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FORECASTING THE PORTUGUESE INFLATION RATE (*)

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Abstract

This paper compares the forecasting performance of alternative models of the quarterly inflation rate in Portugal. We show that a model that combines not only short-run determinants but also indicators of deviations from long-run equilibrium performs better than other approaches. From the analysis of the three potential sources for inflationary pressures considered, the monetary sector seems to be the one that helps to better forecast inflation. The other two, labor and foreign sectors, are probably helpful in forecasting other variables such as wages, unemployment or exchange rates. Our results also show that better inflation forecasts can be made if a reliable indicator of economic activity is more readily available.

Sumário

Este artigo compara a capacidade previsional de modelos alternativos da taxa de inflação trimestral em Portugal. Mostra-se que um modelo que combina não apenas determinantes de curto-prazo mas também indicadores de desvios do equilíbrio de longo-prazo comporta-se melhor do que outras abordagens. Da análise das três origens potenciais de pressões inflacionistas consideradas, o sector monetário parece ser o que ajuda a melhor prevêr a inflação. As outras duas, mercados de trabalho e externo, são provalvelmente úteis na previsão de outras variáveis como sejam os salários, o desemprego ou a taxa de câmbio. Os resultados também mostram que é possível obtêr melhores previsões da inflação se um bom indicador da actividade económica estiver prontamente disponibilizado.

1 Introduction

In this paper we compare the forecasting performance of alternative models of the quarterly inflation rate in Portugal. We show that a model that combines not only short-run determinants but also indicators of deviations from long-run equilibrium performs better than other approaches. This model considers three potential sources of inflation: monetary inflation, wage inflation and imported inflation. The econometric framework followed is based on the multivariate cointegration approach of Johansen (1988). However, due to the limited sample size available, it is impossible to follow the standard approach of a fully simultaneous multivariate model. Instead, an alternative approach is followed (more detailed descriptions are given in Juselius, 1992, Boswijk, 1995, and Ericsson, 1995). First, each subsystem (monetary, wage and imported inflation) is estimated by standard multivariate cointegration methods. From each estimated subsystem, it is then possible to compute a measure of the deviation from long-run equilibrium. These are given by the estimated cointegration relations. And second, a parsimonious short-run model which includes the above cointegration relations is estimated.

In another study, Marques (1990b) also considers the problem of forecasting inflation taking into account domestic demand, wages and imported prices as potential sources of inflationary pressures. Although the conclusions in the two papers differ, they are not contradictory. The approach in Marques (1990b) differs from ours in several important aspects. First, he considers the annual inflation rate while we focus on quarterly inflation. For example, Cecchetti (1995) shows that for the United States different indicators provide information about inflation at different horizons. Also, Marques (1990b) results are based on single equation regressions while our results are based on a multivariate approach. This approach allows all variables to be potentially endogenous and gives the data the job to clarify which variables can be considered exogenous. Finally, the data set used in the two papers cover different time spans.

In the next three sections, we analyze each of the potential sources of inflation considered. In section 5 we combine long-run and short-run determinants and arrive at a final parsimonious forecasting model which is tested against alternative models in section 6. Section 7 presents some general conclusions. In the appendix we give a very brief review of Johansen's multivariate cointegration approach followed in this paper.

2 Monetary Inflation

Consider the potential source of inflation coming from domestic demand pressures. Marques (1990b) considered the ratio of domestic demand to GDP as an indicator. He found that this indicator could explain inflation only with a lag of 3 to 4 years. However, he did not considered explicitly any component of domestic demand. In this paper we focus on monetary supply as a potential source of demand pressures. To determine how excess money may cause inflationary pressures it is necessary to estimate a stable long-run money relationship. There have already been several studies of the demand for money in Portugal (Marques and Lopes (1992) and Sousa (1996)). These studies have confined only to single equation models. We extend the analysis to a multivariate context. We considered several monetary aggregates (M1, M2 and L-). Preliminary investigation indicated that only M1 provided a reasonable long-run monetary relationship. We also experimented with alternative sets of interest rates. The final model considered only the following variables:

NM1 = log of nominal M1,
Y = log GDP at constant prices,
PC = log of consumer price index,
ID = gross nominal interest rate of 6-month time deposits.

An examination of the graphs of these variables and their first differences in figures 1 and 2 suggests that they can be modeled as difference stationary processes with the possibility of one or more breaks in the mean growth rate. Unit-root tests allowing up to two breaks (not reported here) as in Nunes, Newbold and Kuan (1997) confirmed the insights from the graphical analysis. We proceed the analysis assuming difference stationarity of these variables. However, the apparent breaks in the univariate distributions of the series are not considered for now. It is possible that the cointegration relations are stable over the sample period considered but some exogeneous variables induce breaks in the marginal univariate distributions. We considered several exogenous variables entering unrestricted: a constant term, seasonal dummies, and the following dummy variables:

DUMMID3 = 1 in 1983:2, 0 elsewhere;
DUMMID4 = 1 in 1986:3, 0 elsewhere;
DUMMID4_1 = 1 in 1986:4, 0 elsewhere;
DUMMY1 = 1 in 1986:1, 0 elsewhere;
DUMMY2 = 1 in 1993:1, 0 elsewhere.

The first three dummies correspond to huge shifts in the interest rate in a period of monetary regulation. The last two dummies correspond to potential outliers present in the Y series due to changes in national accounting methodology. We have also considered several other exogenous variables such as wages, energy prices, PTE/DEM and PTE/USD exchange rates, German and US interest rates. However, none of these variables were statistically significant. The sample runs from 1980:1 to 1996:4. The results from Johansen's cointegration procedure are presented in table 1.

Starting from a VAR with a lag of $k = 4$, sequential testing suggests a final value of $k = 3$. Several diagnostic tests presented in table 2 for $k = 3$ also confirm this choice. Rank tests in table 1 suggest the presence of only one cointegration relation. Conditional on this result, we proceed to test for additional restrictions.

A test for homogeneity of degree one in income and prices results in a p-value of 0.0037, thereby rejecting this hypothesis. However a test for the weaker hypothesis that the coefficients of income and prices should be equal, but possibly different from -1, is not rejected (the p-value is equal to 0.4985). Therefore, from the results in table 3, it is possible to measure deviations from long-run monetary equilibrium by the variable ECM_NM1 given by:

$$\mathrm{ECM\_NM1} \;=\; \mathrm{NM1} - 0.85283\,(\mathrm{PC} + \mathrm{Y}) + 3.5653\,\mathrm{ID}.$$

Regarding the adjustment parameters, disequilibrium is restored by adjustment in both prices and the interest rate (both α parameters are highly significant). The recursive results presented in figure 3 confirm the stability of the relation and the validity of the restrictions over time.

3 Wage Inflation

Another potential source of inflationary pressures is the labor market. We searched for an equilibrium relation between wages, prices, the unemployment rate and productivity. Marques (1990a) and Luz and Pinheiro (1994) have also considered the existence of equilibrium between real wages and unemployment but using single-equation approaches. We considered the following variables:

WH = log nominal hourly wages,
PC = log of consumer price index,
U = log unemployment rate,
C = log of output/hour in industry.

These series and their first differences are presented in figures 4 and 5. Again, we proceed assuming that the variables are difference stationary.

We also considered the following exogenous variables entering unrestricted: a constant term, seasonal dummies and the first difference of the log of an energy cost index in PTE (DPENEESC). The available sample runs from 1984:2 to 1996:3.

Starting from a lag length of $k = 4$ it follows from sequential testing and several diagnostic tests presented in table 5 that the best choice is $k = 4$. Cointegration results presented in table 4 suggest again that only one cointegration relation is present.

Imposing the restricted rank, we tested whether the equilibrium relationship was in terms of real wages or nominal wages. A p-value of 0.6465 clearly suggests a real-wage formulation. A similar result was obtained by Marques (1990a). An additional test of whether the long-run relationship is between productivity corrected real wages and unemployment gives a p-value of 0.1110. Imposing this constraint gives the results in table 6. It follows that a measure of deviations from long-run equilibrium can be computed as:

$$\mathrm{ECM\_WH} \; = \; \mathrm{WH} - \mathrm{PC} - \mathrm{C} + 0.057217\ \mathrm{U}.$$

A look at the α coefficients reveals that adjustments to approach equilibrium take place both in wages and unemployment, not in prices. The recursive estimation results presented in figure 6 confirm the stability of the relation and the validity of the restrictions over time.

4 Imported Inflation

The last sector considered is the foreign sector. For a small open economy this is clearly a potential source for inflationary pressures. It is possible to consider two equilibrium relations, potentially related, given by equilibrium in the goods market and in the capital market. For example, Johansen and Juselius (1992) consider a multivariate cointegration model for the UK and find that both a purchasing power parity (describing equilibrium in the goods market) and an uncovered interest rate parity relation (describing equilibrium in the capital market) hold. We also considered a model with both domestic and foreign prices, exchange rates, and domestic and foreign interest rates. However, in Portugal, the capital market was regulated during most of the sample available. As expected, we could not find sensible and stable relationships including all these variables. Only when interest rates were excluded, could a sensible relation be found between prices and the exchange rate. Thus, a multivariate cointegration approach to study long-run equilibrium in the capital market does not seem adequate due to the limited sample available.

Other studies have already documented that a purchasing power parity (PPP) relation for Portugal exists only with respect to German prices (see for example Marques, Botas and Machado (1996) using a single equation approach). We considered the following variables:

PC = log of consumer price index,
P* = log of German consumer price index,
DEM = log of PTE/DEM exchange rate.

The graphs of these series and their first differences are given in figures 7 and 8. We also considered a constant term and seasonal dummies. The sample runs from 1979:1 to 1996:4.

The results presented in table 7 suggest a final choice of $k = 3$. Rank tests presented in table 7 once again suggest the presence of only one cointegration relation. Conditional on this restriction, we tested whether the movement in prices in Portugal was equal to that in Germany converted to PTE. This hypothesis was rejected with a p-value of 0.0005. A weaker hypothesis tested was whether the coefficient of P* and DEM was equal. The resulting p-value was 0.4946. Imposing this restriction gives the results in table 9. The estimated deviations from the long-run relation are given by:

$$\mathrm{ECM\_PPP} = \mathrm{PC} - 1.1822\,(\mathrm{P}^* + \mathrm{DEM}).$$

Therefore, it seems that prices in Portugal follow prices in Germany corrected for a constant factor. The α coefficients suggest that adjustment to equilibrium does not come from movements in domestic prices but from changes in the exchange rate. The recursive results presented in figure 9 confirm the stability of the relation and the validity of the restrictions over time.

5 Forecasting Model

In the previous sections we studied three potential sources of inflation. In this section we combine the above results in a single model to forecast quarterly inflation (DPC = Δ PC). Our approach is similar to that followed in Juselius (1992) and Metin (1995) for the Danish and Turkish economies respectively. These papers focus on explaining past inflation. The purpose of this paper is to obtain a forecasting model. Therefore, the information sets available at each period in time are not exactly the same. We consider the following information sets at time $t-1$:

$$\begin{aligned} I_{t-1}^{LR} &= \{\mathrm{ECM\_NM1}_{t-1}, \mathrm{ECM\_WH}_{t-1}, \mathrm{ECM\_PPP}_{t-1}\}, \\ I_{t-1}^{SR} &= \{\mathrm{DPC}_{t-i}, \mathrm{DPNT}_{t-i}, \mathrm{DNM1}_{t-j}, \mathrm{DY}_{t-j}, \mathrm{DID}_{t-j}, \mathrm{DWH}_{t-j}, \\ &\quad\ \mathrm{DC}_{t-j}, \mathrm{DU}_{t-j}, \mathrm{DP^*}_{t-j}, \mathrm{DDEM}_{t-j};\ i = 1,2,3,4;\ j = 1,2\}. \end{aligned}$$

The first set considers deviations from long-run equilibrium as potential sources of inflation. The second set allows for short-run impacts of several variables on the inflation rate. We have also included inflation in non-traded goods (DPNT). We did not try to formulate a model that allows for different evolutions of traded/non-traded prices. However, short-run movements and interactions in both prices are potentially captured by including this variable.

Results in previous sections suggested that movements in prices were important in the adjustment to long-run equilibrium in the monetary sector only. However, it may be the case that such a conclusion could have been biased by not considering all factors simultaneously (see Juselius (1992) for a discussion of this point). In table 10 are presented the results from a regression of DPC on both information sets. The sample runs from 1984:1 to 1996:4. The estimated p-values associated with the three long-run indicators (ECM_NM1, ECM_WH and ECM_PPP) confirm that prices, apart from the short-run influences considered in I^{SR}_{t-1}, adjust only to deviations from monetary equilibrium. Deviations from long-run wage and foreign equilibrium relations are restored by changes in other variables.

Next, we tested whether variables related to the labor market could be removed. We already saw that the ECM_WH indicator was not significant. Also, each of the labor market variables (DWH_{t-j}, DC_{t-j} and DU_{t-j}) is not statistically significant when considered individually. When all these variables are removed from the regression, the corresponding p-value has a value of 0.2638. Therefore, is seems that considering the labor market does not help to better forecast the inflation rate.

Enlarging the sample size to 1980:1-1996:4, we tested for the importance of imported inflation. Not only are again deviations from PPP, measured by ECM_PPP, not significant, but also both foreign price and exchanges rate variables not significant. Omitting all these variables results in a p-value of 0.7435.

Further tests allow us to further simplify the model. The final model includes only: ECM_NM1_{t-1}, DNM1_{t-1}, DNM1_{t-2}, DY_{t-1}, DPC_{t-1}, DPC_{t-4}, DPNT_{t-4}, a constant term and a seasonal dummy SEAS_Q3_t. The results are presented in table 11.

These results contrast with Marques (1990b) results that the major sources of inflation were imported inflation and wages. He found that domestic demand pressures were also relevant but with a delay of almost 3 years. However, as discussed in the introduction to this paper, the two results are not necessarily contradictory. In the next section we evaluate the out-of-sample predictive ability of our model.

6 Forecast Comparisons

In this section we compare the final model estimated in the previous section with four alternative models.

The second model considered is a modification of the model presented in the last section. In fact, the first model requires that the variable Y be available at time t for a forecast to be made for time $t+1$. However it is often the case that this variable (or even a coincident indicator) is available only for $t-1$. An alternative model considers the following modified information sets at time $t-1$:

$$
\begin{aligned}
I^{*LR}_{t-1} &= \{\mathrm{ECM\_NM1}_{t-2}, \mathrm{ECM\_WH}_{t-1}, \mathrm{ECM\_PPP}_{t-1}\}, \\
I^{*SR}_{t-1} &= \{\mathrm{DPC}_{t-i}, \mathrm{DPNT}_{t-i}, \mathrm{DNM1}_{t-j}, \mathrm{DY}_{t-k}, \mathrm{DID}_{t-j}, \mathrm{DWH}_{t-j}, \\
&\quad \mathrm{DC}_{t-j}, \mathrm{DU}_{t-j}, \mathrm{DP^*}_{t-j}, \mathrm{DDEM}_{t-j};\ i=1,2,3,4;\ j=1,2; \\
&\quad k=2,3\}.
\end{aligned}
$$

Following the approach of the previous section the final estimated forecasting model is given in table 12.

The third model is a first differences VAR of the monetary sector. This model ignores the potential information coming from long-run cointegration relation among the variables. Following a general to particular methodology a parsimonious VAR was estimated.

The fourth model decomposes inflation between traded and non-traded goods in a first differences VAR model. Following the same methodology as before, we estimated a parsimonious VAR.

Finally, a fifth model combines the previous two models in a first differences VAR model. Again, we followed the same methodology as before.

The recursive one quarter ahead inflation forecasts for each model are presented in figure 10. In table 13 we compare the one quarter ahead out-of-sample forecasting performance of all five models for the period 1990:1 up to 1996:4. This period is also divided in two sub periods. The estimation sample begins in 1980:1 for all models. To compute the root mean square errors (RMSE), the forecasts in each period were taken from models estimated using observations only up to the previous period.

The best model is the one presented in the previous section. Therefore, it is valuable to combine both short-run and long-run indicators when forecasting quarterly inflation. However, when the alternative information set is used, the forecasting performance decreases and performs worse than the traded/non-traded prices VAR. The other two short-run VAR models, all perform worse. Another interesting fact is that inflation has become more predictable toward the end of the available sample. This conclusion holds for four of the five models considered and might be associated with the decrease in the variance of the process over time.

7 Conclusions

From the analysis of the three potential sources for inflationary pressures considered, the monetary sector seems to be the one that helps to better forecast quarterly inflation. The other two, labor and foreign sectors, are probably helpful in forecasting other variables such as wages, unemployment or exchange rates. Another conclusion that emerges is that a model that combines both short-run and long-run factors forecasts better than purely short-run models. Our results also show that better inflation forecasts can be made if a reliable indicator of economic activity is more readily available. Finally, in recent years, inflation has become easier to forecast.

Appendix: Multivariate Cointegration Analysis

This section gives a brief overview of the multivariate cointegration approach of Johansen (1988). A description of this method and its advantages over a single equation approach can be found in Harris (1995). Let x_t denote a $p \times 1$ vector of stochastic variables. As an approximation of the true data generating process consider the following VAR model:

$$x_t = A_1 x_{t-1} + \cdots + A_k x_{t-k} + \mu + \phi D_t + \epsilon_t,$$

where ϵ_t is a random vector N i.i.d. $(0, \Sigma)$, and D_t are seasonal dummies.

By reparameterizing the above model in an error correction form, it becomes possible to distinguish between short-run and long-run relations:

$$\Delta x_t = \Gamma_1 + \Delta x_{t-1} + \cdots + \Gamma \Delta x_{t-k+1} + \Pi x_{t-k} + \mu + \phi D_t + \epsilon_t.$$

Assuming that all elements in x_t are I(1), the existence of cointegration between the x_t variables depends on the rank of the Π matrix. If there exists cointegration then $0 < r < p$ where r denotes the rank of Π which can be written as

$$\Pi = \alpha \beta',$$

where α and β are $p \times r$ matrices. The determination of the rank r can be done by a likelihood ratio test. Given the rank r it follows that the r cointegration relations $\beta' x_t$ are stationary and represent deviations from the equilibrium long-run relations. The parameters α describe how the variables x_t adjust to attain the long-run equilibrium.

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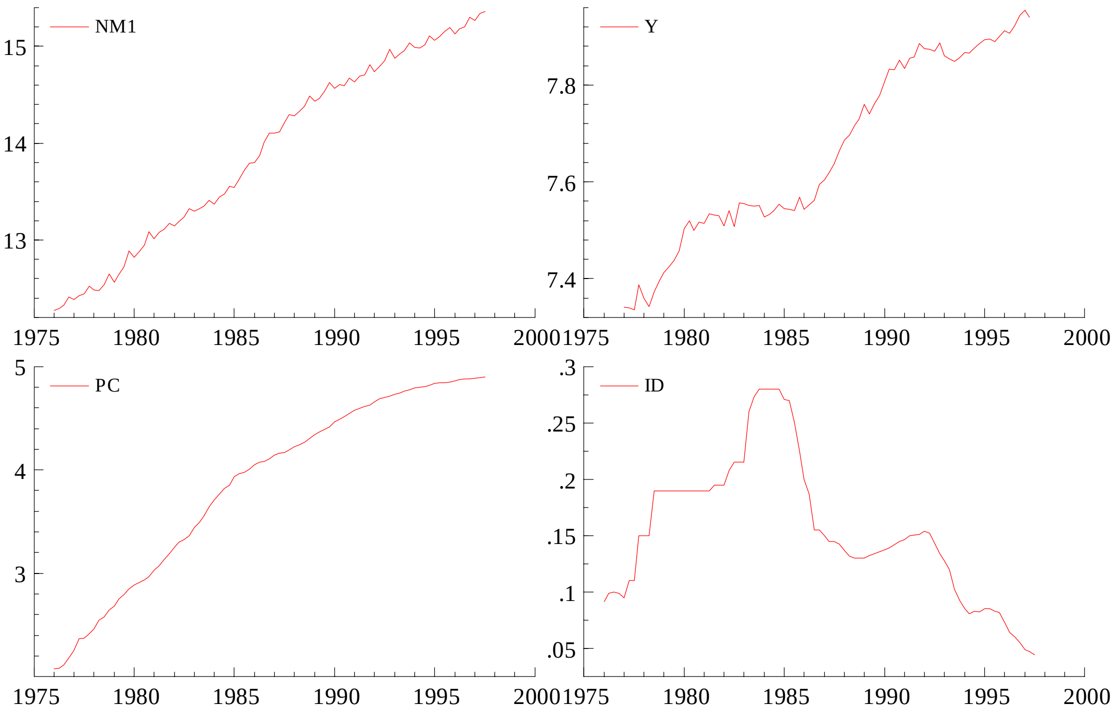
Figure 1: Graphs of NM1, Y, PC and ID.



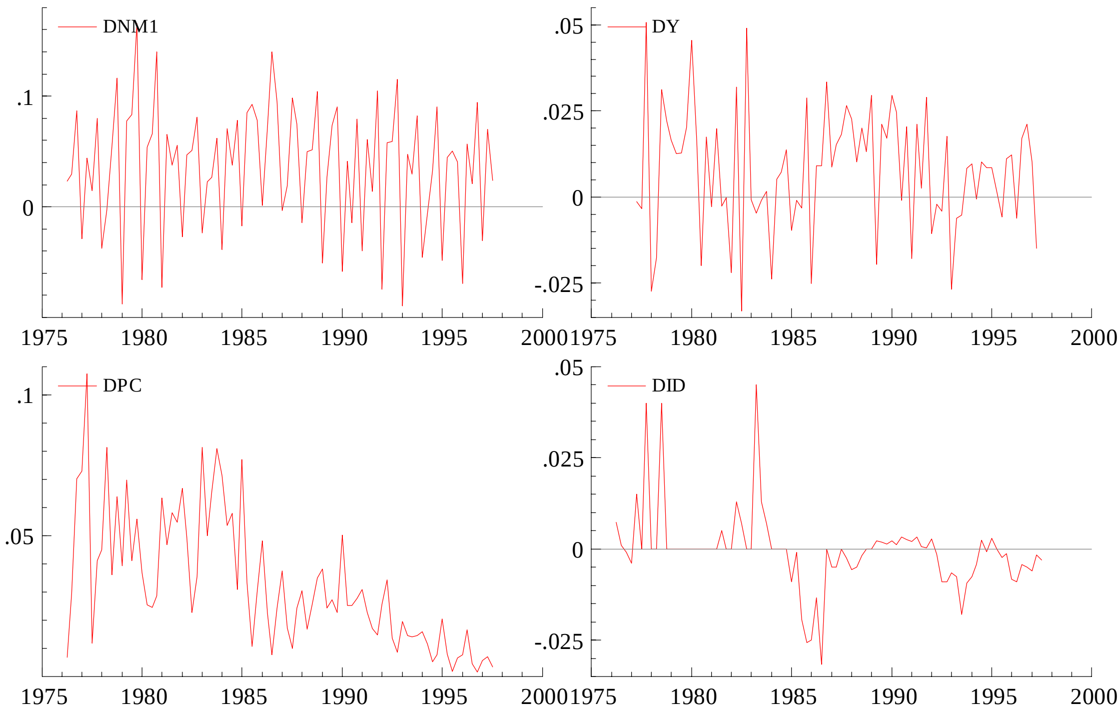


Figure 2: Graphs of first differences of NM1, Y, PC and ID.

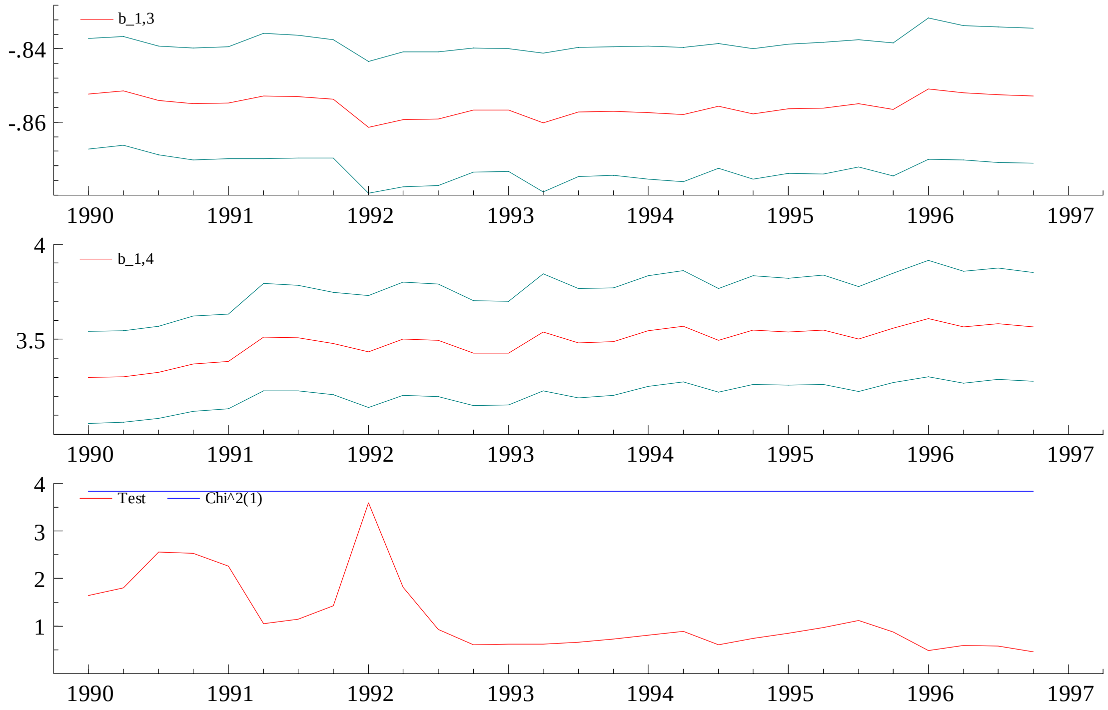


Figure 3: Recursive estimation results for the monetary inflation subsystem.

Figure 4: Graphs of WH, PC, U and C.

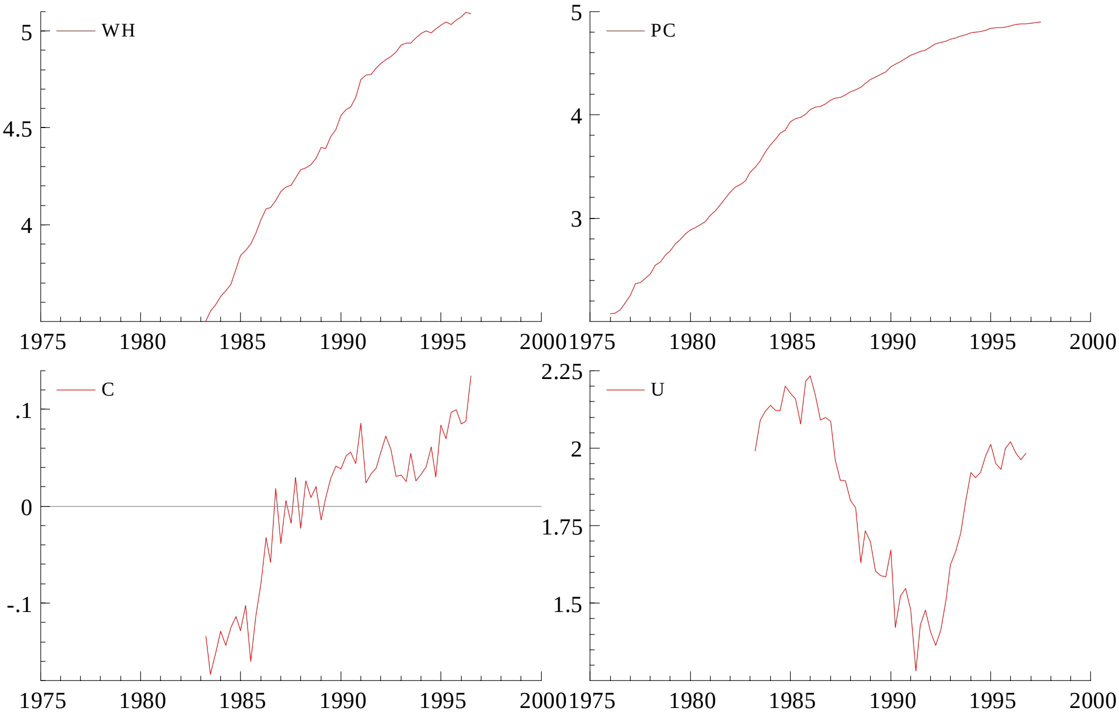


Figure 5: Graphs of first differences of WH, PC, U and C.

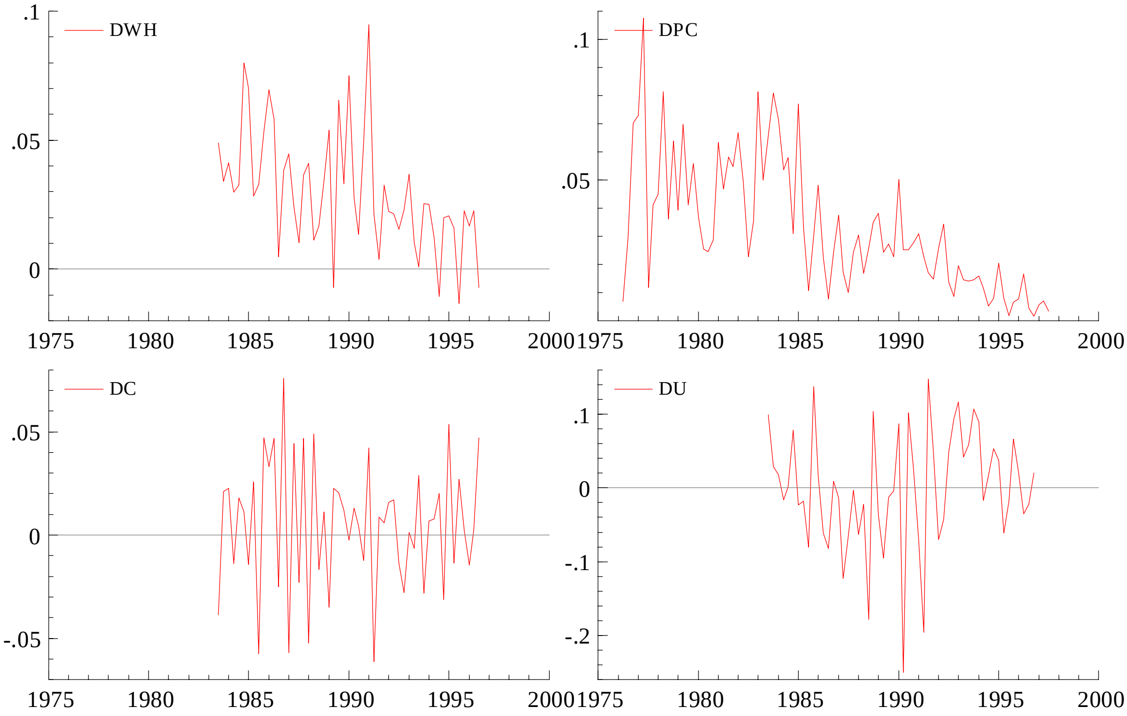


Figure 6: Recursive estimation results for the wage inflation subsystem.

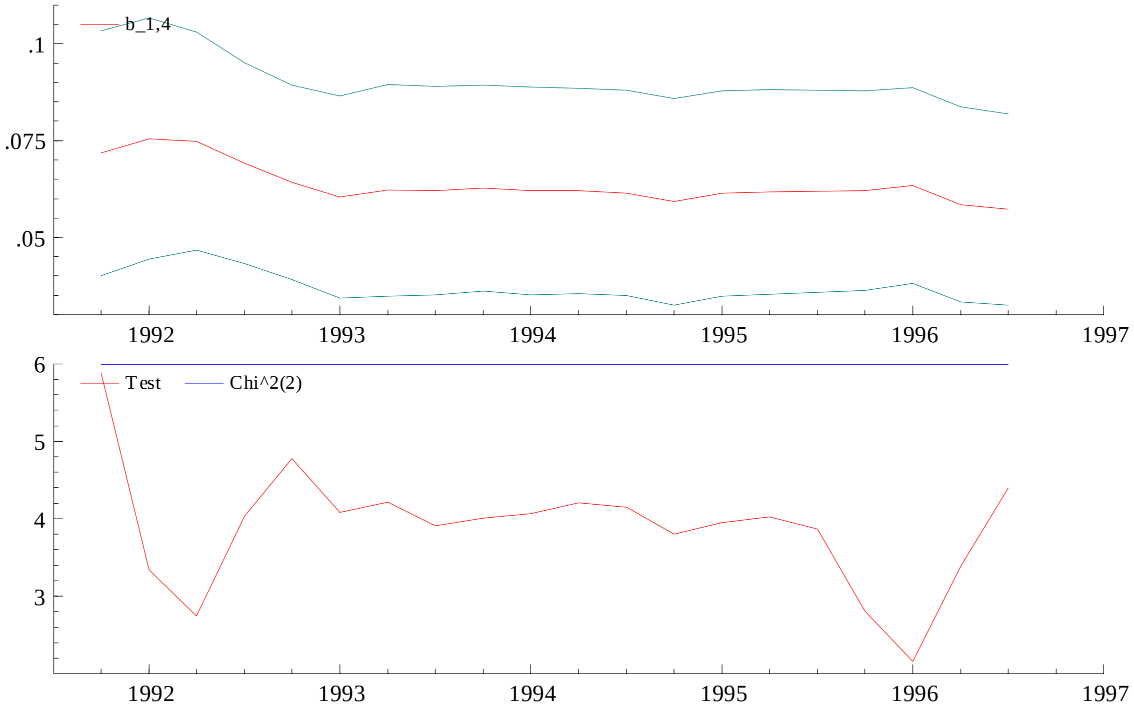


Figure 7: Graphs of PC, P* and DEM.

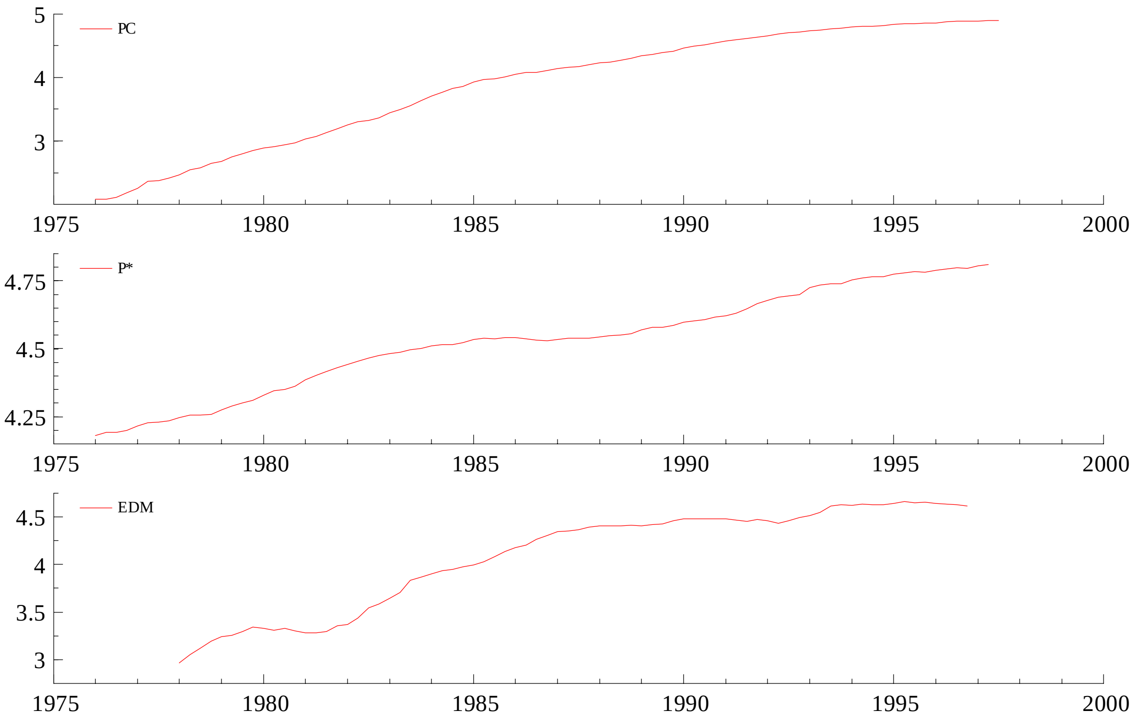


Figure 8: Graphs of first differences of PC, P* and DEM.

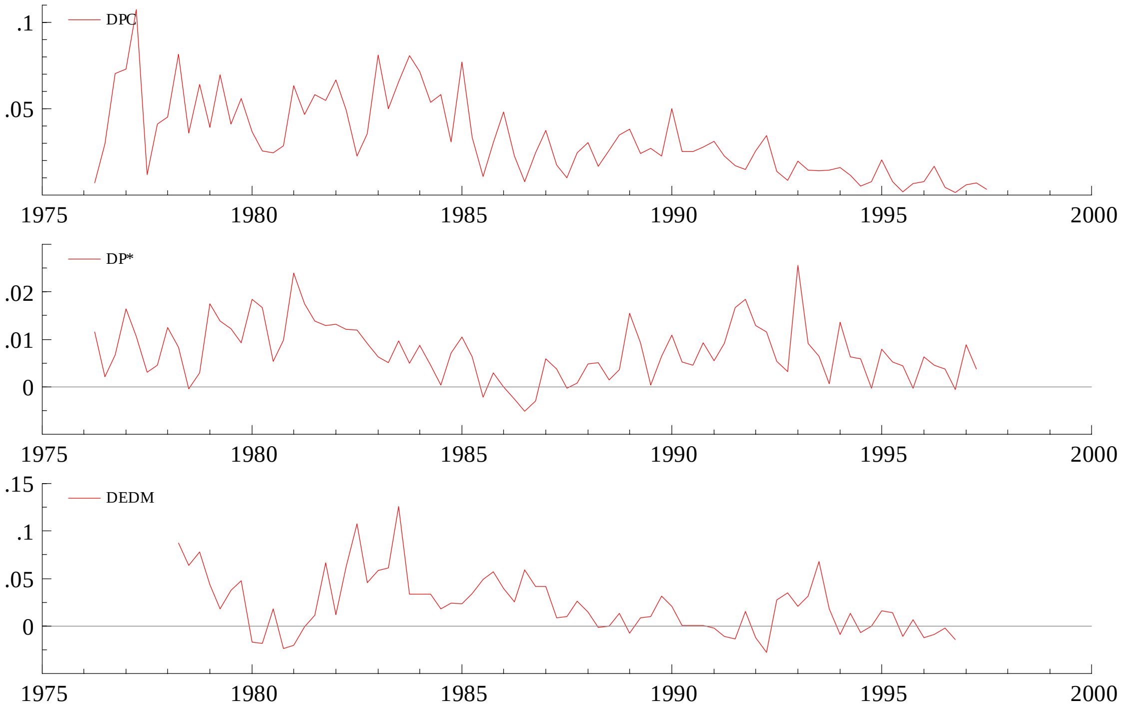


Figure 9: Recursive estimation results for the imported inflation subsystem.

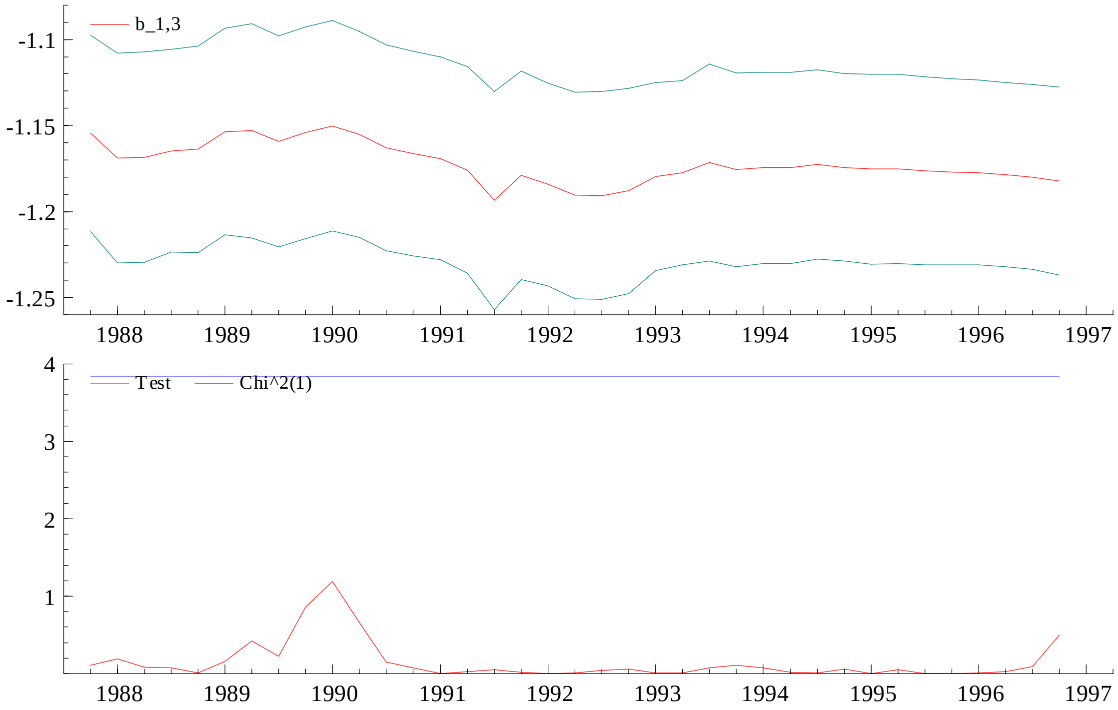


Figure 10: Recursive one quarter ahead forecasts.

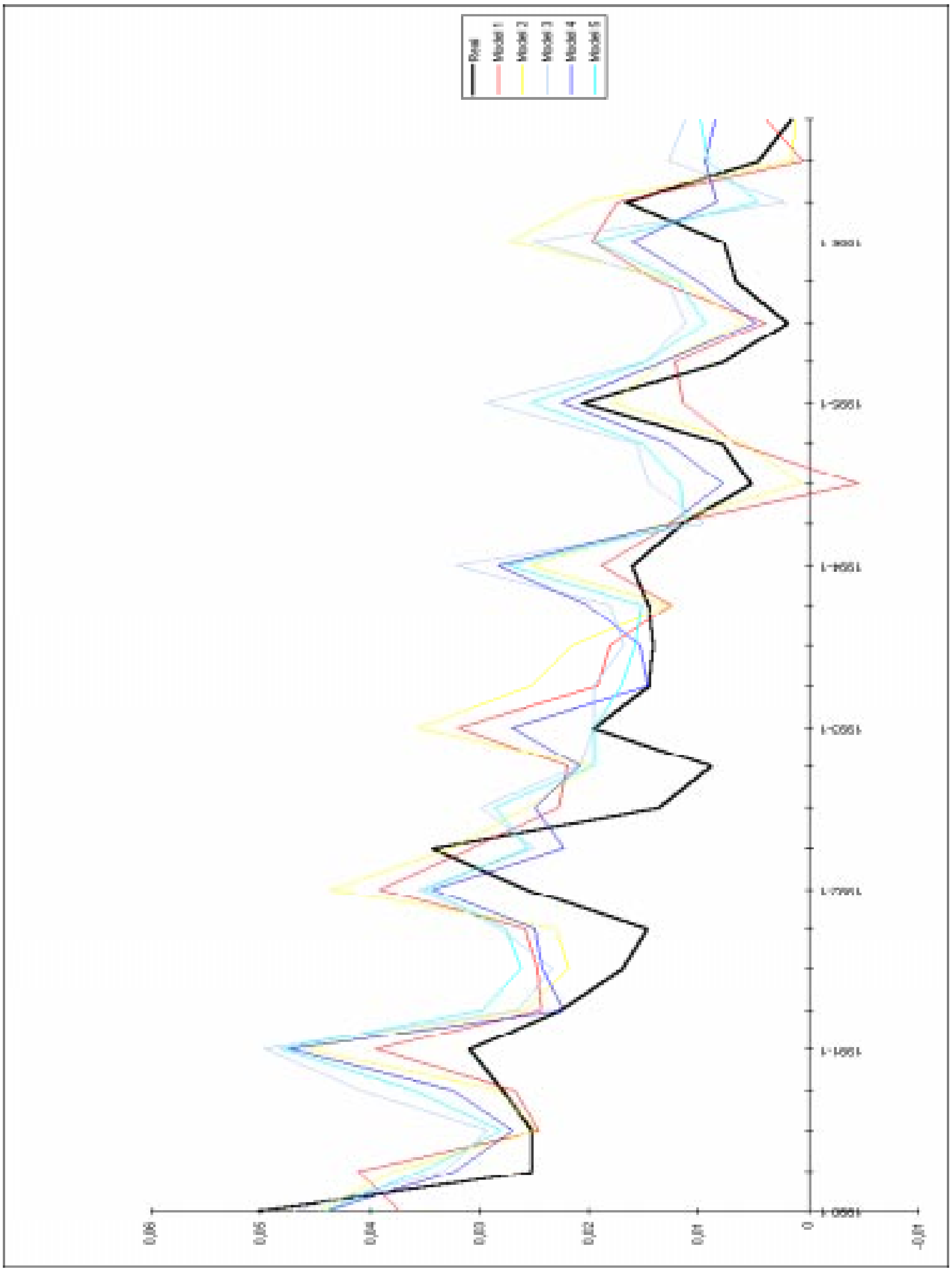


Table 1: Cointegration results for the monetary inflation subsystem.

```
Cointegration analysis 1980:1 to 1996:4

Number of lags used in the analysis: 3

Variables entered unrestricted:
  Constant   dummID3   dummID4 dummID4_1    dummY1    dummY2
   seas_q1   seas_q2   seas_q3

    eigenvalue       loglik    rank
                     1253.55   0
      0.582476       1283.25   1
      0.235508       1292.38   2
      0.131205       1297.16   3
     0.0770311       1299.89   4

Ho:rank=p  -Tlog(1-\mu)   using T-nm    95%   -T\Sum log(.)   using T-nm    95%
 p ==  0         59.39**        48.91**   27.1        92.67**        76.31**   47.2
 p <=  1         18.26          15.04     21.0        33.28*          27.4     29.7
 p <=  2         9.564          7.876     14.1        15.01          12.37     15.4
 p <=  3         5.451*         4.489*     3.8        5.451*         4.489*     3.8

standardized \beta' eigenvectors
          NM1           Y          PC           ID
       1.0000    -0.93466    -0.83964      3.5060
      -1.2334      1.0000      1.0026     -2.6415
      -1.0242      1.1480      1.0000     -1.0186
      0.14621     0.59867    -0.24507      1.0000

standardized \alpha coefficients
 NM1            0.081325     0.26640    0.018478     -0.13005
 Y              -0.10670   -0.098867   -0.010788     -0.10064
 PC              0.15395  -0.0099498   -0.033416    0.0029226
 ID            -0.059100    0.012263   -0.013588    0.0014871
```

Table 2: Tests for the monetary inflation subsystem in table 1.

```
NM1     :Portmanteau  8 lags=   7.4605
Y       :Portmanteau  8 lags=    5.142
PC      :Portmanteau  8 lags=    14.33
ID      :Portmanteau  8 lags=   5.1627
NM1     :AR 1- 5 F( 5, 42) =    0.10109 [0.9914]
Y       :AR 1- 5 F( 5, 42) =     1.2254 [0.3142]
PC      :AR 1- 5 F( 5, 42) =     1.8778 [0.1187]
ID      :AR 1- 5 F( 5, 42) =     1.2321 [0.3112]
NM1     :Normality Chi^2(2)=    0.63864 [0.7266]
Y       :Normality Chi^2(2)=    0.83937 [0.6573]
PC      :Normality Chi^2(2)=     1.3677 [0.5047]
ID      :Normality Chi^2(2)=     2.0946 [0.3509]
NM1     :ARCH 4  F( 4, 39) =     1.2229 [0.3168]
Y       :ARCH 4  F( 4, 39) =     1.2807 [0.2942]
PC      :ARCH 4  F( 4, 39) =     0.2021 [0.9357]
ID      :ARCH 4  F( 4, 39) =     0.3591 [0.8361]
NM1     :Xi^2    F(24, 22) =    0.42939 [0.9769]
Y       :Xi^2    F(24, 22) =    0.73015 [0.7738]
PC      :Xi^2    F(24, 22) =     0.4518 [0.9696]
ID      :Xi^2    F(24, 22) =    0.51848 [0.9402]
Vector portmanteau  8 lags=   109.56
Vector AR 1-5  F(80, 97) =     1.2033 [0.1914]
Vector normality Chi^2( 8)=    4.4294 [0.8165]
Vector  Xi^2   F(240,145) =    0.41236 [1.0000]


Cointegration tests on $\beta$ (rank=1):

   NM1  Y    PC   ID
\beta=   &4   &5   &6   &7

 &4=1;&6=-1; LR-test, rank=1: Chi^2(1) = 10.858 [0.0010] **
 &4=1;&5=-1;&6=-1; LR-test, rank=1: Chi^2(2) = 11.198 [0.0037] **
 &4=1;&5=&6; LR-test, rank=1: Chi^2(1) = 0.4582 [0.4985]
```

Table 3: Restricted cointegration results for the monetary inflation subsystem.

```
General cointegration restrictions:
 &4=1;  &5=&6;

Analysis of restrictions on \alpha and \beta:
- linear restrictions
- \alpha x \beta restrictions are variation free
- \alpha is unrestricted
- \beta  has only within-equation restrictions

General cointegration test 1980:1 to 1996:4

          NM1            Y           PC           ID
       1.0000     -0.85283     -0.85283       3.5653

Standard errors of beta'
          NM1            Y           PC           ID
      0.00000      0.00000     0.010685      0.16620

\alpha
 NM1            0.075616
 Y              -0.11279
 PC              0.15513
 ID            -0.059683

Standard errors of alpha
 NM1            0.079163
 Y              0.044262
 PC             0.033067
 ID             0.013479

loglik = 1283.0196  -log|\Omega| = 37.735871  unrestr. loglik = 1283.2487
```

Table 4: Cointegration results for the wage inflation subsystem.

```
Cointegration analysis 1984:2 to 1996:3

Number of lags used in the analysis: 4

Variables entered unrestricted:
  Constant  DPENEESC   seas_q1   seas_q2   seas_q3

    eigenvalue     loglik for rank
                     819.093   0
      0.553742       839.264   1
      0.217733       845.403   2
      0.125744       848.763   3
     0.0832354       850.935   4

Ho:rank=p  -Tlog(1-\mu)   using T-nm   95%  -T\Sum log(.)  using T-nm   95%
 p ==  0       40.34**       27.43*   27.1      63.69**      43.31    47.2
 p <=  1       12.28         8.349    21.0      23.34        15.87    29.7
 p <=  2       6.719         4.569    14.1      11.06        7.524    15.4
 p <=  3       4.345*        2.955     3.8      4.345*       2.955     3.8

standardized \beta' eigenvectors
           WH          PC           C           U
       1.0000    -0.96877     -1.4290    0.018235
     -0.68295      1.0000    -0.73476   -0.051216
     -0.33754     0.44516      1.0000     0.31860
       2.4951     -1.8528      7.1679      1.0000

standardized \alpha coefficients
 WH             -0.34783     0.19610  -0.0049609  -0.0036190
 PC            -0.052009   -0.068007   -0.031626  -0.0049218
 C             -0.018065    0.032451    0.079208   -0.014635
 U                1.1088     0.94786    -0.15155  -0.0033358
```

Table 5: Tests for the wage inflation subsystem in table 4.

```
WH      :Portmanteau  6 lags=   1.1538
PC      :Portmanteau  6 lags=   2.9194
C       :Portmanteau  6 lags=   4.5268
U       :Portmanteau  6 lags=    18.58
WH      :AR 1- 4 F( 4, 25) =    0.27274 [0.8928]
PC      :AR 1- 4 F( 4, 25) =     1.3338 [0.2850]
C       :AR 1- 4 F( 4, 25) =    0.74396 [0.5712]
U       :AR 1- 4 F( 4, 25) =    0.75849 [0.5621]
WH      :Normality Chi^2(2)=    0.48301 [0.7854]
PC      :Normality Chi^2(2)=     4.4232 [0.1095]
C       :Normality Chi^2(2)=   0.052441 [0.9741]
U       :Normality Chi^2(2)=     1.6998 [0.4275]
WH      :ARCH 4  F( 4, 21) =   0.020222 [0.9991]
PC      :ARCH 4  F( 4, 21) =    0.12617 [0.9713]
C       :ARCH 4  F( 4, 21) =     1.3093 [0.2988]
U       :ARCH 4  F( 4, 21) =    0.37548 [0.8235]
Vector portmanteau  6 lags=   80.906
Vector AR 1-4  F(64, 41) =     1.2204 [0.2501]
Vector normality Chi^2( 8)=    7.9047 [0.4428]
Vector  Xi^2  Chi^2(320) =      336.3 [0.2546]


Cointegration tests on $\beta$ (rank=1):

\beta (rank=1) =
WH   PC   C    U
&4   &5   &6   &7

&4=1;&5=-1; LR-test, rank=1: Chi^2(1) = 0.2104 [0.6465]
&4=1;&5=-1;&6=-1; LR-test, rank=1: Chi^2(2) = 4.3964 [0.1110]
```

Table 6: Restricted cointegration results for the wage inflation subsystem.

```
General cointegration restrictions:
&4=1; &5=-1;&6=-1;

Analysis of restrictions on \alpha and \beta:
- linear restrictions
- \alpha x \beta restrictions are variation free
- \alpha is unrestricted
- \beta  has only within-equation restrictions
- \beta  equality restrictions rewritten

General cointegration test 1984:2 to 1996:3

\beta'
           WH           PC            C            U
       1.0000      -1.0000      -1.0000     0.057217

Standard errors of beta'
           WH           PC            C            U
      0.00000      0.00000      0.00000     0.015264

\alpha
 WH            -0.38943
 PC           -0.077433
 C            -0.047726
 U              0.97412

Standard errors of alpha
 WH            0.090269
 PC            0.065721
 C              0.17408
 U              0.41840

loglik = 837.06585  -log|\Omega| = 33.482634  unrestr. loglik = 839.26407
```

Table 7: Cointegration results for the imported inflation subsystem.

```
Cointegration analysis 1979:1 to 1996:4

Number of lags used in the analysis: 3

Variables entered unrestricted:
  Constant   seas_q1   seas_q2   seas_q3

    eigenvalue     loglik for rank
                    986.490   0
      0.302676      999.468   1
      0.106317      1003.51   2
    0.00943854      1003.86   3

Ho:rank=p  -Tlog(1-\mu)   using T-nm   95%  -T\Sum log(.)  using T-nm   95%
 p ==  0       25.96**      22.71*   21.0      34.73*       30.39*   29.7
 p <=  1       8.093        7.081    14.1      8.776        7.679    15.4
 p <=  2      0.6828       0.5975     3.8     0.6828       0.5975     3.8

standardized \beta' eigenvectors
          PC          P*         DEM
       1.0000     -1.3321     -1.1350
       4.5744      1.0000     -3.9246
      -2.4591      8.1832      1.0000

standardized \alpha coefficients
 PC          -0.0028794  -0.0028972   0.0029917
 P*            0.029805 -0.00074821 -0.00094847
 DEM            0.16052   0.0029993   0.0045378
```

Table 8: Tests for the imported inflation subsystem in table 7.

```
PC      :Portmanteau  8 lags=   3.3627
P*      :Portmanteau  8 lags=   12.434
DEM     :Portmanteau  8 lags=   16.179
PC      :AR 1- 5 F( 5, 54) =     1.7222 [0.1452]
P*      :AR 1- 5 F( 5, 54) =     1.0446 [0.4012]
DEM     :AR 1- 5 F( 5, 54) =     1.7882 [0.1308]
PC      :Normality Chi^2(2)=     0.7088 [0.7016]
P*      :Normality Chi^2(2)=      4.739 [0.0935]
DEM     :Normality Chi^2(2)=    0.93991 [0.6250]
PC      :ARCH 4  F( 4, 51) =     1.4576 [0.2288]
P*      :ARCH 4  F( 4, 51) =    0.57974 [0.6786]
DEM     :ARCH 4  F( 4, 51) =     0.8344 [0.5097]
PC      :Xi^2    F(18, 40) =     1.2983 [0.2403]
P*      :Xi^2    F(18, 40) =     1.3643 [0.2028]
DEM     :Xi^2    F(18, 40) =     1.2588 [0.2654]
PC      :Xi*Xj   F(54,  4) =    0.45513 [0.9185]
P*      :Xi*Xj   F(54,  4) =    0.54815 [0.8625]
DEM     :Xi*Xj   F(54,  4) =    0.33852 [0.9720]
Vector portmanteau  8 lags=   59.707
Vector AR 1-5  F(45,125) =    0.82891 [0.7613]
Vector normality Chi^2( 6)=    7.6264 [0.2668]
Vector  Xi^2   F(108,207) =    0.87538 [0.7788]
Vector  Xi*Xj  F(324,  3) =   0.084382 [1.0000]


Cointegration tests on $\beta$ (rank=1):

\beta (rank=1) =
PC   P*   DEM
&3   &4   &5

&3=1;&4=-1;&5=-1; LR-test, rank=1: Chi^2(2) = 14.631 [0.0007] **
&3=1;&4=&5; LR-test, rank=1: Chi^2(1) = 0.49507 [0.4817]
```

Table 9: Restricted cointegration results for the imported inflation subsystem.

```
General cointegration restrictions:
 &3=1; &4=&5;

Analysis of restrictions on \alpha and \beta:
- linear restrictions
- \alpha x \beta restrictions are variation free
- \alpha is unrestricted
- \beta  has only within-equation restrictions

General cointegration test 1979 (1) to 1996 (4)

\beta'
           PC          P*         DEM
       1.0000     -1.1822     -1.1822

Standard errors of beta'
           PC          P*         DEM
      0.00000     0.00000    0.029521

\alpha
 PC          -0.0026825
 P*            0.026692
 DEM            0.15331

Standard errors of alpha
 PC            0.026523
 P*           0.0093843
 DEM           0.044494

loglik = 999.22034  -log|\Omega| = 27.75612  unrestr. loglik = 999.46787
```

Table 10: Full inflation forecasting model results.

```
Modelling DPC by OLS

The present sample is:  1984:1 to 1996:4

Variable     Coefficient    Std.Error  t-value  t-prob PartR^2
Constant        -0.74764      0.34955   -2.139  0.0444  0.1789
DPC_1            0.20699      0.26380    0.785  0.4414  0.0285
DPC_2            0.11941      0.27792    0.430  0.6718  0.0087
DPC_3            0.61739      0.28920    2.135  0.0447  0.1783
DPC_4           -0.72346      0.28621   -2.528  0.0196  0.2333
DPNT_1          -0.26119      0.19402   -1.346  0.1926  0.0794
DPNT_2          -0.17429      0.17216   -1.012  0.3229  0.0465
DPNT_3          -0.28181      0.17240   -1.635  0.1170  0.1129
DPNT_4           0.53669      0.16443    3.264  0.0037  0.3366
DNM1_1          -0.16184     0.070495   -2.296  0.0321  0.2006
DNM1_2          -0.24217     0.078319   -3.092  0.0055  0.3129
DY_1            0.067696      0.12231    0.553  0.5858  0.0144
DY_2             0.29937      0.12500    2.395  0.0260  0.2145
DID_1          -0.072798      0.31157   -0.234  0.8175  0.0026
DID_2          -0.058026      0.30910   -0.188  0.8529  0.0017
DWH_1           0.095008     0.083846    1.133  0.2699  0.0576
DWH_2            0.11786     0.096395    1.223  0.2350  0.0665
DC_1            0.094192     0.070533    1.335  0.1960  0.0783
DC_2             0.11413     0.072854    1.567  0.1322  0.1046
DU_1           -0.011721     0.032601   -0.360  0.7228  0.0061
DU_2           -0.017633     0.029910   -0.590  0.5618  0.0163
DP*_1            0.30502      0.38786    0.786  0.4404  0.0286
DP*_2           0.039440      0.37361    0.106  0.9169  0.0005
DDEM_1          0.069420      0.11308    0.614  0.5459  0.0176
DDEM_2          0.018904     0.087176    0.217  0.8304  0.0022
ECM_NM1_1        0.13646     0.053267    2.562  0.0182  0.2381
ECM_WH_1       -0.013126     0.054885   -0.239  0.8133  0.0027
ECM_PPP_1      -0.023364     0.035397   -0.660  0.5164  0.0203
seas_q1         0.010662    0.0076873    1.387  0.1800  0.0839
seas_q2       -0.0019879    0.0096152   -0.207  0.8382  0.0020
seas_q3        -0.025050    0.0088442   -2.832  0.0100  0.2764

R^2 = 0.915971  F(30,21) = 7.6305 [0.0000]  \sigma = 0.00745217  DW = 1.90
RSS = 0.001166231373 for 31 variables and 52 observations

Information Criteria:  SC = -8.34967;  HQ = -9.06695;  FPE = 8.86421e-005
```

Table 11: Parsimonious inflation forecasting model results.

```
Estimating the unrestricted reduced form by OLS
The present sample is:  1980:1 to 1996:4

URF Equation 1 for DPC
Variable     Coefficient    Std.Error  t-value  t-prob
DPC_1            0.20463     0.096623    2.118  0.0384
DPC_4           -0.43882      0.13813   -3.177  0.0024
DPNT_4           0.35883     0.095053    3.775  0.0004
DY_1             0.26125     0.080600    3.241  0.0020
DNM1_1          -0.11648     0.036346   -3.205  0.0022
DNM1_2          -0.11679     0.042671   -2.737  0.0082
ECM_NM1_1        0.17744     0.025506    6.957  0.0000
seas_q3        -0.015358    0.0051639   -2.974  0.0043
Constant        -0.79010      0.11442   -6.905  0.0000

\sigma = 0.00981012   RSS = 0.00567806436

standard deviations of URF residuals
          DPC
    0.0098101

loglik = 319.28219  log|\Omega| = -9.39065  |\Omega| = 8.35009e-005  T = 68
log|Y'Y/T| = -6.6471
R^2(LR) = 0.935659  R^2(LM) = 0.935659

F-test on all regressors except unrestricted, F(9,59) = 95.332 [0.0000] **

DPC     :Portmanteau  8 lags=   2.3977
DPC     :AR 1- 5 F( 5, 54) =    0.37178 [0.8658]
DPC     :Normality Chi^2(2)=    0.11046 [0.9463]
DPC     :ARCH 4  F( 4, 51) =    0.64724 [0.6314]
DPC     :Xi^2    F(15, 43) =     2.0362 [0.0349] *
DPC     :Xi*Xj   F(43, 15) =     1.7845 [0.1116]
Vector portmanteau  8 lags=   2.3057
Vector AR 1-5  F( 5, 54) =    0.37178 [0.8658]
Vector normality Chi^2( 2)=   0.11046 [0.9463]
Vector  Xi^2   F(15, 43) =     2.0362 [0.0349] *
Vector  Xi*Xj  F(43, 15) =     1.7845 [0.1116]
```

Table 12: Parsimonious inflation forecasting model results for alternative information set.

```
Estimating the unrestricted reduced form by OLS
The present sample is:  1980:1 to 1996:4

URF Equation 1 for DPC
Variable     Coefficient    Std.Error  t-value  t-prob
DPC_4           -0.35503      0.13792   -2.574  0.0125
DPNT_4           0.28845      0.10019    2.879  0.0055
DNM1_2          -0.13017     0.041035   -3.172  0.0024
DID_1            0.63283      0.12814    4.939  0.0000
ECM_NM1_2        0.17843     0.020993    8.499  0.0000
seas_q1         0.010517    0.0035368    2.973  0.0042
seas_q3        -0.012538    0.0051640   -2.428  0.0182
Constant        -0.79312     0.095021   -8.347  0.0000

\sigma = 0.00977894   RSS = 0.005737659936

standard deviations of URF residuals
          DPC
    0.0097789

loglik = 318.92719  log|\Omega| = -9.38021  |\Omega| = 8.43774e-005  T = 68
log|Y'Y/T| = -6.6471
R^2(LR) = 0.934984  R^2(LM) = 0.934984

F-test on all regressors except unrestricted, F(8,60) = 107.86 [0.0000] **

DPC     :Portmanteau  8 lags=   7.0211
DPC     :AR 1- 5 F( 5, 55) =     1.2634 [0.2929]
DPC     :Normality Chi^2(2)=   0.014098 [0.9930]
DPC     :ARCH 4  F( 4, 52) =    0.23758 [0.9158]
DPC     :Xi^2    F(12, 47) =     2.0151 [0.0440] *
DPC     :Xi*Xj   F(32, 27) =     1.6202 [0.1021]
Vector portmanteau  8 lags=   6.7613
Vector AR 1-5  F( 5, 55) =     1.2634 [0.2929]
Vector normality Chi^2( 2)=  0.014098 [0.9930]
Vector  Xi^2   F(12, 47) =     2.0151 [0.0440] *
Vector  Xi*Xj  F(32, 27) =     1.6202 [0.1021]
```

Table 13: RMSE (in percentage) of one quarter ahead inflation forecasts.

	Models				
Sub-periods	1	2	3	4	5
1990:1-1993:4	0.75	0.92	0.88	0.79	0.83
1994:1-1996:4	0.60	0.70	1.06	0.61	0.79
1990:1-1996:4	0.75	0.90	1.04	0.78	0.88

Models:

1 - parsimonious forecasting model,
2 - parsimonious model for alternative information set,
3 - monetary VAR model,
4 - traded/non-traded prices VAR model,
5 - mixed model.