP studies problems:

i) The multilateral analysis gave evidence for two weak PPP relationships with constant parameters. At the same time, it revealed relationships between the variables of the system which were beyond the initial scope of the analysis, which helped interpretation of the main results. In addition, it indicated that there is no scope for testing for PPP in a bilateral framework in any but the Greek-German case. Bi-lateral analysis mainly confirmed the multi-lateral findings, but provided also contradictory results. Therefore, analysis based only in bi-lateral systems, would have been rather inconclusive.

ii) Both price indices gave similar results with respect to the identification of the main long-run relationships (especially in (and probably due to) the multilateral analysis); there were minor differences between the p^c's and the p^w's systems with respect to the determination of the exogeneity status of the variables, probably indicating differences in measurement, or the industry structure of the different economies.

iii) Finally, the exogeneity status of the exchange rates and the Greek prices with respect to the PPP parameters was rejected in most cases for which PPP was identified. Both results make sense for the case of the Greek small open economy.

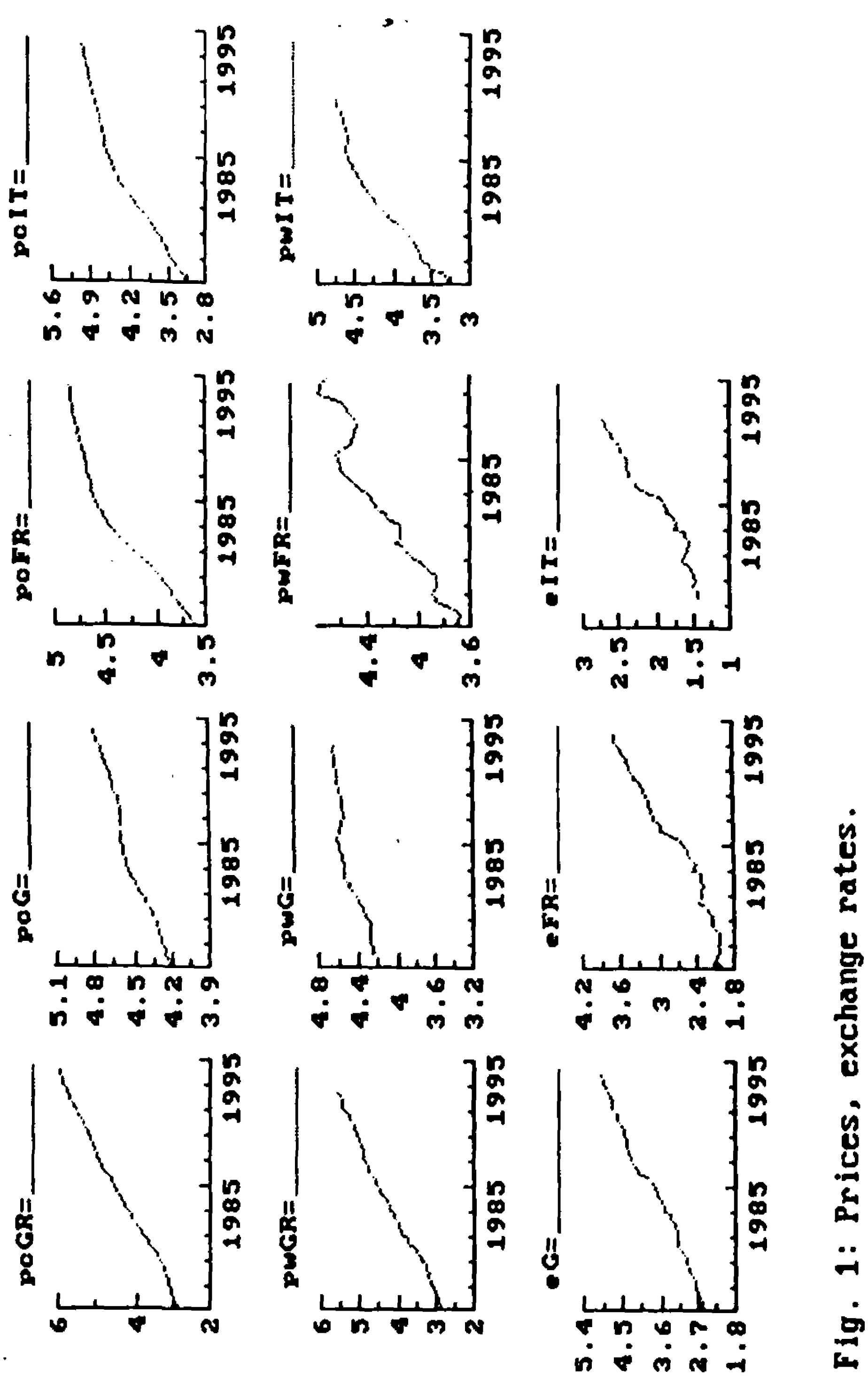

Figure 4.1: The series

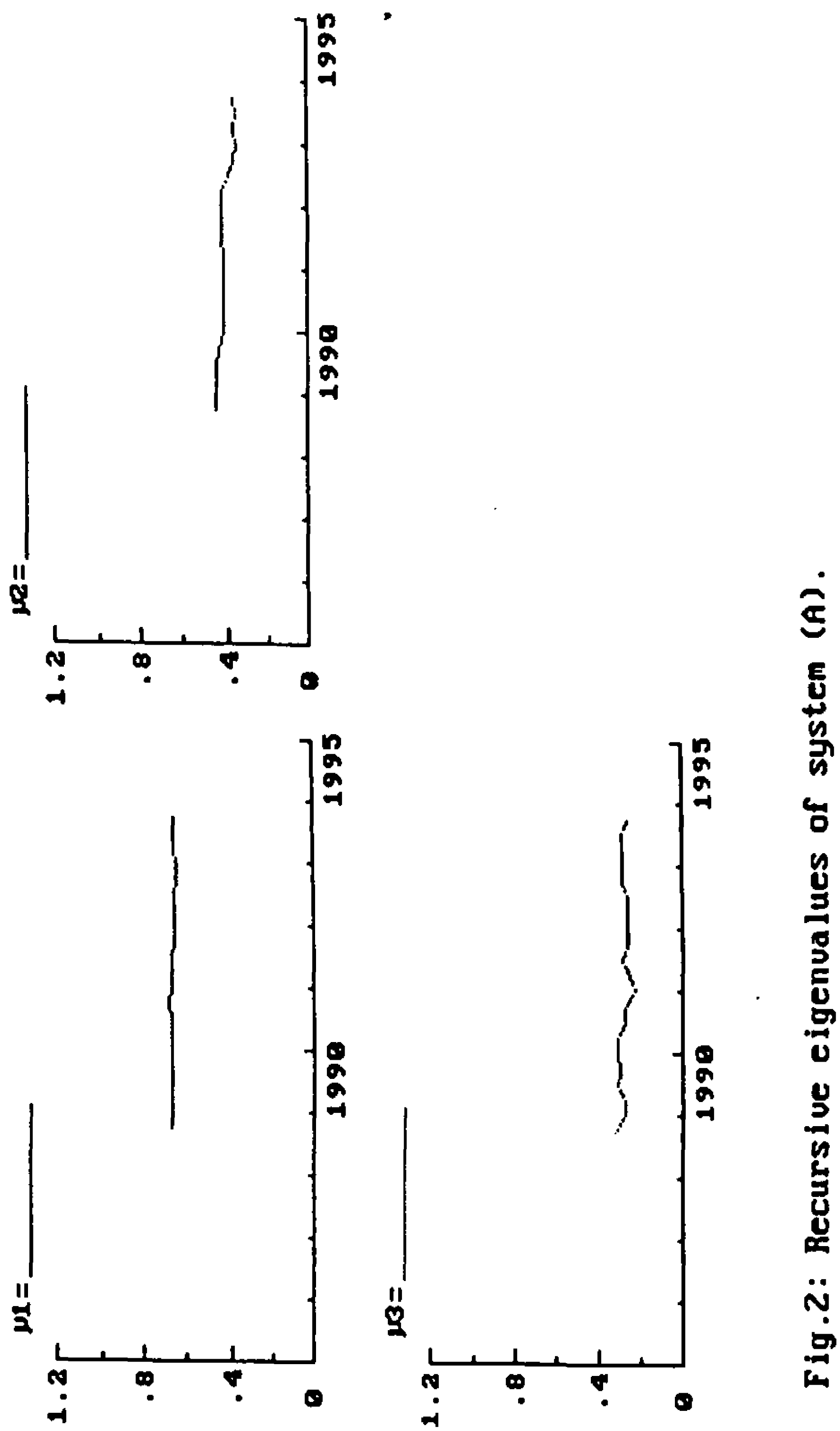

Figure 4.2: Recursive eigenvalues of system A.

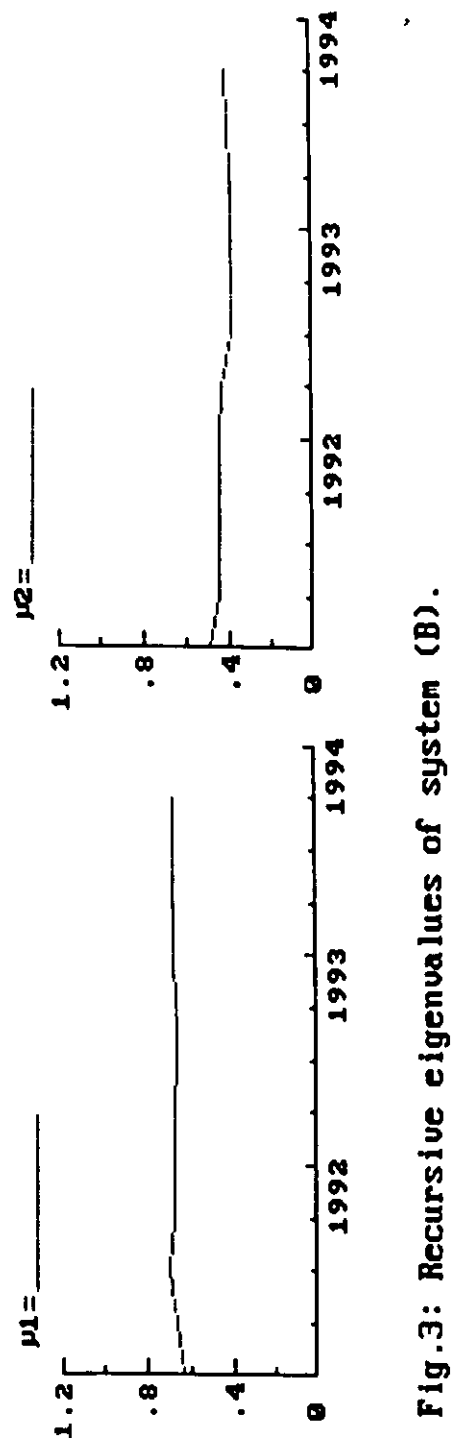

Figure 4.3: Recursive eigenvalues of system B.

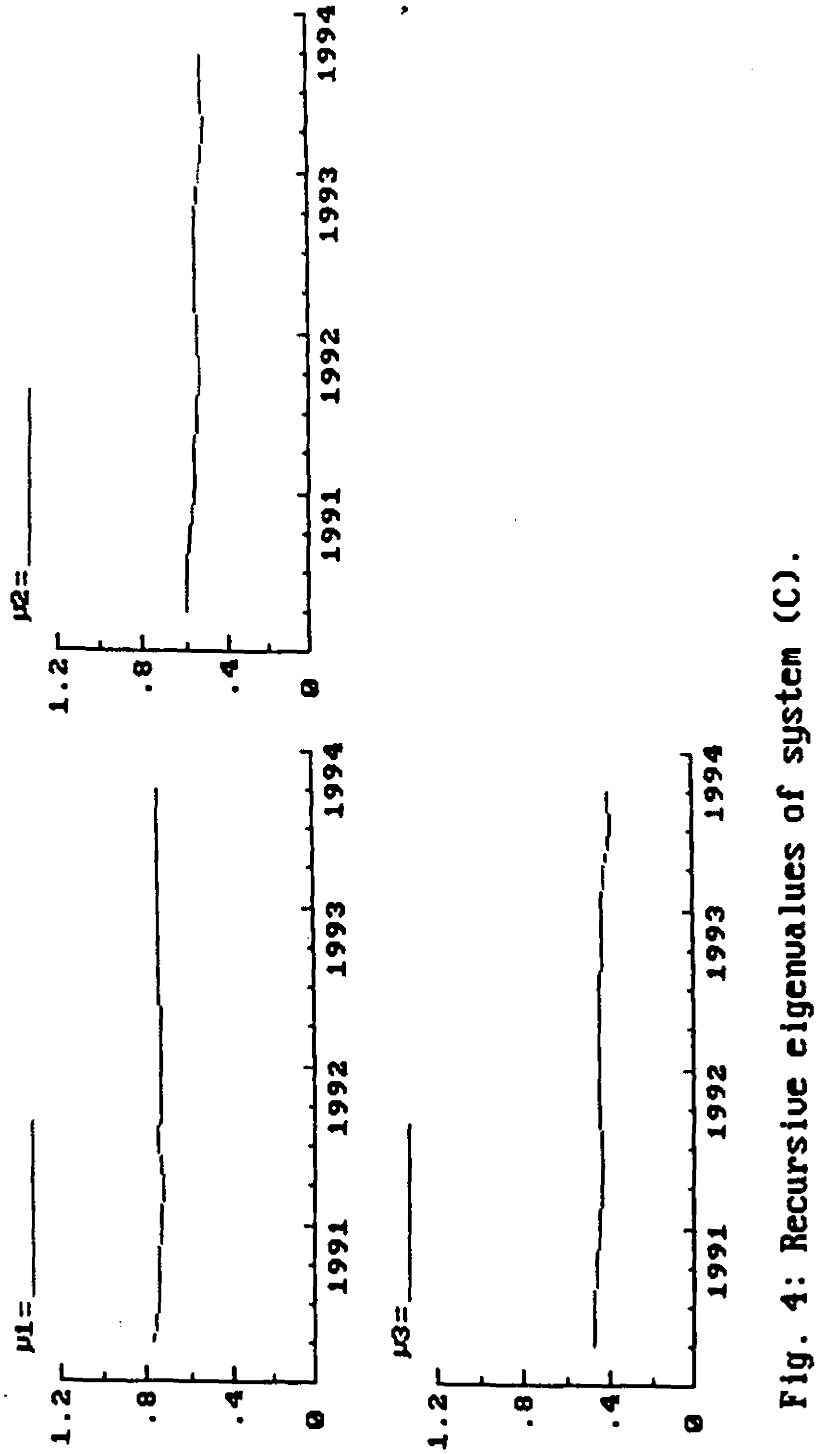

Figure 4.4: Recursive eigenvalues of system C.

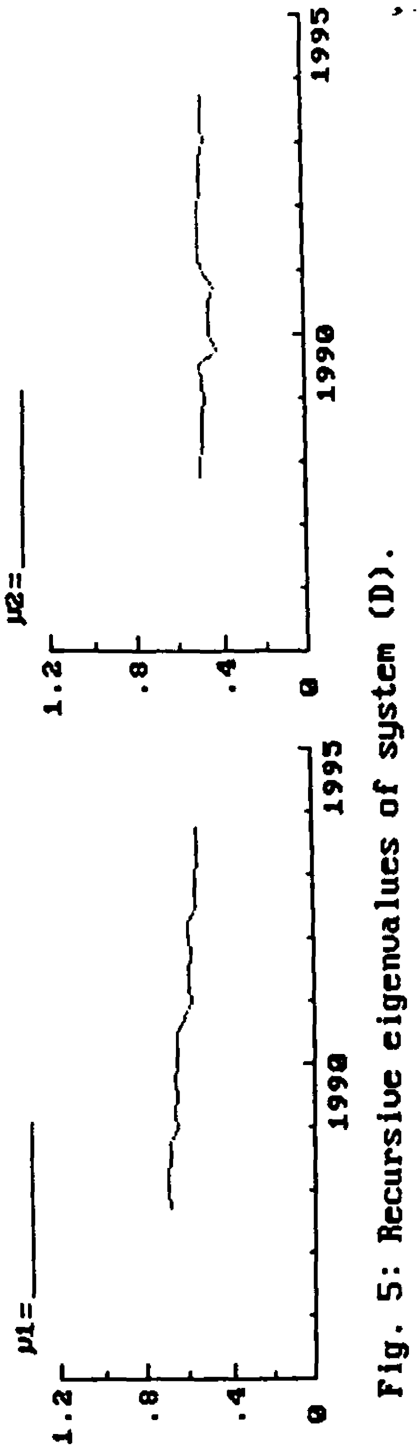

Figure 4.5: Recursive eigenvalues of system D.

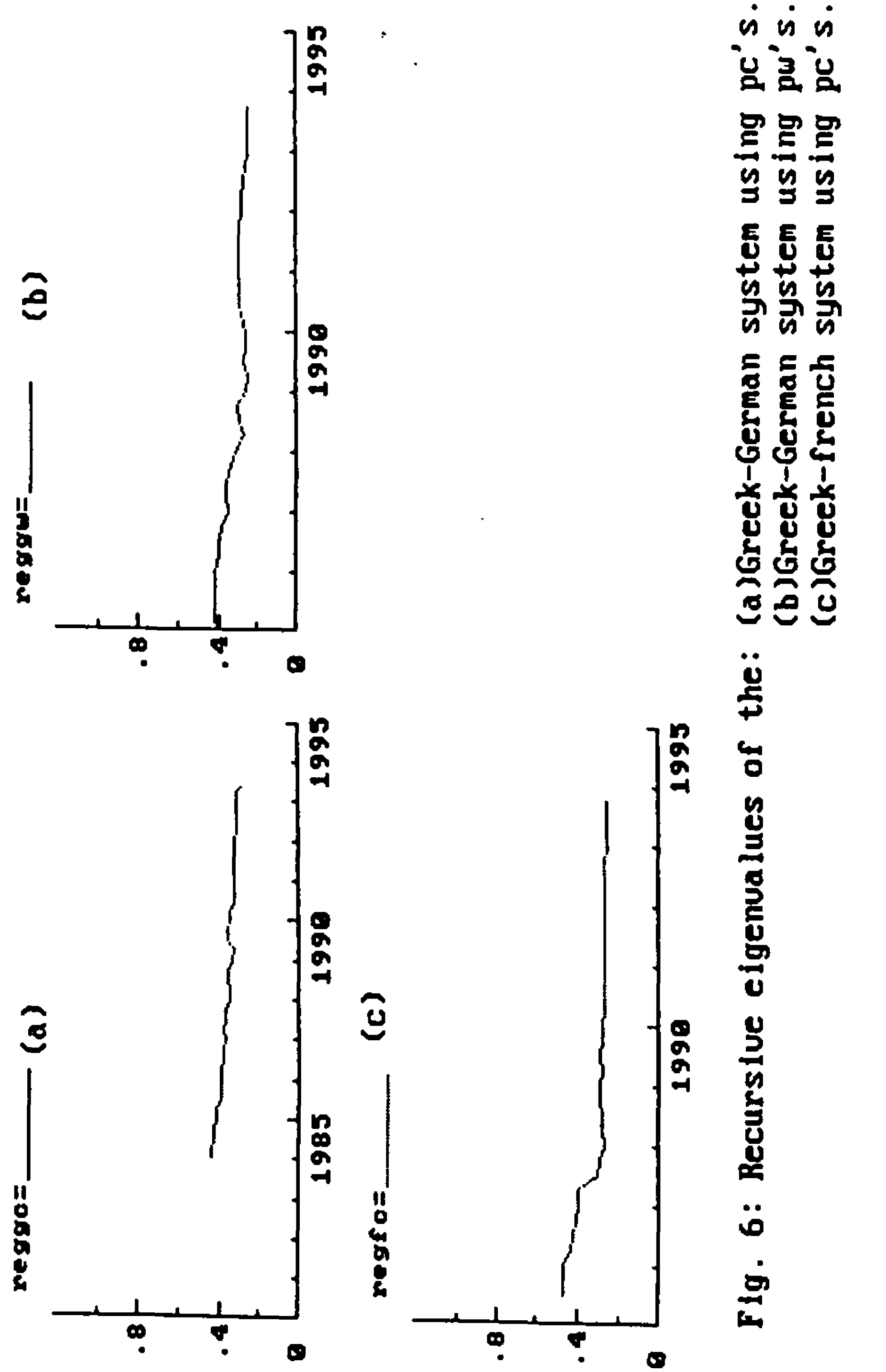

Figure 4.6: Recursive eigenvalues of bilateral systems.

Appendix 4.A: Definition of the regime shift dummy variables

Dummies to account for breaks related to the performance of the Greek economy:

- D831: 1 in 1983:1; 0 otherwise: In January 1983 the Greek drachma is devalued by 15,5%.
- D843: 1 in 1984:3; 0 otherwise: In September 1984, drachma is added to the European Currency Unit.
- D854: 1 in 1985:4; 0 otherwise: In October 1985 measures for a stabilization package include a drachma devaluation by 15%.

Dummies that enter the French VARs:

- D771: 1 in 1977:1; 0 otherwise: A liberalisation of the goods prices (which were frozen in the previous months) and VAT change take place in January 1977.
- D801: 1 in 1980:1; 0 otherwise: In France, energy prices and oil products prices rise sharply in January 1980, as a result of the second oil price shock, which took place at the begining of 1979.
- D822: 1 in 1982:2; 0 otherwise: In June 1982, a realignment of the French franc in the EMS takes place (The French franc depreciates by 6%).
- D852: 1 in 1985:2; 0 otherwise: At the beginning of 1985 a number of price control measures were lifted, with the fuel and automobile price controls lifted in February and July 1985 respectively.

Dummies that enter the German VARs:

- D791: 1 in 1979:1; 0 otherwise: To account for the sharp rise in the prices of oil products.
- D803: 1 in 1980:3; 0 otherwise: To account for a temporary fall in prices caused by tight monetary policy measures.

- D814: 1 in 1981:4; 0 otherwise: A realignment of 5.5 % of the Deutsch mark in the EMS takes place in October 1981.

Dummies that enter the Italian VARs:

- D801: 1 in 1980:1; 0 otherwise: Public services and energy prices rise in January 1980 in order to accomodate the second oil price shock.
- D911: 1 in 1991:1; 0 otherwise: In January 1991, public spending cuts as decided in the state budget and a wage freezing accord had as a result a fall in inflation.
- D924: 1 in 1992:4; 0 otherwise: Withdrawal of the Italian lira from the ERM in September 1992.

Appendix 4.B: Diagnostics of the VAR systems

Table 1: Diagnostic statistics of the multi-country VARs using p^c's.

	A) Greek- German-French VAR	B) Greek- German-Italian VAR
Sample:	1976.2-1993.4	1978.4-1993.4
Dummies in D_t:	D854, D822, D852, D831, D832, D843.	D854, D801, D911, D831, D832, D924.
Lags used:	5	5
Equations residuals tests		
AR F(.,.) (cr. value ≈	F(5,31) 2.52)	F(4, 23) 2.80
	e_G: 1.190	e_G: 1.198
	e_{FR}: 1.060	e_{IT}: 2.783
	p^c_{GR}: 0.987	p^c_{GR}: 1.034
	p^c_G: 1.989	p^c_G: 3.90*
	p^c_{FR}: 1.255	p^c_{IT}: 2.062
N χ^2 (2) (cr.value: 5.99)		
	e_G: 3.11	e_G: 4.272
	e_{FR}: 5.177	e_{IT}: 2.953
	p^c_{GR}: 2.454	p^c_{GR}: 1.634
	p^c_G: 2.670	p^c_G: 1.461
	p^c_{FR}: 0.481	p^c_{IT}: 3.512
VARs residuals tests		
Vec AR F(.,.) (cr. value ≈	F(125, 39) 1.58	F(100, 19) 1.70)
	0.998	1.389
VecN χ^2(10) (cr. value: 18.31)		
	15.096	16.028

Table 2: Diagnostic statistics of the multi-country VAR using p^w's.

	C) Greek- German-French VAR	D) Greek- German-Italian VAR
Sample:	1981.2-1993.4	1978.4-1993.4
Dummies in D_t:	D854, D861, D831, D822.	D854, D911, D924, D831, D832.
Lags used:	5	4
Equations residuals tests		
AR F(.,.) (cr. value ≈	F(3, 15) 3.29	F(4, 28) 2.78
	e_G: 3.807*	e_G: 2.050
	e_{FR}: 2.013	e_{IT}: 1.225
	p^w_{GR}: 3.256	p^w_{GR}: 2.696
	p^w_G: 1.670	p^w_G: 2.782
	p^w_{FR}: 3.197	p^w_{IT}: 2.677
N χ^2 (2) (cr.value: 5.99)		
	e_G: 0.387	e_G: 1.802
	e_{FR}: 2.425	e_{IT}: 3.311
	p^w_{GR}: 1.758	p^w_{GR}: 2.383
	p^w_G: 8.516*	p^w_G: 1.319
	p^w_{FR}: 0.200	p^w_{IT}: 4.569
VARs residuals tests		
Vec AR F(.,.) (cr. value ≈	F(.,.)	F(100, 43) 1.60)
	n a	1.499
VecN χ^2(10) (cr. value: 18.31)		
	18.087	8.701

Table 3: Diagnostic statistics of the two-country VARs using p^w's.

	Germany	Italy	France
Sample:	1976.2-1993.4	1978.1-1990.1	1981.2-1993.4
Dummies included in D_t:	D854, D831, D791, D814.	D854, D831.	D854, D861, D831, D832, D822.
Lags used:	5	4	4
Equation residual tests			
AR F(.,.)	F(5, 43)	F(4, 29)	F(4, 26)
(cr. value ≈	2.43	2.70	2.74
e	2.30	1.558	2.927*
p^w_{GR}	1.23	0.408	0.047
p^w_f	0.69	0.346	1.296
N χ^2 (2) (cr.value: 5.99)			
e	0.04	2.907	4.337
p^w_{GR}	3.12	0.219	0.228
p^w_f	0.01	0.019	1.898
VAR residual tests			
Vec AR F(.,.)	F(45, 92)	F(36, 56)	F(36, 48)
(cr. value ≈	1.50	1.65	1.62)
	1.02	1.0752	1.547
VecN $\chi^2(6)$ (cr. value: 12.59)			
	2.58	10.932	7.558

Table 4: Diagnostic statistics of the two-country VARs using p^{c}'s.

	Germany	Italy	France
Sample:	1975.3-1993.4	1978.3-1993.4	1976.1-1993.1
Dummies included in D_t:	D854, D861, D791, D831, D832, D801, D924, D931.	D854, D831, D801, D924.	D854, D831, D823, D832, D801.
Lags used:	3	4	5
Equation residual tests			
AR F(.,.)	F(5, 48)	F(4, 37)	F(5, 42)
(cr. value ≈	2.43	2.62	2.42
e	1.185	0.755	1.243
p^c_{GR}	3.217*	0.459	0.516
p^c_f	1.113	1.383	0.580
N χ^2 (2) (cr.value: 5.99)			
e	5.686	3.899	4.991
p^c_{GR}	1.948	4.701	4.558
p^c_f	2.443	1.490	2.889
VAR residual tests			
Vec AR F(.,.)	F(45,107)	F(36, 80)	F(45, 89)
(cr. value ≈	1.51	1.60	1.54)
	1.071	0.997	1.042
VecN χ^2(6) (cr. value: 12.59)			
	9.146	10.139	10.479

Bibliography

[1] Chen, B. (1995), "Long-run Purchasing Power Parity: Evidence from some European Monetary system Countries", Applied Economics, 27, 377-383.

[2] Cheung, Y-W. and K.S. Lai (1993a), "Long-run Purchasing Power Parity during the recent float", Journal of International Economics, 34, 181-192.

[3] Cheung, Y-W. and K.S. Lai (1993b), "Finite-sample sizes of Johansen's Likelihood Ratio Tests for Cointegration", Oxford Bulletin of Economics and Statistics, 55, 313-328.

[4] Clements, M. P. and Mizon, G.E. (1991),"Empirical Analysis of Macroeconomic Time Series: VAR and Structural Models", European Economic Review, 35, 887 - 932.

[5] Dockery, E. and Georgellis, Y. (1994), "Long-run Purchasing Power Parity: The case of Greece 1980-1992", Applied Economics Letters, 1, 99-101.

[6] Doornik, J.A. and Hendry, D.F. (1994), "PC-GIVE and PC-FIML Professional, Version 8: An Interactive Econometric Modelling System", London: International Thomson.

[7] Dornbusch, R., (1988), "Exchange rates and inflation", Cambridge: MIT Press.

[8] Dornbusch, R., (1989), "Real exchange rates and macroeconomics: A selective survey", Scandinavian Journal of Economics 91, 401- 432.

[9] Engle, R.F. and Granger, C.W. (1987), "Cointegration, and Error Correction: Representation, Estimation and Testing", Econometrica, 55, 251-276.

[10] Ericsson, N.R. (1992), "Cointegration, Exogeneity and Policy Analysis: Representation, Estimation and Testing", Journal of Policy Modeling, 14, 251-280.

[11] Froot, K.A. and K. Rogoff (1995). "Perspectives on PPP and Long run Real Exchange Rates", in M. Obstfelt and K. Rogoff (eds.) Handbook of International Economics Vol. 3, North Holland: Amsterdam, 1995.

[12] Georgoutsos, D. and G. Kouretas, (1992), "Long run purchasing power parity in the 1920's: the Greek experience", Applied Economics 24, 1301- 1306.

[13] Giovannetti, G. (1992), "A survey of recent empirical tests of the Purchasing Power Parity Hypothesis", Banca Nazionale di Lavoro Quarterly Review, no. 180, 81-101.

[14] Gonzalo, J. (1994), "Five Alternative Methods of Estimating Long Run Equilibrium Relationships", Journal of Econometrics, 60, 203-233.

[15] Hakkio, C.S., (1984), "A re-examination of the purchasing power parity", Journal of International Economics 17, 265- 277.

[16] Hendry, D.F. (1989)," PC-GIVE: An Interactive Econometric Modelling System", Oxford: Oxford Institute of Economics and Statistics.

[17] Hendry, D.F. (1995), "Dynamic Econometrics", Oxford: Oxford University Press.

[18] Hunter, J., (1992), "Tests of cointegrating exogeneity for PPP and UIP in the United Kingdom", Journal of Policy Modeling 14, 453-463.

[19] Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors", Journal of Economic Dynamics and Control, 12, 231-254.

[20] Johansen, S. (1992), "Testing weak exogeneity and the order of cointegration in UK money demand data", Journal of Policy Modelling, 14, 313-335.

[21] Johansen, S. and Juselius K., (1990), "Maximum Likelihood Estimation and Inference on Cointegration - with Applications to the Demand for Money", Oxford Bulletin of Economics and Statistics, 52, 169-210.

[22] Johansen, S. and Juselius K., (1992), "Testing structural hypotheses in a multivariate cointegration analysis of the PPP and the UIP for UK", Journal of Econometrics 53, 211-244.

[23] International Financial Statistics (1986), "Supplement on Price Statistics", Supplement Series, 12.

[24] Karfakis, C. and D. Moschos, (1989), "Testing for long run PPP: a time series analysis of the Greek drachma", Economics Letters 30, 245-248.

[25] MacDonald R. and I.W. Marsh, (1995), "On Fundamentals and Exchange Rates: A Casselian Perspective", mimeo, Department of Economics, University of Strathclyde, Scotland, UK.

[26] MacDonald R. and Taylor, M. (1993), "The Monetary Approach to the Exchange Rate: Rational Expectations, Long-run Equilibrium and Forecasting", International Monetary Fund Staff Papers, 40, 89-107.

[27] Mizon, G.E. (1995), "Progressive Modelling of Macroeconomic Time-series: The LSE Methodology", in K. D. Hoover (ed), Macroeconometrics: Developments, Tensions and Prospects, Derdrecht: Kluwer.

[28] Moschos, D. and Stournaras, Y. (1991), "Domestic and Foreign Price Links in an Aggregate Supply Framework: The case of Greece", mimeo, Bank of Greece and University of Athens.

[29] OECD (1994a), "Consumer Price Indices: Sources and Methods", Main Economic Indicators Supplement, April 1994.

[30] OECD (1994b), "Producer Price Indices: Sources and Methods", Main Economic Indicators Supplement, April 1994.

[31] Sideris, D., (1994), "Testing for Long Run Purchasing Power Parity: The case of the Greek drachma", mimeo, European University Institute.

[32] Spanos, A.,(1986), "Statistical Foundations of Econometric Modeling", Cambridge: Cambridge University Press.

[33] Taylor, M. (1988), "An empirical examination of long run purchasing power parity using cointegration techniques", Applied Economics, 20, 1369-81.

Chapter 5

Modelling consumer price inflation in Greece.

Abstract

The present chapter attempts to model price inflation in Greece by taking into account all possible sources suggested by economic theory. The aim is to build a data-coherent and empirically constant model which could thus clarify the relative importance of the factors determining consumer price inflation and make it easier to understand the role that the economic authorities can play in its determination. To this end, all alternative hypotheses of a small open economy that consider both monetary and cost-push causes are used. In addition, the existence and stability of any long-run relationships predicted by economic theory for price formation are tested by applying cointegration analysis. The next step is to build a general overparameterised, error correction model in which the obtained long-run relationships play the role of error correction terms. The general model can be further reduced by making use of statistical and theoretical considerations thus leading to a final parsimonious and theoretically interpretable model. Since the general model embeds various theoretical models, such as the Phillips curve, and closed and open economy monetarist models, we test for the empirical relevance of these in the process of obtaining the final model. Moreover, the significance of the parameters of the error correction terms indicate which variables drive inflation in the long run.

5.1 Introduction

The incentive of this chapter is to investigate the determinants of consumer price inflation in Greece over the last twenty years. The aim is to build a data-coherent and empirically constant model which could thus clarify the relative importance of the factors determining consumer price inflation and make it easier to understand the role that the economic authorities can play in its determination.

This is of particular interest because: a) The period under consideration is characterised by high and persistent inflation. In particular, while lower than the OECD average for the years till the early 70's, the inflation rate in Greece rose sharply after the first oil price shock and remained in the highest positions in the OECD and EU areas from then on. b) The period covers different political regimes and a number of institutional changes; hence, a parameter constant model can be considered to provide trustworthy answers about what have been the main and deep causes of price inflation in Greece.

In addition, the present work analyses in debth issues that have not been emphasised in the existing literature on Greek inflation: i) First of all, it integrates (takes into account of) all the alternative theoretical hypotheses that have been used in the literature to explain inflation, in an effort to build a general model that covers the effects of all the possible determinants of inflation and encompasses different models. Alternative hypotheses of a small open economy that consider both monetary and cost-push causes are used, in an effort to identify the effects of the different factors.

ii) Second, the econometric methodology adopted, makes it possible to model the short run dynamics of inflation while taking into account of some long-run relationships predicted by economic theory. The existence and stability of these relationships are investigated by applying cointegration analysis. Three long-run relationships which have been assumed alternatively in the relevant literature on Greek inflation are of interest: that between money and prices, that between foreign and domestic prices and that between wages and prices. The derived long run relationships can then be included as error correction terms in dynamic models of inflation.

iii) Finally, emphasis is given on the importance that the parameter constancy and the provision of good forecasts have in modelling. Empirical analysis of the short run dynamics of Greek inflation is done in a system of equation context, which is consistent with the weak exogeneity results obtained in the analysis of the long run structure. The inflation equation obtained in this way provides reliable forecasts given that no variable is considered *a priori* exogenous, and that feedback from prices to the other variables is not precluded. The forecasting ability of the system can thus be evaluated by using predicted values of all variables rather than actual values of key variables. In addition, the final model is shown to be parameter constant, which further implies that the structure of the inflationary process in Greece does not appear to have changed over the 80's and early 90's.

The remainder of the chapter is organised as follows: Section 5.2 briefly presents the theoretical background and a survey of the literature on Greek inflation. Section 5.3 presents the data set and comments on some univariate properties of the series. In Section 5.4, the cointegration analysis is performed: first, the long run relationships are attempted to be identified in a general system of equations accounting for the possible interractions among all the variables of interest; in a second step, the long term relationships are investigated in three partial (conditional) systems. In Section 5.5, the structure of Greek inflation is analysed in the context of a dynamic system which is consistent with the weak exogeneity results obtained in the cointegration analysis. The model captures long run effects that were ignored in most of the previous studies, which were in first differences only. It is data-coherent, empirically constant and has straightforward economic implications. The conclusions are summed up in the final section.

5.2 The economic background. Other studies on Greek inflation.

5.2.1 The economic background.

Basic alternative concepts analysing the problem of inflation are:

i)The view that inflation is cost-push, determined mainly by increases in wages in excess of labour productivity, and increases in prices of imported raw materials, which reflect either foreign inflation or domestic currency devaluations; this view dominated the economic analysis of price formation in open economies during the 70's.

ii)The above cost-push view incorporated later the "law of one price" hypothesis; according to it, inflation is determined not only by raw material import prices but also by finished goods' import prices.

iii)The monetarist approach, which postulates that the cause of inflation lies in excessive monetary growth, and thus that the desired policy measure is to control the money supply.

iv)The Phillips curve which supports a negative relation between inflation and unemployment. The concept of the Phillips curve in its short-run form can be associated with supply side cost-push effects, while in its long-run form can be seen as describing demand pull effects when aggregate demand is above the full employment level.

The present work aims to encompass all the above alternative approaches. In this sense, it is similar to the works done by Surrey (1989), Juselius (1992), Artis and Kontolemis (1994) who investigate the inflation determination in the UK, Denmark and UK respectively.

5.2.2 Other studies on Greek inflation.

There exist several empirical studies which analyse Greek inflation based on the above alternative theoretical arguments and, consequently, raise different issues for examination. They often lead to different conclusions, which in turn, give rise for different (policy) suggestions made for the conduct of the Greek macroeconomic policies[1]. They, therefore, deserve here a brief review.

Among the recent studies to be reviewed are those by Leventakis and Brissimis (1980), Sarantis (1984), Alogoskoufis (1986), (1989), Alogoskoufis and Philippopoulos (1991), Dogas (1992) and Papadopoulos (1993).

Leventakis and Brissimis (1980) model inflation for the period 1958-1978 using annual data. They use two alternative theoretical specifications for their models on inflation, both estimated on a single equation framework: The first one is a cost-push, demand-pull model in which the main inflation determinants turn out to be the increase in labour costs, import prices and a measure of excess demand. The second one is a monetary model, which, estimated in reduced form, indicates that the basic inflation determinants are the growth in the money supply, the public debt, the import prices, the output, and the excess demand measure. They finally conclude that monetary and cost-push theories of inflation fare equally well on empirical grounds, based on the fact that both models

[1]Compare, for example, the suggestions made by Stournaras (1992) in his analysis for the recent Greek macroeconomic performance, which is based on an empirical monetary model of inflation to the ones made by Katseli (1990b) which are based on a cost push econometric model.

provide acceptable values for the diagnostics; however, they do not compare the two models statistically.

In his paper modelling the wage-price spiral in Greece, Sarantis (1984) uses quarterly data for the period 1969.1-1980.3. He adopts a non-monetary cost-push and demand-pull model in which the main determinants of Greek inflation turn out to be the rate of change of the unit labour costs, the foreign prices, the exchange rate and a measure of excess demand.

Alogoskoufis (1986) investigates Greek price formation in an extended "scandinavian" model that includes the effects of the monetary growth, the increases of the imported good prices and the wage-price spiral. In that work, the author analyses Greek inflation over the period 1963 - 1984 using annual data; he ends up with the conclusion that the main determinants of Greek inflation are the wage acceleration relative to productivity and the depreciations of the drachma, while excess monetary growth does not play a major role.

Alogoskoufis (1989) developes and estimates two general equilibrium models which analyse the role of the macroeconomic policies related to the wage and price setting for the determination of output, competitiveness and the external balance. For the inflation specification, the non-monetary cost-push model he uses, turns out to be statistically well-specified and provides reasonable results, for the 1955-1986 period. According to it, the inflation rise is due to rises in the wages and the import prices.

Alogoskoufis and Filippopoulos (1991) search for credibility effects due to changes in the exchange rate and the political regimes on the inflation process in Greece. They find positive evidence for both theoretical arguments in a single equation specification, which, however, models just wage inflation, for the 1958-1989 period.

Dogas (1992) makes use of a non-monetarist model, the so-called "bargaining" model of wage determination when modelling inflation for the period 1963-1988, using annual data series. He obtaines a two-equation system in which the endogenous variables are the wage and price inflation. The main price inflation determinants turn out to be the changes in agricultural prices, wages, import prices and the public deficit which is used as demand variable.

Papadopoulos (1993) constructs a small empirical macroeconomic model for the open economy of Greece, which aims to examine the interaction between policy instruments and the macroeconomic variables of output, prices and the balance of payments. He estimates inflation in a system framework: his findings suggest that excess demand for goods and imported inflation are the major contributing factors to the overall inflation rate.

5.2.3 Issues to be further analysed.

In summary, the recent applied studies on Greek inflation test empirically for the validity of alternative theoretical models on inflation. All of them end up with the formation of reasonable and statistically welspecified models and they all conclude with the statement that the chosen model fares well for the explanation of inflation. However, they leave a number of theoretical and methodological issues to be analysed more deeply. These have to do with:

The underlying model:

With the exception of Alogoskoufis (1986), no other study attempts to test empirically for the validity of the alternative theories in a general system which includes all of them, so that a comparison between them can also be possible. Such an attempt is made in the present work.

Stability of the inflation model:

With the exception of Leventakis and Brissimis (1980), the rest of the authors assume stability of the estimated models of inflation they obtain, but they do not test formally for it.

In addition, there seem to be a disagreement on the grade of importance that policy regime changes had on the inflation determination process. The authors' attitude ranges from that of Alogoskoufis and Philippopoulos (1991) to that of Papadopoulos (1993): In particular, Alogoskoufis and Philippopoulos (1991) support that any change in the government has a significant effect in the determination of inflation, while Papadopoulos (1993) does not take into account of any policy change (even though, this also has to do with the degree of "generality" of each model). Nevertheless, most of the discussed studies agree on the importance that the fall of the military dictatorship in 1974 had on the economic performance of Greece, whereas a big number of them support that other important regime shifts are associated with the entrance of Greece at the European Union in 1981 and the end of the expansionary macroeconomic policies in 1986 (see *inter alia* Alogoskoufis (1996), Giavazzi (1996) and Maroulis (1996)).

Long-run relationships:

In most of the studies discussed, the authors analyse the determinants of inflation using the differences of the relevant variables, thereby losing valuable information on the long run behaviour of the series. In the present attempt, particular emphasis is given in the long run relationships of the series, which can all be argued to correspond to policy suggestions for controlling the price level[2].

In addition, in the present paper, the analyses of the long-run relationships of the different sectors are made in a system context and therefore all the available information of the data set is used.

Single equation versus system analysis:

Some of the studies mentioned analyse inflation in a single equation framework, some others in a system of equations framework. In the present application, the aproach adopted allows the statistical properties of the series to indicate the framework in which inflation should be modelled. Inflation is finaly modelled in a system framework according to the weak exogeneity status of the variables involved.

The analysis is consistent with the "general to specific" framework (see Spanos (1986), Hendry (1995)). In a first step, wellspecified (congruent) VAR systems which investigate the interrelations of the variables of interest (the functioning of the three sectors) are estimated; then the Johansen (Johansen (1988)) maximum likelihood technique is performed, in order to specify the cointegration space rank and to identify the long run relationships. In a final step, the long run information is used in the final model which describes the short run dynamics of inflation.

5.3 The data set.

This section describes the data available and considers some of their basic properties. All data are quarterly, spanning 1974.3 - 1995.2. Allowing for lags and transformations, estimation is over 1975.3 - 1995.2 unless otherwise stated. The period under analysis is characterised by a managed exchange rate system and a new political regime after the

[2]Economic theory indicates that control can come through adherence to an internal or to an external standard. Internal standards may include a money supply target or a wages policy; the external standard suggests targeting the exchange rate against a low inflation currency.

fall of the military junta in July 1974 which meant a big number of changes in the policy decision making process.

5.3.1 The series. Descriptive analysis.

The data observations are quarterly and all but the unemployment series are seasonally unadjusted. Seasonally unadjusted series were preferred to the published adjusted ones, because of the possible implications that the use of adjusted data may have in modelling[3]; nevertheless, the use of an adjusted unemployment series was considered necessary after the analysis of the seasonal pattern of the series made by using the ARIMA model-based programm SEATS (see Gomez and Maravall (1994)) as already described in Chapter 3. Throughout the paper, lower-case letters which refer to the variables signify logarithms of capitals and D denotes the first difference operator.

The Greek consumer price index (CPI) P is the central series of this study. The variables that are used to account for the labour market effects on inflation are the hourly earnings in manufacturing W, which can be considered as representative of the labour payments in Greece and the unemployment level SU series. A number of interesting features concerning the behaviour (pattern) of the labour market variables and the possible relationships between them can be derived by the visual inspection of the graphs (a) - (c) in Figure 5.1.

Graph 5.1 (a) plots the logs p and w of the price and wage series respectively, whereas graph 5.1 (b) contrasts their respective annual inflation rates $D4p$ and $D4w$. The plots of the variables are mean and variance adjusted in order to match. As shown in (b), the annual wage and price inflation rates follow relatively similar patterns if we exclude the 1979-1985 subperiod. The unrelated patterns during that subperiod which is characterised by, on average, expansionary policies is probably due to the fact that alternative wage indexation agreements were followed. However, in the 1974-1979 subperiod, the price inflation seems to precede (be followed by) wage inflation, whereas, in the 1986-1995 subperiod it seems to follow wage inflation. This may be due to the different income policies followed in the two subperiods. Graph (c) plots the pattern of the unemployment series su together with that of the real wage series rw derived as the log of the ratio W/P. There is visual evidence of a simultaneous rise in real wage and unemployment during the

[3]For a detailed analysis, see *inter alia* the papers in Hylleberg (1992) and Ericsson, Hendry and Tran (1994).

expansionary policy period 1979-1985. This rather counter-intuitive feature can be due to the structural rigidities of the labour market (see also Papademos (1990) and Katseli (1990a) for similar arguments).

The foreign influence on Greek inflation has been chosen to be represented by that of Germany. This is done so, because most of the Greek trade is with European countries, whose exchange rates and inflationary performance are linked to the Deutsch mark and the performance of Germany via the European Monetary System, for most of the years analysed. The empirical results in Chapter 4 also support this decision. The variables used in the analysis to cover the external effects are therefore the German consumer price index P_G and the Deutsch mark / drachma exchange rate E_G.

Figures 5.2 and 5.3 plot the graphs of the foreign sector series. Graphs (a) and (b) in figure 5.2 plot the logs of the German price index and its annual inflation rate respectively, contrasting them with the corresponding transformations of the Greek consumer price index. There is visual evidence for similarities in the behaviour of the two series[4]. Graph 5.2 (c) plots the quarterly growth rate of the Greek price index Dp and the mark/drachma exchange rate De; it provides evidence of the different impact that the two drachma devaluations (in 1983.1 and 1985.4) had on the Greek inflation rate.

Graph (a) in Figure 5.3 plots the logs of the German price index converted to domestic prices (derived as the product $P_G \times E_G$) fp_G and the import price index p_{imp}. This is done in order to compare the German price index used to represent the foreign influence in the present study with the import price index which is a commonly used measure of the foreign effects in the empirical literature modelling inflation in open economies (see *inter alia* Alogoskoufis (1986) in an analysis of Greek inflation, and De Brouwer and Ericsson (1995) in an analysis of the inflation process in Australia). As shown in the graph, the two series follow very similar patterns; in particular, they almost coincide during the post-1985 period. The evidence reflects the high trade interrelations between Greece and the European Union countries especially in the post-EEC period for Greece, and further supports the choice of Germany as the country representing the foreign sector. Graphs (b), (c) and (d) in Figure 5.3 plots the German price index converted to Greek prices fp_G and its quarterly and annual inflation rates respectively, contrasting them with the corresponding transformations of the Greek CPI. There is visual evidence for similarities in the behaviour of the compared series, especially for the pre-1979 and the post-1986

[4]Note that the plots of the series are mean and variance adjusted.

subperiods.

For the monetary effects on inflation the narrow measure of money M1 is chosen given that it is believed to be the critical variable related with inflation in the building of the monetary models[5] (see *inter alia* Artis and Kontolemis (1994), and Browne and Fell (1996) for similar arguments in favour of the choice of a narrow money measure in inflation models). The plots of the log of M1, denoted as m, its quarterly Dm and annual growth $D4m$ together with p, Dp and $D4p$ are given in graphs (a), (b) and (c) of Figure 5.4 respectively. Graph (d) in Figure 5.4 plots the log of the real M1 money stock $(m-p)$. It shows that real M1 remained relatively constant during the whole period examined, with a rise for the pre-1980 subperiod and a noticeable decline in the 1984-1989 years. This decline is probably due to the increased availability of assets outside M1 and the deregulation (restructuring) of the financial system that started during these years.

5.3.2 Univariate analysis of the time properties of the series.

A univariate analysis of the data series investigating their integration properties is first attempted. To this end, fourth order Augmented Dickey-Fuller (ADF) tests are performed for all the variables considered. The results obtained are reported in Table 5.1. Unit root tests are given for the levels and the first differences of all series and for the second differences of the p and p_G series. The third column in Table 5.1 reports the ADF test values, whereas the second one reports the deviation from unity of the estimated largest root; this deviation should be approximately zero if the series has a unit root.

[5]Note that, as Juselius (1991) observes, the choice of the observational variables is of great importance for the results of the econometric modelling.

Table 5.1: **Augmented Dickey-Fuller Tests**[1].

Variables	coeff	t(ADF)	lag length
p	-0.0554	-1.971	4
w	-0.0079	-0.325	4
e_G	-0.0715	-1.515	4
su	-0.0563	-1.764	4
m	-0.2070	-1.647	4
p_G	-0.0226	-2.015	4
Dp	-0.5023	-3.137	4
Dw	-1.2110	-4.150**	4
De_G	-0.8741	-3.551*	4
Dp_G	-0.2523	-2.211	4
Dm	-0.9642	-4.629**	4
Dsu	-0.6550	-4.259**	4
D^2p	-2.223	-4.850**	4
D^2p_G	-2.451	-5.261**	4

[1]: Constant and trend included
* significant at 5% level
** significant at 1% level

Empirically, the earnings w, money m, unemployment su and exchange rate e_G variables appear to be I(1), whereas the Greek and German CPI indices p and p_G appear to be I(2), if inference is to be made on the ADF statistics alone. However, the I(1) status for the Greek CPI is just marginally rejected (it could be accepted at a 10% significance level) and, in addition, the estimated root for Dp is 0.498 (= 1 - 0.502), which numerically is much less than unity. The estimated root for Dp_G (0.75) is also numerically less than unity.

In addition, it is important to note that inferences from the ADF tests do not seem to be very reliable, given that they are low power tests, sensitive to the presence of innovations. Specifically, in the presence of changes in the structure of an $I(0)$ series, full-sample unit root tests are known to be biased toward the false null hypothesis of no-stationarity (see *inter alia* Perron (1989), (1990), and Hendry and Neale (1991)).

Hence, in the multivariate cointegration analysis below, the variables of interest are treated as if they are I(1), while recognising that some caveats may apply. Specifically, it may be valuable to investigate the cointegration properties of the series, assuming that they may be I(2) (see Johansen (1992)), but doing so is beyond the scope of this work.

5.4 The analysis of the long run structure.

This section investigates for possible long-run relationships which could account for price formation as claimed by the alternative inflation theories. The cointegration results are obtained by applying the Johansen's maximum likelihood procedure. The cointegration analysis includes:

a)testing for the existence of possible long run relationships,

b)testing further for particular sructural theoretical restrictions which may be expressed by the existed relationships,

c)testing for the exogeneity/ endogeneity status of the variables involved in the relationships, and

d) investigation of the parameter constancy of the obtained relationships.

The analysis takes into account all four alternative channels through which inflation may be determined as advocated by the alternative theories. In order to be consistent with the "general to specific" methodology, we initially attempted to test for the existence of the relative long run relationships in a very general system modelling the interdependence of all the possible inflation determinants. The system analysis provides with two cointegrating vectors which, however, can be given reasonable interpretations just in the case in which they are tested separately. The results of the tests concerning the structure of the cointegrating space were rather inconclusive. Therefore, in a second step, a cointegration analysis of the conditional systems which model the functioning of the alternative sectors which determine inflation, was further considered.

In subsections 5.4.1 - 5.4.4 we present the cointegration analysis performed in the general and conditional systems. Finally, subsection 5.4.5 further tests for parameter constancy of the derived cointegrating relationships by estimating them in a reduced sample period.

5.4.1 The analysis of the long run structure in a general system.

In a general framework, the long run relations can be investigated by applying cointegration analysis to a VAR system which models jointly the behaviour of all the possible determinants of Greek inflation. Even though different general specifications were tried, we decided to present here the one modelling a VAR for the variables $z_t = ($ p, w, su,

m, fp_G). The decision to model just the named five variables was also made in order to keep the system manageable and not to have problems with the degrees of freedom.

The five-dimensional VAR is estimated using four lags of the variables and includes a constant, seasonals and a number of impulse dummies (D801, D831, D854, D902) to account for particular economic events (see Appendix 5.A for the events they account for). The results of the VAR diagnostics tests are reported in Table B.1 in Appendix 5.B. Even though the assumption of normality is violated for the VAR residuals, and for the residuals of the wage and the imported price equations (but quite marginally), it was decided to present the results of the cointegration analysis as indicative of the joint long-run structure of the variables.

Table 5.2: **Cointegration analysis of the general system.**

Testing for the Π rank.					
Eigenvalues	H_0	Max. Eigen.	95%	Trace	95%
0.3937	$r = 0$	39.54**	33.5	90.25**	68.5
0.2623	$r \leq 1$	26.04	27.1	50.71*	47.2
0.2147	$r \leq 2$	19.10	21.0	26.67	29.7
0.0516	$r \leq 3$	4.190	14.1	7.574	15.4
0.0419	$r \leq 4$	3.384	3.8	3.384	3.8
Standardised eigenvectors.					
p	fp_G	w	su	m	
1	-2.026	-0.949	1.396	0.943	
10.95	1	-3.784	-3.321	-5.663	
0.594	-1.547	1	-0.433	-0.007	
-23.64	15.99	-1.243	1	8.061	
-0.354	-0.212	-0.373	-0.006	1	
Adjustment coefficients.					
p	-0.0058	-0.0123	0.0131	0.0010	0.0061
fp_G	0.0246	-0.0187	0.0180	-0.0021	-0.0049
w	0.0299	0.0170	0.0587	0.0014	0.0027
su	-0.1052	0.0034	0.0581	-0.0032	0.0238
m	-0.0062	0.0019	0.0021	-0.0006	-0.0641

The outcomes of the maximum eigenvalue and trace statistics that came out of the Johansen cointegration analysis, the estimated eigenvalues and eigenvectors and their loadings are given in Table 5.2. The trace statistic provides evidence for two cointegrating vectors, whereas the maximum eigenvalue test rejects the assumption of two cointegrating vectors at the margin; given that, as Cheung and Lai (1993) support, the trace statistic is more robust to non-normality, we continue the analysis assuming two cointegrating relationships.

The graphs of the eigenvalues when estimated recursively (*Rec1*, *Rec2*) are presented in figure 5.5.a. Parameter constancy is evident for the estimated coefficients of the first cointegrating relationship; this is not so, though, for the parameters of the second one.

Table 5.3 presents the outcomes of the likelihood ratio tests testing for the long run theoretical relationships of interest. These are: a relationship among wages w, prices p and possibly unemployment su; that between money m and prices p; that between foreign (German) prices converted to domestic prices fp_G and domestic prices p.

Table 5.3: Testing the general system.

Testing for theoretical restrictions.

		p	w	fp_G	m	su	$\chi^2(dof)$	p-value
H_{G1}:	β_{G1}:	-1	1	0	0	a	4.882 (2)	0.0870
H_{G2}:	β_{G2}:	1	0	0	b	0	13.03 (2)	0.0015 **
H_{G3}:	β_{G2}:	1	0	c	0	0	4.731 (2)	0.0939
H_{G4}:	β_{G2}:	1	0	-1	0	0	19.41 (3)	0.0002 **
H_{G5}:	H_{G1}	$\cap$	H_{G3}				11.63 (4)	0.0203*

Testing for weak exogeneity.

H_{G6}:	$H_{G7} \cap$ w. ex. of m wrt β_{G2}, β_{G1}	0.296 (2)	0.862

H_{G1} H_{G2} and H_{G3} test for the three relationships separately. Hypothesis H_{G1} tests for cointegration between real wage and unemployment for the specification of the first cointegrating vector. It is accepted by the data for a value of -0.107 for the coefficient of su. H_{G2} tests for a money-price relationship for the specification of the second eigenvector and is rejected by the data. H_{G3} tests for a long run relationship between p and p_G and is accepted for a value of 0.9 for the coefficient of fp_G, which implies a "weak PPP" relationship between Greece and Germany. "Strong PPP" as expressed by H_{G4} is rejected by the given data set. Finally, the hypothesis H_{G5} which tests jointly for H_{G1} and H_{G3} is rejected by the data (quite marginally, though).

However, this final result should be interpreted with caution, given that interpretation of the cointegration outcomes can become complicated in large scale systems due possibly to pure statistical interrelations between variables which are not theoretically linked. If, policies which, though, did not result in rises in employment. This was probably due to insiders - outsiders effects, downward real wage rigidities and inability of the productive sector to react to positive shocks because of labour market rigidities (firing, hiring costs) and the fact that it had to function in the new competitive EU environment. Since the coefficients are plausible, given the peculiarities of the Greek economy during the examined period, we choose it as an acceptable long run wage equation. The result is consistent with the general system outcome reported in subsection 5.4.1.

Finally, the hypotheses H_{W2} - H_{W4} whose results are also given in the low part of Table 5.4 assume weak exogeneity for the variables p, w and su with respect to the long-run parameters. The cointegrating vector does not enter the wage equation. This probably suggests that wages are determined exogenously with respect to the labour market situation, mainly by institutional (and macroeconomic) factors (see also Katseli (1990a) for similar findings and arguments).

5.4.3 Long run analysis of the foreign sector.

According to external theories of inflation, domestic prices increase either because of increases of foreign input prices or of devaluation of the domestic currency. In the present application we are interested in a combination of the two theories, namely whether Greek prices have the tendency in the long run to follow the foreign prices measured in a common currency. This is essentially the question whether purchasing power parity holds in the long run or not. Extensive investigation of this subject has been done in Chapter 4. Here, we repeat the analysis for the more extended time period until 1995. The foreign influence is decided to be represented by Germany which is considered to proxy the European countries' influence.

A four lag VAR for the vector of the form $z = (p, p_G, e_G)$ which also includes a constant, seasonals, and event specific dummies is estimated. Its residuals do not present serious autocorrelation and non-normality problems as reported in Table B.3 in Appendix 5.B.

Table 5.5: **Cointegration analysis of the foreign sector.**

Testing for the Π rank.

Eigenvalues	H_0	Max. Eigen.	95%	Trace	95%
0.2416	$r = 0$	22.13*	21.0	28.99	29.7
0.0456	$r \leq 1$	3.738	14.1	3.867	15.4
0.0016	$r \leq 2$	0.128	3.8	0.128	3.8

Standardised eigenvectors.

p	e_G	p_G
1	-0.921	-1.606
-1.828	1	5.590
-7.039	7.682	1.000

Adjustment coefficients.

p	0.0179	0.0138	0.00029
e_G	0.1582	0.0094	-0.00056
p_G	0.0248	-0.0017	0.00010

Testing for theoretical restrictions.

Hypothesis				$\chi^2(dof)$	p-value
	$(e_G$	p	$p_G)$		
H_{F1}:	1	$-a$	a	2.933 (1)	[0.0868]
H_{F2}:	1	-1	1	17.53 (2)	[0.0002] **

Testing for weak exogeneity.

				$\chi^2(dof)$	p-value
H_{F3}:	$H_{F2} \cap$	w. ex.	of p	9.143 (3)	[0.0274]*
H_{F4}:	$H_{F2} \cap$	w. ex.	of p_G	7.199 (3)	[0.0658]
H_{F5}:	$H_{F2} \cap$	w. ex.	of e_G	9.620 (3)	[0.0221]*

Detailed results of the Maximum Likelihood cointegration analysis are reported in Table 5.5. According to them, there is evidence for one cointegrating relationship, with constant parameters as evidenced by the graph of the recursive estimate of the largest eigenvalue of the system presented in figure 5.5.c.

The outcomes of the theoretical restrictions of interest are reported in the lower part of Table 5.5. Hypothesis H_{F1} tests for "weak" PPP between Greece and Germany and is accepted by the data (for a value of the coefficient $a = 0.916$). Hypothesis H_{F2} tests for "strong" PPP and is rejected by the given data set. The results are consistent with those obtained in the bilateral PPP analysis performed in Chapter 4. In addition, hypothesis H_{F3} test for "weak" PPP between the two countries with coefficients which equal those obtained in Chapter 4; they are accepted by the data: the result provides further evidence for parameter constancy of the obtained cointegrating relationship. We therefore decided to continue the analysis considering the "weak" PPP of the form:

$$e_G - 0.92(p - p_G),$$

to be a reasonable relationship expressing the long run foreign influence to Greek prices.

As indicated by the results of the weak exogeneity tests reported in the low part of Table 5.4, it is just German prices that can be considered as weakly exogenous with respect to the long run PPP parameters. The results are in agreement with those of multivariate testing for PPP in Chapter 4.

5.4.4 Long run analysis of the monetary sector.

The monetary view assumes that inflation is mainly demand-pull and therefore price increases are due to monetary growth in excess of the growth in real factors. The question investigated here is, therefore, whether monetary growth affects inflation in the long run or, in other words (empirically), whether the money stock is cointegrated with prices[6].

To this end, a VAR system for the vector of the form $z = (p, m)$ is estimated using multivariate least squares. The conditioning variables set includes centred seasonals a constant and a regime shift dummy. The variables included in the conditioning set are concentrated out of the likelihood function. Estimation is done using four lags of the variables, as likelihood ratio tests indicated. Table B.4 in Appendix 5.B reports the properties of the VAR residuals; they present no serial correlation or non-normality.

Table 5.6 presents the detailed results of the Johansen cointegration analysis. According to the outcomes of both statistics, there is no evidence for cointegration between the two series.

To conclude, cointegration analysis of the partial systems provide similar results as those of the general system in terms of existence, stability and economic interpretation of the long run relationships. This further strengthens the validity of the results. In addition, they provide reasonable results with respect to the exogeneity status of the involved variables.

[6]See also the Greek money demand analyses by Psaradakis (1993), and Ericsson and Sharma (1996) for recent attempts to investigate long-run interdependence between monetary variables and inflation in Greece.

Table 5.6: **Cointegration analysis of the monetary sector.**

Testing for the Π rank.

Eigenvalues	H_0	Max. Eigen.	95%	Trace	95%
0.08952	r = 0	7.597	14.1	8.73	15.4
0.01389	r ≤ 1	1.133	3.8	1.133	3.8

Standardised eigenvectors.		Adjustment coefficients.	
p	m	p	m
1	-0.9879	-0.0564	0.0274
-0.8072	1	-0.0013	-0.0151

5.4.5 Parameter constancy of the cointegrating relationships.

Cointegration analysis provided two reasonable long-run relationships which can be taken into account when modelling the short-run dynamics of inflation. However, before going on modelling, we further test for parameter constancy of the estimated long-run relationships.

Table 5.7: **The labour market vector: 1975.3-1985.3.**

Testing for the Π rank.

Eigenvalues	H_0	Max. Eigen.	95%	Trace	95%
0.5452	r = 0	31.52**	21.0	45.76**	29.7
0.2882	r ≤ 1	13.61	14.1	14.24	15.4
0.0159	r ≤ 2	0.642	3.8	0.642	3.8

Standardised eigenvectors.			Adjustment coefficients.		
w	p	su	w	p	su
1.000	-4.461	3.868	0.0173	-0.0006	-0.0869
-0.676	1.000	-0.233	0.4512	-0.1355	0.1706
0.367	-0.852	1.000	-0.0126	-0.0067	-0.0090

Testing for restrictions.

Hypothesis				$\chi^2(dof)$	p-value
	(w	p	su)		
$H_{W1'}$:	1	-1		5.581 (1)	[0.0181]*
	(1	-1	-0.20)		

As Clements and Hendry (1995), Mizon (1995) notice, inclusion of the cointegrating relationships as error correction terms in econometric models should be made with caution given that it has serious implications for the models' forecasting power: They often provide very good forecasts (even in cases where regime shifts have taken place during the examined period) because of the full sample error correction terms which reflect possible regime shifts.

A way to deal with this problem is by reestimating the obtained cointegrating relationships for a period up to the possible regime shift. To this end, we perform cointegration analysis for the two sectors for the period 1975.3 - 1985.3, given that 1985.4 seem to be characterised by an important shift on the implementation of macroeconomic policies.

Table 5.8: **The foreign sector vector: 1975.3-1985.3.**

Testing for the Π rank.

Eigenvalues	H_0	Max. Eigen.	95%	Trace	95%
0.5261	$r = 0$	29.87**	21.0	32.5*	29.7
0.0493	$r \leq 1$	2.022	14.1	2.631	15.4
0.0150	$r \leq 2$	0.608	3.8	0.608	3.8

Standardised eigenvectors.			Adjustment coefficients.		
p	e_G	p_G	p	e_G	p_G
1	-1.206	-1.430	-0.0509	0.0501	0.0215
-2.271	1	6.469	0.0245	-0.0338	0.0084
-0.103	-0.176	1	0.0192	0.1527	0.0015

Testing for restrictions.

Hypothesis				$\chi^2(dof)$	p-value
	(e_G	p	p_G)		
$H_{F1'}$:	1	-a	a	0.259 (1)	[0.6106]
	(1	-0.714	0.714)		

The results of the cointegration analysis for the reduced sample are reported in Tables 5.7 - 5.8. For both systems there is evidence for one cointegrating vector, results consistent with those of the full sample analysis. In addition, testing for the theoretical restrictions of interest provide similar results. This suggests that estimation of a dynamic model of the Greek price inflation using the reduced sample cointegrating vectors as error correction terms would lead to a similar specification to the full sample one, and, consequently, to similar *ex ante* forecasts.

5.5 A model of inflation

5.5.1 Encompassing the VAR

The next step is to model the short run dynamics of inflation, while taking into account the information of the long run structure. The aim is to combine all the competing theories and in order to do so, we model inflation using the following set of explanatory variables:

$I = (Dp_{t-j}, Dp_{Gt-j}, Dw_{t-j}, De_{Gt-j}, Dsu_{t-j}, Dm_{t-j}, ecm(w)_{t-1}, ecm(PPP)_{t-1})$;

j=0,1,2,3,4,5.

where $ecm(w)$ and $ecm(PPP)$ are the restricted cointegrating relationships derived by the analysis of the productive and foreign sectors respectively which are used as error correction terms. In other words, the information set contains present and past values of the growth of the series and the long run steady state relations derived in the sectoral analysis. It also contains a set of dummy variables to account for specific economic events, seasonals and a constant.

In a first step, analysis is made in a closed system which models jointly the behaviour of prices, wages, unemployment, money supply, and the Deutsch mark/ drachma exchange rate[7]. To this end, a fifth - order VAR named VECM(I), for the vector of the form (Dp, De_G, Dw, Dsu, Dm) which includes the cointegrating relationships $ecm(w)_{t-1}$, $ecm(PPP)_{t-1}$ as error correction terms, and a set of conditioning variables is estimated using multivariate least squares. The conditioning set includes a constant, seasonals, the dummies D791, D801, D811, D902 and German price inflation Dp_G, in all its five lags. The obtained acceptable diagnostics for its specification are given in Table C.1 in Appendix 5.C.

A first attempt to produce a simultaneous equation model resulted to model SEM(I) described in Table C.2 in Appendix 5.C; its diagnostics are reported in Table C.3 in Appendix 5.C. The interesting thing to note is that in the relevant equation, money growth depends mainly on its own lag values, (whereas the exchange rate growth lag is not significant, but its absence would mean worsening of the diagnostic tests); prices do not enter

[7]It is just the German price variable which is assumed to be strongly exogenous for the system; given the weak exogeneity results obtained in the cointegration analysis, it is mainly assumed that the rest of the system variables do not Granger cause German prices; this was done based on theoretical grounds and in order to keep the system manageable.

the money equation, implying that prices do not Granger cause money. The evidence, together with the weak exogeneity results of the cointegration analysis in subsection 5.4.1, imply that money can be considered strongly exogenous for the formation of prices, and, hence, that valid analysis can be performed in a conditional system modelling jointly Dp, De_G, Dw, and Dsu.

In a next step, a fifth-order VAR, named VECM(II) for the four variables is developed, in which Dm_j, where $j = 0, 1, 2, 3, 4, 5$, is included in the conditioning variables set. Its diagnostics presented in Table C.4 in Appendix 5.C indicate that it is welspecified, and hence can be used as a general system against which theoretical restrictions can be tested. Its sequential reduction based on statistical and theoretical criteria led to the preferred SEM(II) model. The specification of its equations are reported in Tables 5.9 (a) - 5.9 (c). All SEM(II) equations imply reasonable theoretical relations, which are analysed in the following subsection.

5.5.2 The system's theoretical properties.

The inflation equation

The specification of the inflation equation is given in table 5.9 (a). The equation, being in an error correction form, allows for different speeds of reaction to the different determinants of inflation, yet through the error correction terms ensures that the long-run relationships hold in steady state (see Davidson *et al* (1978)).

The equation's estimated coefficients are generally highly significant and they obtain the "right" expected sign. First of all, price inflation is significantly and positively influenced by its past values. Among the domestic labour variables, past wage inflation has an overall positive but very modest effect on inflation, evidence which gives some support to the cost-push theories; in addition, the deviations of the nominal wage from the steady state wage relation have a significant effect, which enters with the "right" sign. Taken together, these results indicate that there is a domestic part of Greek inflation which is quite important even though not dominant. However, adjustment to the long-run labour market equilibrium takes place very slowly as shown by the low ecm_w coefficient (0.038).

On the other hand, the foreign effect on Greek inflation short run dynamics turns out to be more important. First of all, Greek inflation is very sensitive to changes in the Deutsch mark/ drachma exchange rate with any devaluation of drachma having a positive and immediate effect on inflation. Second, the coefficient on the German inflation is very large; almost half (0.46) of German inflation feeds into Greek inflation. The results indicate strong foreign influence.

Table 5.9(a): **The preferred system SEM(II). (1975.4 - 1995.2)**

Equation for Dp

Variable	Coefficient	t-value	t-prob
Dp_{t-1}	0.18008	2.475	0.0159
Dp_{t-5}	0.17039	2.534	0.0137
Dw_{t-1}	-0.10098	-3.546	0.0007
Dw_{t-3}	0.13681	4.261	0.0001
Dw_{t-4}	-0.03586	-1.548	0.1264
Dm_{t-2}	-0.06226	-2.554	0.0130
Dm_{t-3}	0.08680	3.157	0.0024
$De_{(G)t}$	0.16867	5.021	0.0000
$De_{(G)t-1}$	0.06016	2.199	0.0314
$Dp_{(G)t}$	0.46276	1.847	0.0693
$Dp_{(G)t-1}$	0.30613	1.461	0.1489
Dsu_{t-4}	0.01606	1.033	0.3056
ecm(w)$_{t-1}$	0.03845	3.798	0.0003
ecm(PPP)$_{t-1}$	-0.01688	-8.726	0.0000
D791	0.02389	3.530	0.0008
D811	0.05068	6.715	0.0000
D831	-0.02406	-2.459	0.0166
D902	0.02857	4.479	0.0000
Seas$_t$	-0.04619	-9.615	0.0000
Seas$_{t-1}$	-0.02167	-5.802	0.0000
Seas$_{t-2}$	-0.05849	-14.404	0.0000

External transmission effects as a result of being out of equilibrium in the goods market are also estimated in the inflation formulation. The estimate of the speed of adjustment coefficient to the long-run "weak" PPP between Greece and Germany is quite significant but takes the very low value -0.016. This indicates that Greek prices adjust to possible disequilibria in the goods market, evidence which is against the nominal price stickiness hypothesis, but this adjustment to disequilibrium is very gradual.

Monetary effects play just an (overall positive but) modest role in inflation formation, as indicated by the significant but low coefficients obtained for the second and third lag of the money growth. Finally, unemployment exerts a very modest short run positive effect and a negative long run effect through the error correction term.

A number of interventions, also affect inflation formation as indicated by the effects of the impulse dummies which turned out significant in the model specification: they all have a very modest effect with the dummy D811 which accounts for the entrance of Greece in the EU (and a concequent rise of the agricultural product prices to adjust to the European ones) obtaining the largest coefficient. D791 accounts for the second oil price shock, D831 for a drachma devaluation, and D902 for the productive - labour sector restructuring. (Actually, the dummies D791 and D811 may indicate that the oil and agricultural product prices affect inflation. It should also be added that the dummy D831, even though is not significant, was kept in order to have normal residuals). Finally, seasonality affects inflation whereas the constant has a very low and insignificant effect.

The static long-run solution of the model given in table 5.9(a) can be derived if we set all growth rates equal to zero:

$$p = 0.71\ w + 0.31\ e_G + 0.29\ p_G - 0.071\ su$$

The long-run coefficient estimates are plausible and sensitive. Numerically, the coefficient on wages costs is the largest, followed by that on the exchange rate, and that on the foreign prices. Hence, the fundamental force in price formation, in the long run, is wages, followed by the exchange rate and the foreign prices, whereas unemployment (which can be considered as an excess demand variable), has a minor negative effect.

To conclude on the theoretical implications of the model, the model supports mainly the cost-push theories of inflation in which inflation is determined by both external and internal factors, whereas the monetary factors have a very modest direct short-run effect. This obviously does not mean that monetary policy does not affect inflation, given that monetary transmision pathways may include the exchange rate and nominal wage formation *inter alia*. In the model, foreign factors seem to play the most dominant role in the short run inflation determination, while mainly domestic but also foreign factors determine the long run equilibrium for inflation. However, even though inflation adjusts to possible disequilibria in the good and labour markets, (evidence against price stickiness), this adjustment is very gradual and slow.

The other equations

The other equations of SEM(II) reported in tables 5.9.(b), 5.9.(c) also imply reasonable theoretical relations.

Table 5.9 (b): The preferred SEM(II)

Variable	Coefficient	t-value	t-prob
Equation for De_G			
Dp_{t-2}	0.1945	1.871	0.0658
$De_{(G)t-1}$	0.1781	2.438	0.0175
$Dp_{(G)t-2}$	1.1299	2.405	0.0190
ecm(PPP)$_{t-1}$	-0.0054	-3.542	0.0007
D831	0.1508	8.214	0.0000
D832	-0.0759	-3.589	0.0006
D801	-0.0822	-4.334	0.0001
D854	0.1643	8.873	0.0000
Seas$_{t-2}$	-0.0155	-2.815	0.0064
Equation for Dsu			
Dp_{t-1}	0.6370	1.985	0.0513
Dw_{t-3}	-0.1182	-1.066	0.2883
Dsu_{t-2}	0.0724	0.805	0.4237
Dsu_{t-3}	0.1059	1.186	0.2398
Dsu_{t-4}	-0.3603	-4.171	0.0001
ecm(w)$_{t-1}$	0.2792	5.638	0.0000
D801	0.0283	0.793	0.4305
D902	-0.0194	-0.550	0.5839
Seas$_t$	-0.0220	-1.200	0.2345
Seas$_{t-1}$	-0.0146	-1.073	0.2872
Seas$_{t-2}$	-0.0168	-1.033	0.3054
Constant	0.1811	5.467	0.0000

The growth in unemployment is again affected by the history of the process; the error correction term enters its equation with the "right" sign and a relatively high valued and significant coefficient. High unemployment persistence is also indicated by the equation: the equation reparameterised in levels implies that present unemployment is determined by its first lag by a coefficient of 0.972. This may be due to insider-outsider effects and labour market rigidities.

The exchange rate movements depend positively on its past values and the German price changes; the low error correction term coefficient implies slow adjustment to equilibrium; finally, the drachma devaluation dummies turn out significant in its specification.

The wage inflation is positively affected by its own history and the price inflation rate, whereas the growth in unemployment exercises an overall negative effect.

Table 5.9 (c): The preferred SEM(II)

Variable	Coefficient	t-value	t-prob
Equation for Dw			
Dw_{t-1}	0.1627	1.566	0.1223
Dw_{t-3}	0.2475	2.235	0.0288
Dw_{t-4}	0.1833	1.809	0.0751
Dp_{t-4}	-0.5088	-2.067	0.0427
Dp_{t-5}	0.4274	1.791	0.0780
Dsu_{t-1}	-0.0924	-1.560	0.1236
Dsu_{t-4}	0.0787	1.346	0.1829
D801	0.0705	2.752	0.0077
D811	0.0579	2.333	0.0228
D831	-0.0642	-2.493	0.0152
$Seas_{t-1}$	-0.0249	-1.536	0.1294
$Seas_{t-1}$	-0.0111	-1.092	0.2789
$Seas_{t-1}$	-0.0441	-2.485	0.0155
Constant	0.0404	2.676	0.0094

5.5.3 The system's statistical properties.

The system's diagnostics.

The system values obtained for the diagnostics of the equations' residuals are reported in Table 5.10. The system can still be considered relatively wellspecified even though there is evidence for serial correlation in the residuals for Dsu. Nevertheless, it should be noted that a number of factors which may play an important role in explaining the dynamics of the misspecified equation were not taken into consideration as the main purpose of the present analysis was to take into account the feedback effects of price inflation to the rest of the variables, and not proper modelling of their behaviour.

Table 5.10: System's diagnostics

Standard deviations		
Dp	0.0061055	
De_G	0.0178237	
Dsu	0.0341005	
Dw	0.0228675	
Equation residual tests		
AR F(.,.)	F(5, 39)	t-value
Dp	2.3311	[0.0605]
De_G	3.4234	[0.0117] *
Dsu	3.8729	[0.0047]**
Dw	2.2167	[0.0720]
N χ^2 (2) (cr.value: 5.99)		
Dp	2.2890	[0.3184]
De_G	6.0804	[0.0478] *
Dsu:	0.2293	[0.8917]
Dw	5.7318	[0.0569]
VAR residual tests		
$VecAR$ 1-5 F(80,168)	0.96201	[0.5706]
$VecN$ χ^2 (8)	13.395	[0.0990]

Parameter constancy, forecasting and encompassing

Parameter constancy

To test for parameter constancy of the inflation model, it was decided to test it for the post 1985.4 period. This was decided given that from 1985 and on, we observe a switch in the macroeconomic policies followed in Greece. The policies are now more restrictive and are characterised by modest state interventions; moreover, the years after 1985 are characterised by the openning of the Greek economy to the international competitive environment and the gradual independence of the Bank of Greece (see also Maroulis (1996)).

Nevertheless, testing the model for parameter constancy for this period is of interest, given that it covers a number of policy switches. The years 1989 - 1991 are characterised by relative political and economic instability given that a number of short-lived governments succeed each other, and pursue different policies. The 1990 - 1993 conservative goverment episode is followed by a socialist government one.

To this end, the model is reestimated by recursive least squares for that period using a specification without the D902 dummy. The graphs of the recursively computed 1-step ahead by twice their standard errors are plotted in figure 5.6. They revealed no serious indication of parameter non-constancy in the inflation equation though there is a suggestion of some nonconstancy around 1990.2, (the quarter of the government change which meant changes in the labour market institutions) for the inflation equation.

Forecasting

The forecasting strength of the model is also asessed. The model was reestimated with sample data for 1975.4 - 1985.3 and then used to forecast Dp, De_G, Dw and Dsu for the period 1985.4 - 1995.2. The outcome is reasonable as indicated by the graphs in Figure 5.7. The forecasts track the behaviour of inflation very well.

The satisfactory forecasting performance of SEM(II) is further indicated by the outcomes of the forecasting statistics reported in Table 5.11. The statistics also reveal that it forecasts better than the general VECM(II). Finally, the means and standard deviations for the forecast errors given also in 5.11 indicate that the best forecasts are achieved for the inflation equation.

The forecasting ability of the model is of particular importance given that, all forecasting values of the series have been provided by the system. In addition, even though the forecasts cannot be considered as *ex ante* given that they have been estimated using the full sample error correction terms, cointegration analysis for the reduced sample performed in the previous section, provided with similar cointegrating vectors. Therefore, it is very likely that inflation modelling for the reduced period would have produced a SEM with a similar specification.

Table 5.11: **Evaluation of forecasting abillity**

VECM(II): Period 1985 (4) to 1995 (2)	
F_1 using Ω	F(156,7)= 8.8029 [0.0026]**
F_2 using V[e]	F(156,7)= 1.5347 [0.2874]
F_3 using V[E]	F(156,7)= 1.6796 [0.2410]
SEM(II): Period 1985 (4) to 1995 (2)	
F_1 using Ω	F(156,27)= 2.0602 [0.0149]*
F_2 using V[e]	F(156,27)= 1.3431 [0.1859]

Descriptive statistics of forecast errors.

VECM(II)				
	Dp	Dw	Dsu	De_G
Mean	0.00602	-0.02022	0.01156	-0.03724
SD	0.01906	0.06424	0.07184	0.039886
SEM(II)				
	Dp	Dw	Dsu	De_G
Mean	0.00602	-0.02191	0.00312	-0.00163
SD	0.01069	0.02505	0.03030	0.03031

Encompassing

Loosely speaking, encompassing is the ability of one model to account for the results of another model. At a conceptual level, the model SEM(II) encompasses a range of alternative models presented in the literature, given that it embeds the alternative theoretical arguments for inflation formation. In addition, because it is empirically constant, broad classes of models may not encompass it, even in principle.

In the present study, a parameter constant inflation equation was also estimated in Chapter 3, in the context of a different system, SEM1. Even though conceptually the present model SEM(II) encompasses that in Chapter 3 (given that it is more general), it was decided to compare the two models formally. To this end, they are compared based on the restrictions that they imply against a general model that encompasses both of them: According to the test statistics values obtained, SEM(II) encompasses the general model (the relevant χ^2 statistic value is $\chi^2(107) = 99.18$ [p-value = 0.6921]), whereas SEM1 does not ($\chi^2(122) = 238.22^{**}$ [p-value = 0.0000]).

5.6 Conclusions.

The aim of the present chapter was to determine the factors that contributed to the formation (acceleration) of inflation in Greece over the last twenty years. To this end, Greek inflation was investigated in terms of three kinds of macroeconomic explanations: 1) internal theories which assume inflation as cost-push and pay particular attention to the wage-price spiral, 2) external theories which emphasise the foreign transmission effects on small open economies and 3) monetarist theories which view inflation as a monetary phenomenon.

In the analysis, particular attention was given to the investigation of the existence of three long run "key" relationships among the variables that possibly determine inflation: that between wages and prices, that between foreign and domestic prices and that between money and prices. In order to do so, cointegration analysis is performed in three VAR systems modelling the alternative sectors, as well as in a general VAR modelling the interractions among them. The following two equilibrium relationships finally come out from the analysis: a) a long run wage relation in which nominal wages follow consumer prices with positive unemployment effects, and b) a "weak" PPP relationship between Greece and the country which can be considered to proxy the EMS countries, Germany.

Then, the obtained long run relationships were used in modelling the short run dynamics of inflation. Dynamic modelling was done in a system of equation context, consistent with the exogeneity testing results of the cointegrating analysis. It led to a system which provided with an inflation equation which is wellspecified and has constant parameters. According to it, Greek inflation is mainly cost push, determined by both external and domestic factors, whereas monetary factors have very modest short-run effects. In its short run dynamics, it is strongly affected by foreign factors and to a less extent by domestic forces. Nevertheless, the long run solution of the model indicate, that in the long run inflation is determined mainly by wages and to a less extend by the exchange rate and foreign prices, in order of significance. Finally, even though inflation adjusts to possible disequilibria in the good and labor markets, (evidence against price stickiness), this adjustment is very gradual and slow.

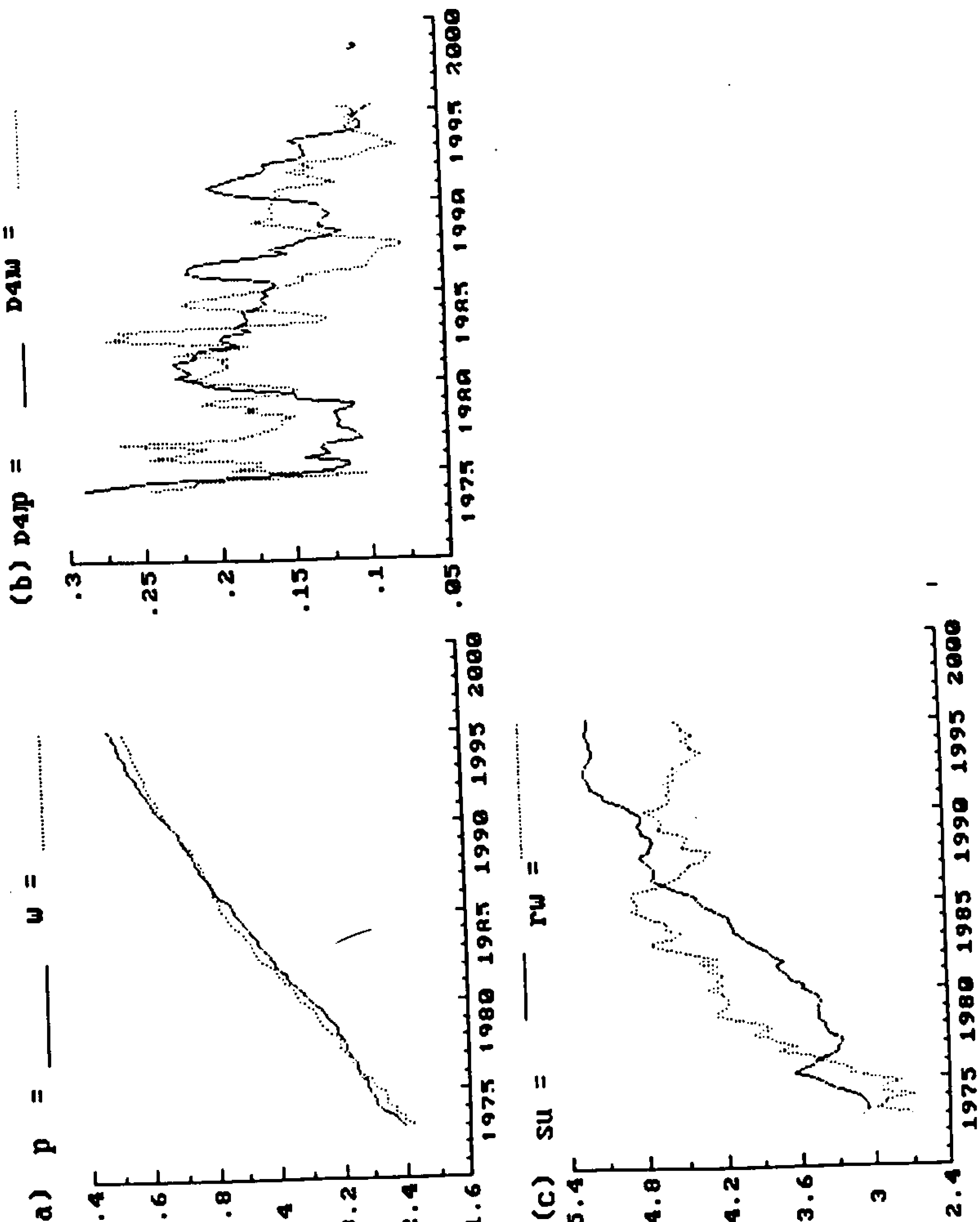

Figure 5.1: The productive sector series

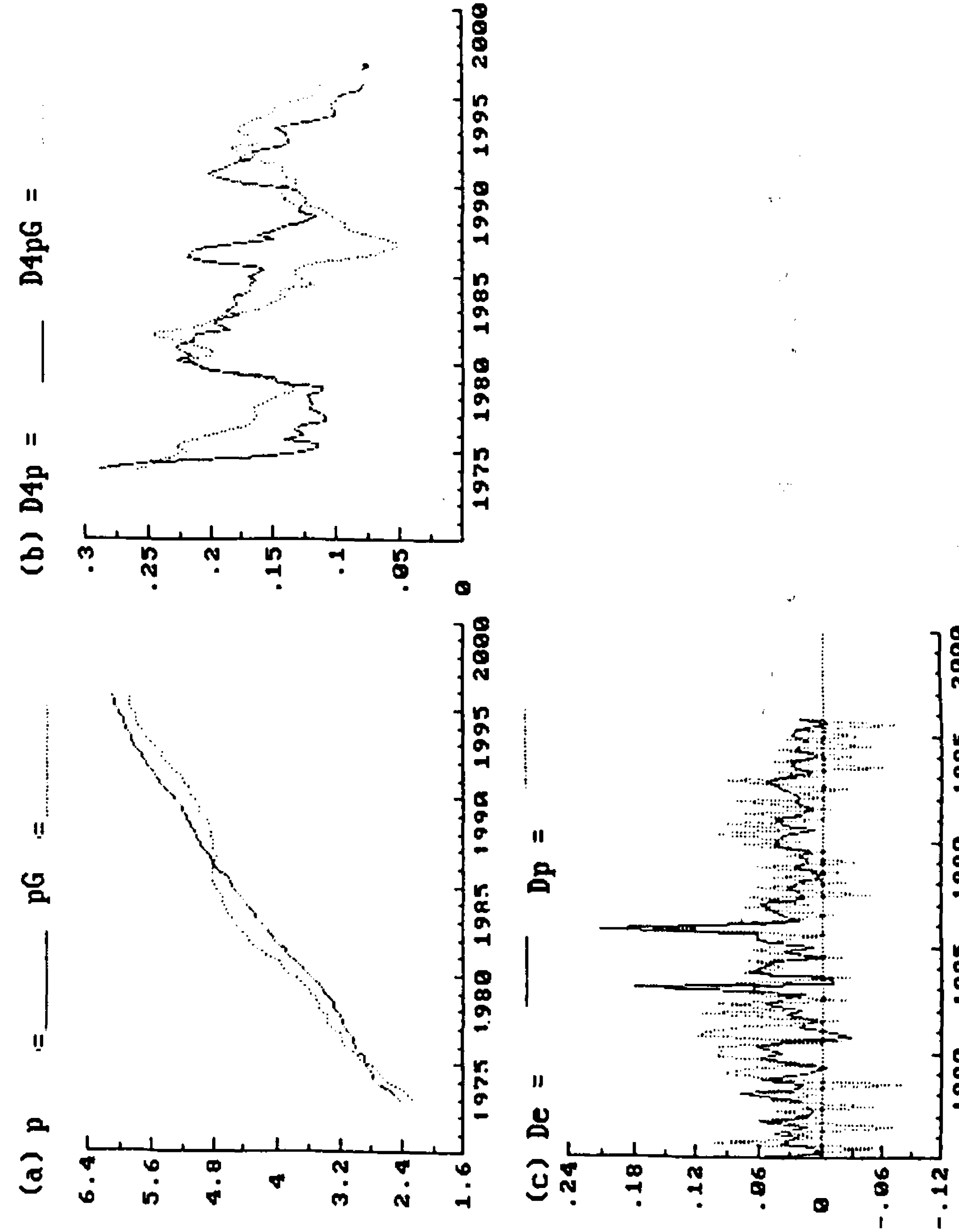

Figure 5.2: Foreign sector series 1

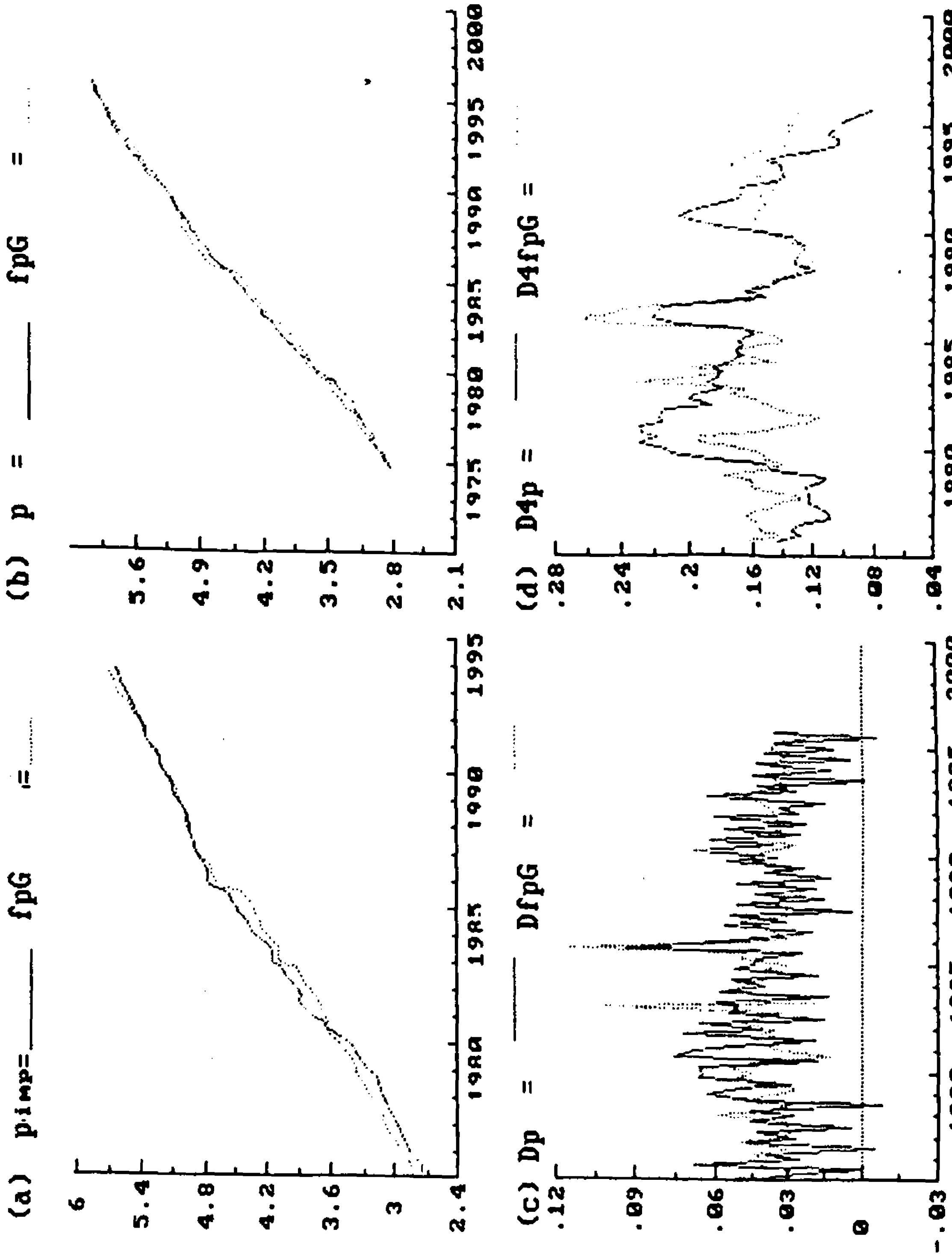

Figure 5.3: Foreign sector series 2

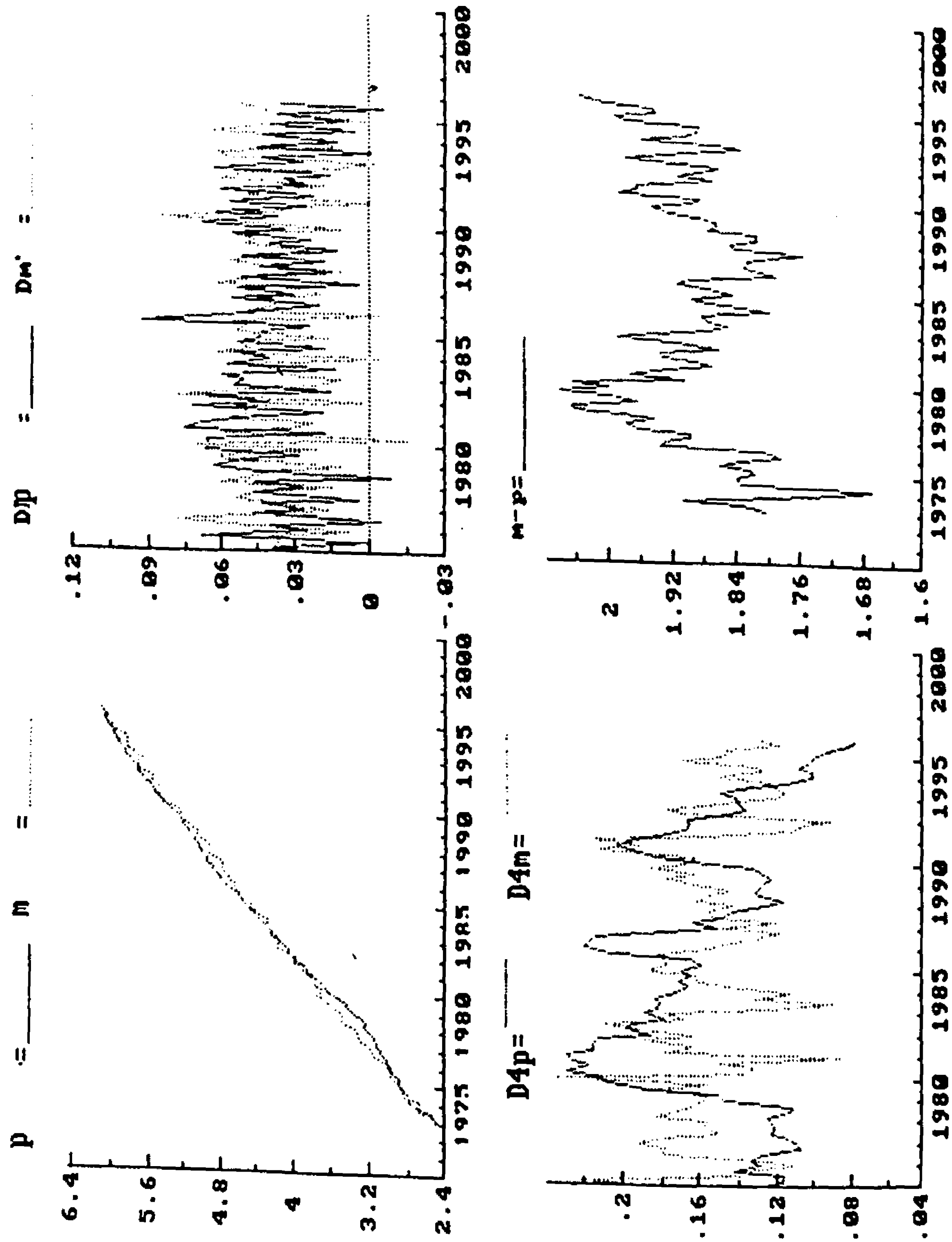

Figure 5.4: Monetary sector series

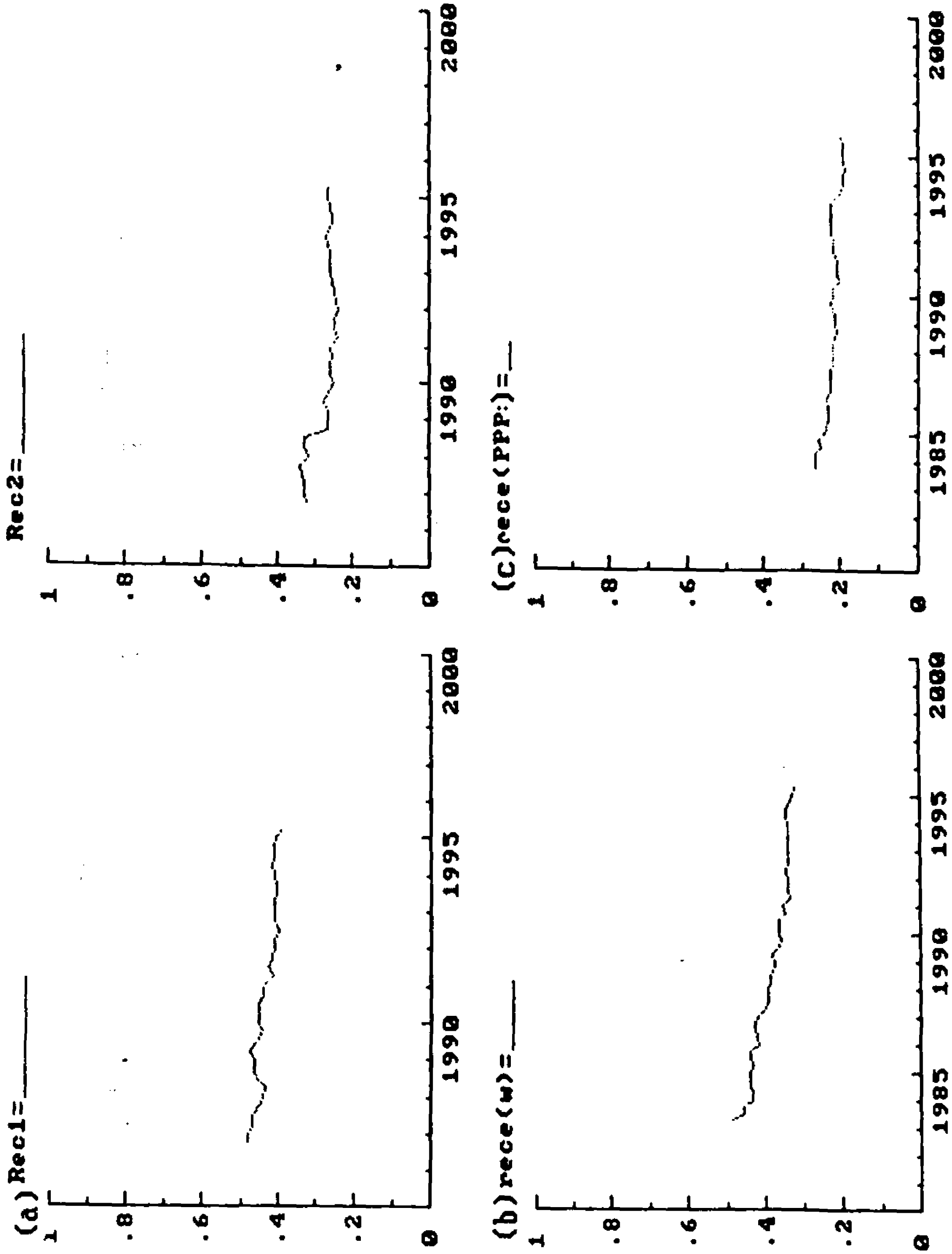

Figure 5.5: Recursive eigenvalues of the systems

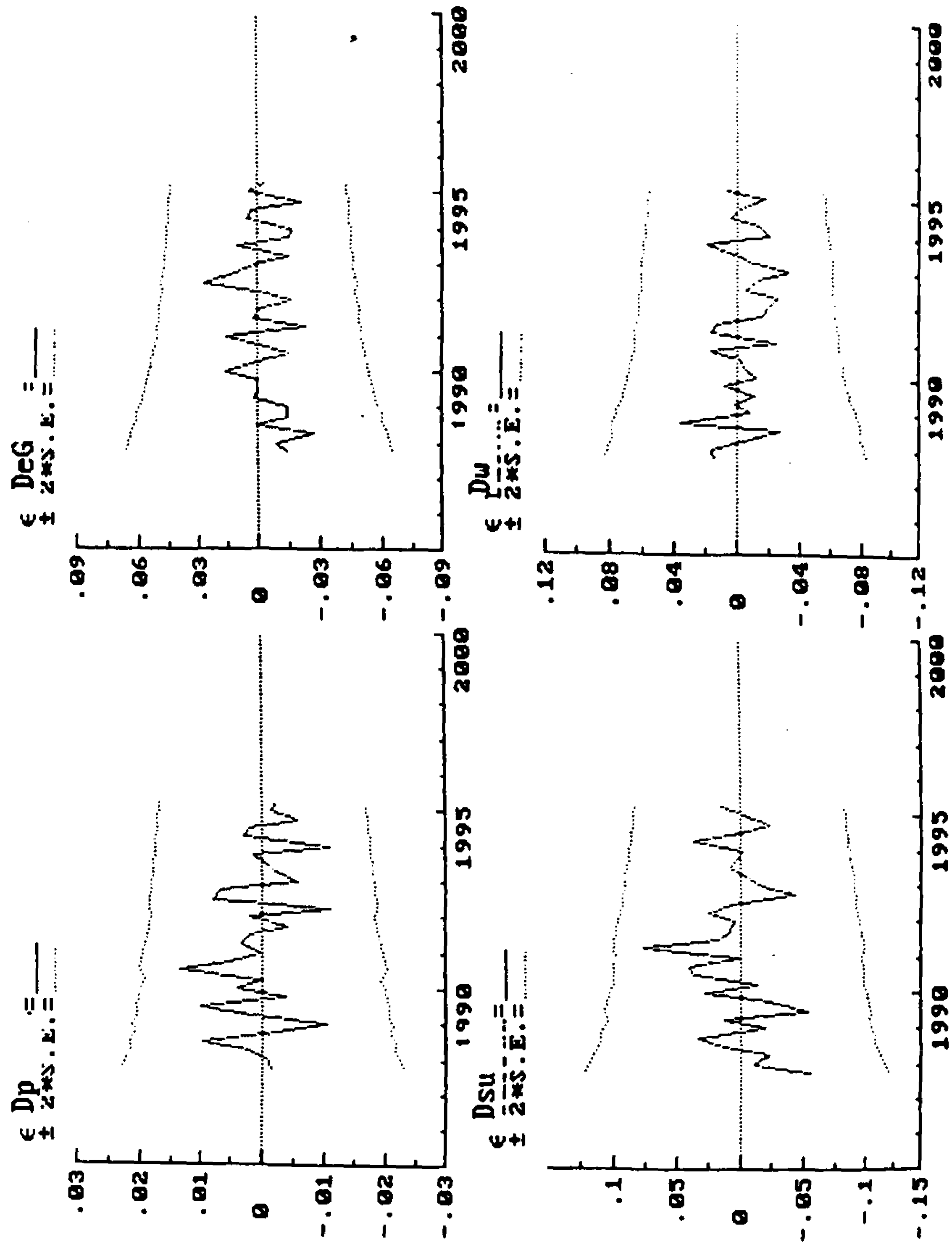

Figure 5.6: Recursively estimated 1-step residuals

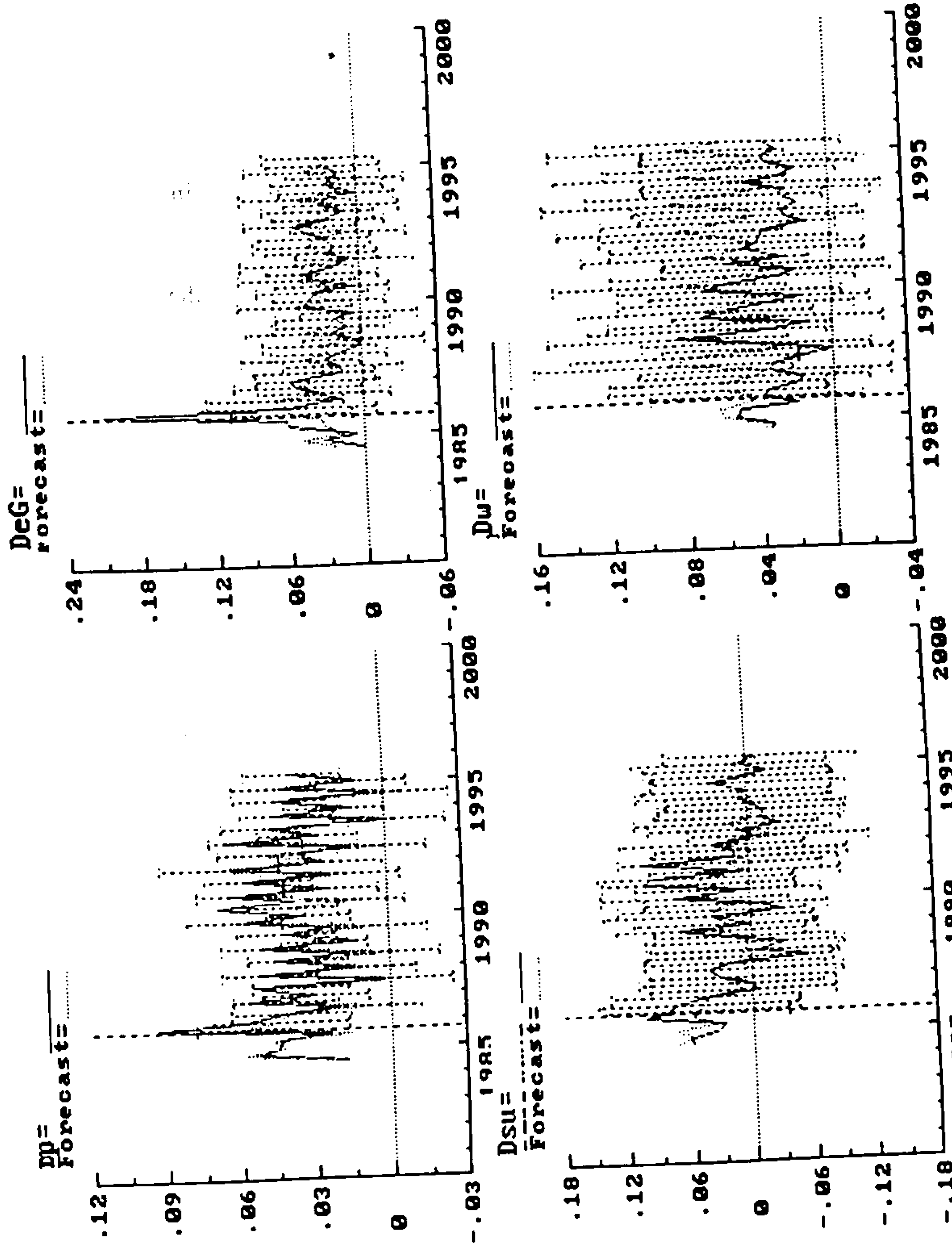

Figure 5.7: Forecasts of SEM(II)

Appendix 5.A: Definition of the regime shift dummy variables

- D791: 1 in 1979:1; 0 otherwise: To account for the sharp rise in the prices of oil products.
- D801: 1 in 1980:1; 0 otherwise: To account for a decline in the money demand caused by a rise in the deposit interest rates that took place in 1979.4.
- D811: 1 in 1981:1; 0 otherwise: In January 1981, Greece becomes an EEC member-country.
- D831: 1 in 1983:1; 0 otherwise: In January 1983 the Greek drachma is devalued by 15,5%.
- D854: 1 in 1985:4; 0 otherwise: In October 1985 measures for a stabilization package include a drachma devaluation by 15%.
- D902: 1 in 1990:2; 0 otherwise: To account for a number of restrictive policies concerning mainly the functioning of the productive sector taken by the newly elected (in April 1990) conservative government.
- D924: 1 in 1992:4; 0 otherwise: To account for the withdrawal of major currencies from the ERM in September 1994.

Appendix 5.B: Diagnostics of the initial VARs

Table B.1: **Diagnostics of the general VAR.**

Sample:	1975.4-1995.2	
Dummy Variables	D801, D802, D831, D854, D903.	
Lags used:	4	
Equation residual tests		
AR F(.,.)	F(5, 45)	t-value
p	2.436	[0.0489] *
fp_G	0.880	[0.5018]
w	0.771	[0.5751]
su	2.150	[0.0766]
m	2.386	[0.0529]
N χ^2 (2) (cr.value: 5.99)		
p	4.802	[0.0906]
fp_G	8.772	[0.0125] *
w	6.415	[0.0405] *
su	5.492	[0.0642]
m	3.991	[0.1359]
VAR residual tests		
$VecAR$ F(125,108)	1.1382	[0.2452]
$VecN$ $\chi^2(10)$	23.78	[0.0082] **

Table B.2: **Diagnostics of the productive sector VAR.**

Sample:	1975.3-1995.2	
Dummy Variables	D854, D903.	
Lags used:	4	

Equation residual tests

AR F(.,.)	F(5, 57)	t-value
w	1.7747	[0.1327]
p	1.5898	[0.1777]
su	2.0736	[0.0820]
N χ^2 (2) (cr.value: 5.99)		
w	1.9451	[0.3781]
p	4.1121	[0.1280]
su	3.6162	[0.1640]

VAR residual tests

VecAR F(45, 134)	1.1713	[0.2433]
VecN $\chi^2(6)$	8.9987	[0.1737]

Table B.3: **Diagnostics of the foreign sector VAR.**

Sample:	1975.3-1995.2	
Dummy Variables	D791, D801, D831, D832, D854, D861, D924, D931.	
Lags used:	3	

Equation residual tests

AR F(.,.)	F(5, 55)	t-value
p	2.0662	[0.0836]
e_G	1.2299	[0.3077]
p_G	2.5138	[0.0547]
N χ^2 (2) (cr.value: 5.99)		
p	2.6977	[0.2595]
e_G	7.6089	[0.0223] *
p_G	2.7493	[0.2529]

VAR residual tests

$VecAR$ 1-5 F(45,128)	1.2456	[0.1717]
$VecN$ $\chi^2(6)$	12.821	[0.0460] *

Table B.4: **Diagnostics of the monetary sector VAR.**

Sample:	1975.2-1995.2	
Dummy Variables	D801.	
Lags used:	4	

Equation residual tests

AR F(.,.)	F(5, 63)	t-value
p	0.7584	[0.5831]
m	0.9672	[0.4447]
N χ^2 (2) (cr.value: 5.99)		
p	2.2616	[0.3228]
m	2.4281	[0.2970]

VAR residual tests

VecAR 1-5 F(20,114)	1.1274	[0.3324]
VecN $\chi^2(4)$	4.5964	[0.3313]

Appendix 5.C: The SEM(I)

Table C.1: **VECM (I) diagnostics**

Equation residual tests		
AR F(.,.)	F(5, 40)	t-value
Dp	1.1894	[0.3316]
De_G	0.8689	[0.5104]
Dm	0.8552	[0.5194]
Dsu	1.0048	[0.4274]
Dw	1.6159	[0.1780]
N χ^2 (2) (cr.value: 5.99)		
Dp	1.5019	[0.4719]
De_G	1.8317	[0.4002]
Dm	2.9081	[0.2336]
Dsu	0.2746	[0.8717]
Dw	6.2294	[0.0444] *
VAR residual tests		
VecAR 1-5 F(125, 187)	1.02	[0.4661]
VecN χ^2 (10)	11.032	[0.3550]

Table C.2: **The five-dimensional SEM(I).**

Variable	Coefficient	t-value	t-prob
Equation for Dp			
Dp_{t-1}	0.19339	2.687	0.0091
Dp_{t-3}	0.06800	1.126	0.2641
Dp_{t-5}	0.17419	2.520	0.0142
Dw_{t-1}	-0.09402	-3.042	0.0034
Dw_{t-3}	0.13241	3.937	0.0002
$De_{(G)t}$	0.15540	4.685	0.0000
$De_{(G)t-1}$	0.04764	1.677	0.0983
Dm_{t-3}	0.11507	4.437	0.0000
$Dp_{(G)t}$	0.48386	2.362	0.0211
$\mathrm{ecm(w)}_{t-1}$	0.02866	2.739	0.0079
$\mathrm{ecm(PPP)}_{t-1}$	-0.01386	-6.767	0.0000
Dsu_{t-4}	0.01163	0.708	0.4815
D811	0.05049	6.529	0.0000
D791	0.02513	3.609	0.0006
D902	0.02678	3.965	0.0002
D801	0.02852	4.138	0.0001
D831	-0.02535	-2.658	0.0099
Seas_t	-0.05153	-11.401	0.0000
Seas_{t-1}	-0.02033	-5.183	0.0000
Seas_{t-2}	-0.05715	-13.470	0.0000

Variable	Coefficient	t-value	t-prob
Equation for Dw			
Dw_{t-1}	0.11147	1.075	0.2861
Dw_{t-3}	0.21633	1.982	0.0516
Dw_{t-4}	0.18371	1.848	0.0691
Dp_{t-4}	-0.46454	-1.906	0.0609
Dp_{t-5}	0.42808	1.816	0.0740
Dsu_{t-1}	-0.08951	-1.529	0.1310
Dsu_{t-4}	0.07605	1.318	0.1920
D831	-0.06133	-2.411	0.0187
D811	0.05604	2.282	0.0257
D801	0.07058	2.776	0.0071
Seas_t	-0.02393	-1.490	0.1410
Seas_{t-1}	-0.01067	-1.056	0.2948
Seas_{t-2}	-0.04203	-2.394	0.0195
Constant	0.04145	2.775	0.0072
Equation for *Dsu*			
Dsu_{t-2}	0.07657	0.962	0.3918
Dsu_{t-3}	0.14043	1.590	0.1165
Dsu_{t-4}	-0.35833	-4.221	0.0001
Dw_{t-3}	-0.16923	-1.117	0.2680
Dp_{t-1}	0.58797	1.863	0.0669
ecm(w)_{t-1}	0.27285	5.600	0.0000
Constant	0.18052	5.536	0.0000
Seas_t	-0.02085	-1.149	0.2549
Seas_{t-1}	-0.01544	-1.145	0.2563
Seas_{t-2}	-0.01607	-0.995	0.3233

Variable	Coefficient	t-value	t-prob
Equation for Dm			
Dm_{t-1}	-0.32661	-4.122	0.0001
Dm_{t-3}	-0.16433	-1.932	0.0576
Dm_{t-4}	-0.23242	-2.298	0.0247
$De_{(G)t-1}$	-0.14591	-1.431	0.1572
D801	0.11170	3.876	0.0002
D854	0.03801	1.325	0.1898
$Seas_t$	-0.06435	-6.812	0.0000
$Seas_{t-2}$	0.04351	4.945	0.0000
Constant	0.07935	8.788	0.0000
Equation for $De_{(G)t}$			
$De_{(G)t-1}$	0.1857	2.560	0.0128
$Dp_{(G)t-1}$	-1.2074	-2.768	0.0073
$Dp_{(G)t-2}$	1.1655	2.496	0.0151
Dp_{t-2}	0.1959	1.898	0.0621
$ecm(PPP)_{t-1}$	-0.0052	-3.483	0.0009
D831	0.1515	8.334	0.0000
D801	-0.0824	-4.371	0.0000
D854	0.1639	8.912	0.0000
$Seas_{t-2}$	-0.0157	-2.874	0.0054

Table C.3: **SEM(I) diagnostics**

Standard deviations		
Dp	0.006345	
De_G	0.017687	
Dm	0.028304	
Dsu	0.033877	
Dw	0.022656	
Equation residual tests		
AR F(.,.)	F(5, 40)	t-value
Dp	3.5105	[0.0101] *
De_G	3.4626	[0.0110] *
Dm	7.2374	[0.0001] **
Dsu	4.3126	[0.0031] **
Dw	2.2549	[0.0674]
N χ^2 (2) (cr.value: 5.99)		
Dp	1.4399	[0.4868]
De_G	5.8740	[0.0530]
Dm	4.9103	[0.0858]
Dsu	0.1294	[0.9373]
Dw	7.8043	[0.0202] *
VAR residual tests		
$VecAR$ 1-5 F(125, 187)	0.99538	[0.5069]
$VecN$ χ^2 (4)	16.371	[0.0895]

Table C.4: **VECM (II) diagnostics**

Equation residual tests		
AR F(.,.)	F(5, 26)	t-value
Dp	0.664	[0.6540]
De_G	1.919	[0.1254]
Dsu	0.698	[0.6298]
Dw	0.421	[0.8295]
N χ^2 (2) (cr.value: 5.99)		
Dp	4.4197	[0.1097]
De_G	2.1821	[0.3359]
Dsu	4.1063	[0.1283]
Dw	0.02639	[0.9869]

VAR residual tests		
VecAR 1-5 F(80, 33)	1.081	[0.4109]
VecN χ^2 (10)	10.804	[0.2131]

Bibliography

[1] Alogoskoufis, G. (1986), "On the Determinants of Consumer Price Inflation in Greece", Greek Economic Review, 8, 245-266.

[2] Alogoskoufis, G. (1989), "Macroeconomic Policy and the External Constraint in the Dependent Economy: The Case of Greece" Birkbeck College Discussion Paper, no 89/3.

[3] Alogoskoufis, G. (1996), "The two faces of Janus: Institutions, Policy Regimes and Macroeconomic Performance in Greece", Economic Policy, 149-184.

[4] Alogoskoufis, G. and N. Christodoulakis (1991), "Fiscal Deficits, Seignorage and External Debt: The Case of Greece", in G. Alogoskoufis, L. Papademos and R. Portes (eds.), External Constraints on Macroeconomic Policy: The European Experience, Cambridge, Cambridge University Press and CEPR.

[5] Alogoskoufis, G. and A. Philippopoulos (1991), "Political parties, elections and exchange rate regimes: On the deeper determinants of inflation in Greece", Birkbeck College discussion paper no 5/91.

[6] Artis, M. and Kontolemis, Z. (1994), "Inflation in the UK in the 1980s", mimeo. European University Institute and University of Manchester.

[7] Banerjee A. and Hendry D.F. (1992), "Testing Integration and Cointegration: an Overview", Oxford Bulletin of Economics and Statistics, 54, 3, 225 - 255.

[8] Box, G.E.P. and Jenkins, G.M (1970), "Time Series Analysis Forecasting and Control", San Francisco: Holden-Day.

[9] Browne, F. and J. Fell (1996), "The Changing Institutional Context of Monetary Policy and its Implications for Inflation", mimeo, European Monetary Institute.

[10] Cheung, Y-W. and K.S. Lai (1993), "Finite -sample sizes of Johansen's Likelihood Ratio Tests for Cointegration", Oxford Bulletin of Economics and Statistics, 55, 313-328.

[11] Clements, P. M. and Hendry D. F. (1995), "Macroeconomic Forecasting and Modelling", The Economic Journal, 105, 1001-1013.

[12] Clements, M. P. and Mizon, G.E. (1991), "Empirical Analysis of Macroeconomic Time Series: VAR and Structural Models", European Economic Review, 35, 887 - 932.

[13] Davidson, J.E.H., Hendry, D.F., Srba, F. and Yeo, J.S. (1978), "Econometric Modelling of the Aggregate time seies Relationship between Consumer's Expenditure and Income in the United Kingdom", Economic Journal, 88, 661-692.

[14] De Brower, G. and N.R. Ericsson (1995), "Modelling Inflation in Australia", International Finance Discussion Papers, no 530.

[15] Dickey, D. and Fuller, W. (1981), "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", Econometrica, 49, 1657-1672.

[16] Dogas, D. (1992), "Market Power in a Non Monetarist Inflation Model of Greece", Applied Economics, 24, 367-378.

[17] Doornik, J.A. and Hendry, D.F. (1994), "PC-GIVE and PC-FIML Professional, Version 8: An Interactive Econometric Modelling System", London: International Thomson.

[18] Ericsson, N.R., Hendry D. F. and Tran H. (1993), "Cointegration, Seasonality, Encompassing and the Demand for Money in the United Kingdom", International Finance Discussion Papers, no 457.

[19] Ericsson, N.R. and S. Sharma (1996), "Broad Money Demand and Financial Liberalisation in Greece", International Finance Discussion Papers, no 559.

[20] Giavazzi, F. (1996), Comment on Alogoskoufis, G. (1996), "The two faces of Janus: Institutions, Policy Regimes and Macroeconomic Performance in Greece", Economic Policy, 149-184.

[21] Gomez, V. and Maravall, A. (1994),"Estimation, Prediction and Interpolation for Nonstationary Series with the Kalman Filter". Journal of the American Statistical Association, 89, 611-624.

[22] Gonzalo, J. (1994), "Five Alternative Methods of Estimating Long Run Equilibrium Relationships", Journal of Econometrics, 60, 203-233.

[23] Hendry, D.F. (1989)," PC-GIVE: An Interactive Econometric Modelling System", Oxford: Oxford Institute of Economics and Statistics.

[24] Hendry, D.F. (1995), "Dynamic Econometrics", Oxford: Oxford University Press.

[25] Hendry, D.F. and Mizon G.E. (1993), "Evaluating Dynamic Econometric Models by Encompassing the VAR", chapter 18 in Models, Methods and Applications of Econometrics, Essays in Honor of Rex Bergstom, Phillips, P.C.B. (ed.), Oxford: Basil Blackwell, 272 - 300.

[26] Hendry, D.F. and A. J. Neale (1991), "A Monte Carlo Study of the Effects of Structural Breaks on Tests for Unit Roots", Chapter 8 in Hackl, P., and A.H. Westlund (eds.), Economic Structural Change, Analysis and Forecasting, IIASA and Springer-Verlag, Berlin.

[27] Hylleberg, S. (ed) (1992), "Modelling seasonality", Oxford University Press, Oxford.

[28] Johansen, S. (1992), "An I(2) Cointegration Analysis of the Purchasing Power Parity between Australia and the United States", chapter 9 in C.P. Hargreaves (ed.) Macroeconomic Modelling in the Long Run, Aldershot, Hants, England, Edward Elgar, 229-248.

[29] Juselius, K. (1992), "Domestic and Foreign Effects on Prices in an Open Economy: The Case of Denmark", Journal of Policy Modeling, 14, 401 - 428.

[30] Juselius, K. (1991), "Long-run Relations in Australian Monetary Data", University of Copenhagen, Institute of Economics, Discussion Paper no 91-18.

[31] Katseli, L. (1990a), "Economic Integration in the Enlarged European Community: Structural Adjustment of the Greek Economy"in Bliss, C. and J. de Macedo (eds), Unity with Diversity in the European Economy: The Community's Southern Frontier, Cambridge University Press and CEPR, Cambridge and London.

[32] Katseli, L. (1990b), Comment on Daniel Gros "Seignorage and EMS discipline" in De Grauwe, P. and L. Papademos (eds), the European Monetary System in the 1990's. CEPR and the Bank of Greece, Longman, London and New York.

[33] Leventakis, J. and Brissimis, S. (1980), "Two Econometric Models for the Explanation of Inflation in Greece: 1958 - 1978", The Greek Economy, Bank of Greece, Athens (in Greek).

[34] Maravall, A. and Gomez, V. (1994),"Program SEATS, Signal Extraction in ARIMA Time Series: Instructions for the User", European University Institute Working Paper ECO, no 94/28.

[35] Maroulis, D. (1996), Comment on Alogoskoufis, G. (1996), "The two faces of Janus", Studies of Economic Policy, 1, 65-69 (in Greek).

[36] Mizon, G.E. (1995), "Progressive Modelling of Macroeconomic Time-series: The LSE Methodology", in K. D. Hoover (ed), Macroeconometrics: Developments, Tensions and Prospects, Derdrecht: Kluwer.

[37] Moschos, D. and Stournaras, Y. (1991), "Domestic and Foreign Price Links in an Aggregate Supply Framework: The case of Greece", Discussion Paper, Center of Economic Research, University of Athens.

[38] Papademos, L. (1990), Greece and the EMS: Issues, Prospects and a Framework for Analysis" in De Grauwe, P. and L. Papademos (eds), the European Monetary System in the 1990's, CEPR and the Bank of Greece, Longman, London and New York.

[39] Papadopoulos, A., (1993), "The Effects of Monetary, fiscal and Exchange Rate Policies on Output, Prices and the Balance of Payments in the Open Economy of Greece: 1955-1990", Applied Economics, 25, 879-890.

[40] Perron, P., (1989), "The Great Crash, the Oil Shock and the Unit Root Hypothesis", Econometrica, 57, 1361-1402.

[41] Perron, P., (1990), "Testing for a Unit Root in Time Series with a Changing Mean", Journal of Business and Economic Statistics, 8, 153-162.

[42] Psaradakis, Z. (1993), "The Demand for Money in Greece: An Exercise in Econometric Modelling with Cointegrated Variables", Oxford Bulletin of Economics and Statistics, 55, 2, 215-236.

[43] Sarantis, N., (1984), "Expectations, Unemployment, Trade Unions and Wage Inflation in Greece", Greek Economic Review, 4, 284-302.

[44] Spanos, A.,(1986), "Statistical Foundations of Econometric Modelling", Cambridge: Cambridge University Press.

[45] Stournaras, Y., (1992), "Greece on the Road to Economic and Monetary Union: Problems and Prospects", in Gibson, H., D. and Tsakalotos, E. (eds), "Economic and Financial Liberalisation: Prospects for Southern Europe", MacMillan Press, London.

[46] Surrey, M.J.C., (1989), "Money, Commodity Prices and Inflation: Some Simple Tests", Oxford Bulletin of Economics and Statistics, 51, 219-239.

Chapter 6

Conclusion.

The three applied studies included in the present thesis analysed aspects that have to do with the price formation and the stagflationary features of the Greek economy during the post -1974 years. The analysis is of further interest given that it was performed by making use of recent developments in the field of the econometric modelling. The econometric models (presented in the thesis) were obtained following the "general to specific" methodology and provided interesting theoretical implications for the functioning of the Greek economy during the years analysed. In addition, they were shown to have constant parameters, feature which is of importance given the policy changes that took place during the examined period, and to provide good forecasts.

In particular, chapter 3 modells the interdependence among wages, prices, unemployment and productivity in a system of equations framework. The aim is to investigate the reasons which caused the contemporaneous rises in unemployment and real wages observed in the period. The first interesting result came out of the cointegration analysis: according to it, there is evidence of one relationship in which real wage cointegrates with productivity with positive unemployment effects. The positive unemployment impact indicates insider-outsider phenomena and rigidities in the labour market that have to do with hiring and firing costs and structural inefficiencies of the productive sector. In addition, nominal wages turn out to be weakly exogenous with respect to the long run parameters. The result states that, in the long-run, nominal wages were determined exogenously to the labour market situation, implying probably that they were negotiated in a different (higher) level than the labour market one (because of high wage aspirations) and/or that they were determined by institutional factors.

Secondly, the equations obtained in the finally selected simultaneous equations model provided usefull insights for the dynamics of the variables analysed. In the wage equation, which could be considered as a wage setting equation, wage in the short run depends positively on previous nominal wage values, result which implies nominal wage rigidity; unemployment has a lower negative effect to its determination, reflecting probably a minor concern for the unemployment pattern, while past price inflation has a positive effect. The estimates of the unemployment equation suggest a very high degree of persistence for unemployment; the unemployment short run dynamics are also strongly and positively effected by nominal wage, result reflecting again nominal wage rigidity, and negatively by productivity growth. In the system, prices and productivity are also modelled as endogenous variables. The price inflation equation covers the feedback of the wage inflation, previous price inflation and the derived long run relationship, whereas productivity growth is shown to depend mainly on its own path and wage inflation.

Chapter 4 analyses the foreign sector effects on Greek prices by testing for long-run Purchasing Power Parity with Greece's three main trading partners. In addition, it attempts to provide answers to the main methodological issues related with the testing of PPP. These are: the choice between a multilateral and a bilateral approach, the choice of the appropriate price index and the problem of the simultaneous determination of prices and exchange rates. The PPP hypothesis is tested in a multi-lateral and a bi-lateral framework, using two alternative price indices and without imposing *a priori* any endogeneity/exogeneity status for the variables.

The analysis provides evidence for long-run weak PPP between Greece and Germany and between Greece and France. However, it is just weak PPP with Germany which is supported by all the estimated systems (multi- and bi-lateral ones), using the two alternative price indices. PPP with France is mainly accepted in the multi-lateral systems and, therefore, can be considered as a "secondary" relationship. The results imply that Greece tried mainly to preserve constant competitiveness with Germany, which is its main trading partner, with a currency that dominated the exchange rates of all European countries. On the other hand, PPP with France can be due to the facts that both countries tried to keep constant competitiveness with Germany and that the French franc was linked to the Deutsch mark through the ERM mechanism.

With respect to the methodological PPP problems, the analysis also indicated that: i) Multi-lateral testing was preferable to bi-lateral, given that it provided more robust and easy to interpret results. ii) The choice of the price index did not alter the results concerning the existence of long-run PPP. iii) In most cases for which PPP was identified, weak exogeneity was rejected for the status of the Greek prices and the exchange rate, result which makes sense for the small open economy of Greece.

Chapter 5 attempts to model price inflation in Greece over the last twenty years. It integrates all the theoretical hypotheses used in the literature to explain inflation in an effort to clarify the relative importance of the factors determining it. The econometric strategy adopted, makes it possible to model the short run dynamics of inflation, while taking into account of some long run relationships obtained by cointegration analysis. Dynamic modelling is done in a system of equation context, consistent with the weak exogeneity testing results, and led to a wellspecified and constant parameter model. According to it, inflation is mainly cost push, determined by both external and domestic factors, whereas monetary factors have modest short-run effects. In its short-run dynamics it is strongly affected by foreign factors and to a less extent by domestic forces. Nevertheless, in the long run it is determined by wages, the exchange rate and foreign prices in order of significance. Finally, even though it adjusts to possible disequilibria in the goods and labour markets, this adjustment takes place very slowly.

The analysis done in the present thesis resulted in models with sensible economic and statistical properties. These models, however, should not be considered to be the end of the story, especially if we take into account the fast developments in the field of econometric modelling (see, for example, Banerjee, Hendry and Mizon (1996) and the articles referred therein). Nevertheless, they demonstrate the benefits gained from developing parsimonious data representations within the context of a well-structured modelling methodology.

Bibliography

[1] Banerjee A., D.F. Hendry and G.E. Mizon (1996), "The Econometric Analysis of Economic Policy", Oxford Bulletin of Economics and Statistics, 58, 4, 573-600.

[2] Granger, C.W.J. (1990) (ed), "Modelling Economic Series: Readings in Econometric Methodology", Oxford: Oxford University Press.

[3] Hendry, D.F. (1995), "Dynamic Econometrics", Oxford: Oxford University Press.

[4] Johansen, S. (1995), "Likelihood-based Inference in Cointegrated Vector Autoregressive Models", Oxford University Press, Oxford.

[5] Mizon, G.E. (1995), "Progressive Modelling of Macroeconomic Time-series: The LSE Methodology", in K. D. Hoover (ed), Macroeconometrics: Developments, Tensions and Prospects, Derdrecht: Kluwer.

[6] Spanos, A.,(1986), "Statistical Foundations of Econometric Modelling", Cambridge: Cambridge University Press.