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The Effect of Joining the EMS: Monetary Transmission Mechanisms in Spain

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The Effect of Joining the EMS: Monetary Transmission Mechanisms in Spain.

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Abstract

The paper presents a cointegrated VAR analysis of monetary transmission mechanisms and changes in them after Spain joined the EMS in 1989. Analyses of long-run price homogeneity within the $I(2)$ model turned out to be crucial for understanding the joint behaviour of money, income, prices, and interest rates. The empirical results demonstrated the crucial role of shocks to nominal interest rates, in particular to the long-term bond rate, for the long-run movements in Spanish prices. In addition, the paper provides further insights on the macroeeconomic effects of joining the EMS and financial deregulation. The increased economic integration within the EU is shown to have completely changed the dynamics of the conventional IS-LM transmission mechanism.

Keywords: Cointegration, Long-Run Impact, Money Demand, $IS{-}LM$, Monetary Policy, Capital Liberalization.

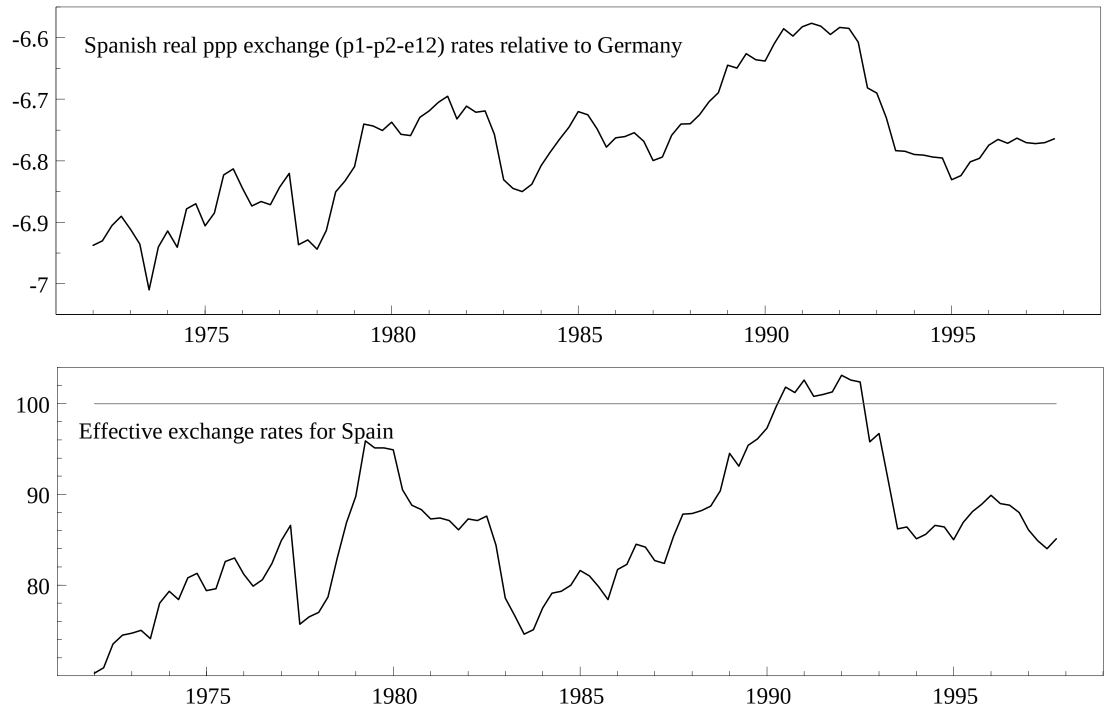

Figure 1.1: The graph of the Spanish real ppp exchange rates relative to Germany (upper panel) and the effective exchange rate (lower panel).

1. Introduction

A country joining the European Monetary Union refrains from pursuing an independent monetary policy. The economic consequences of this European experiment do not yet seem fully understood. But to be able to evaluate the costs of lost monetary autonomy one would need to know whether monetary policy in the past has been effective in achieving its goal, *i.e.* curbing inflation in a period of expansionary demand and, possibly, stimulating real growth in a recession. Given the long lasting recession in Europe, from the late eighties to the mid nineties, with modest real growth rates, high rates of unemployment, low inflation rates and high real interest rates, this question seems particularly important. Therefore, the idea is to study the monetary mechanisms of the Spanish economy over the past twenty years to get an improved empirical understanding for how these mechanisms have changed with the increased European economic integration.

It was a starting hypothesis in Juselius (1997, 1998a) that the deviation from the PPP steady-state position and the degree of capital liberalization are crucial for how monetary mechanisms work for a country joining ERM. For capital deregulated countries, which adopted the narrow 2.25% bands of the ERM and were above their PPP steady-state position, such as Germany and Denmark, the empirical results in Juselius (1996, 1998a, 1998b) demonstrated the impotency of monetary policy: Pure monetary shocks (changes in money stock) had minor effects (if any) on inflation. Changes in short interest rates had only short-run but hardly any long-run effects on inflation or on any of the intermediate instruments. For a capital regulated country, such as Italy, which adopted the broad currency bands of the ERM when its real PPP exchange rates were below its long-run steady-state value, the results in Juselius and Gennari (1999) demonstrated much higher effectiveness of monetary policy.

Spain joined the EMS quite late, in 1989. It removed most restrictions on capital movements somewhat later and adopted the broad 6% bands of the ERM. As a result of speculative attacks it devalued its currency in September and November 1992. Based the above hypothesis we expect monetary policy in Spain to be more effective before 1989 when it was capital regulated and below the PPP steady-state level (see fig. 1.1). Moreover, we expect domestic interest rate control to be less effective after Spain joined the EMS in 1989 and, in particular, after it removed most capital regulations in 1990. This presumes that the level of long-term interest rate has increasingly become internationally determined after the worldwide capital deregulation in the eighties.

This is more or less in line with the conclusions by Escriva and Malo de Molina (1991). They claim that the strict use of monetary objective has probably been ineffective in reducing monetary growth both in the pre- and post-ERM period and point to need for addressing the following important issues: (i) coordination of monetary and fiscal policy, (ii) the role of monetary targets when there are limits to the fluctuations of exchange rates, (iii) the managements of targets in term on money aggregates, (iv) the management of interest rate in the short term.

Empirical work on monetary mechanisms in Spain has primarily focused on the estimation of aggregate money demand relations in a single equation framework. See for example Dolado and Escriva (1990), Cabrero et. al. (1992), Vega (1995). All of them report various problems, but implausible income coefficients and parameter instability seem particularly worrying from an econometric point of view. Several possible explanations to these problems are suggested: The omission of wealth in the specification of aggregate demand for money might have biased the income coefficient. Increases in the saving ratio and private sector wealth might have induced parameter instability in the coefficient for income. Important financial innovations affecting the return on money might have influenced the sensitivity of money demand to changes in the rate of return. A strong competition between banks for deposits leading to high yield accounts can be a possible explanation for the observed parameter instability in the long run money demand relation. Finally, the greater portfolio diversification caused by the lifting of previous controls on capital movements might have led to changes in the behavior of agents' demand for money.

We attempt here to explain some of the previous empirical problems by adopting a multivariate approach to the analysis of the period before and after Spain joined the EMS and at the same time offer new empirical insight on the issues proposed by Escriva and Malo de Molina (1991). A system approach based on the cointegrated VAR model for money, income, prices, and interest rates allows us to estimate money demand and money supply as part of a monetary system characterized by long-run and short-run effects, interactions and feedback. By estimating the model separately over the two periods 1975:4-1989:1 and 1988:1-1996:3 it is possible to shed some light on the changing mechanisms caused by capital deregulation and increased economic integration.

The empirical analysis investigates first long-run price homogeneity between nominal money stock and prices based on the I(2) model. This part of the econometric analysis turned out to be mandatory for understanding the joint behavior of nominal money, prices and real income, and helps to explain some of the problems encountered in previous studies.

The organization is as follows: Section 2 discusses the institutional background and how the monetary procedures have changed over the sample period. Section 3 discusses some methodological aspects of the econometric approach as well as cointegration implications of the hypothetical steady-state relations. Section 4 defines the statistical model and Section 5 determines the empirical properties of the model in nominal money and prices for the pre and post EMS period. Section 6 investigates the hypothesis of long-run price homogeneity in the I(2) model for both periods and discusses the implications for analyzing real money when not finding it. Section 7 reports cointegration tests of the hypothetical long-run steady-state relations, selects for each period three steady-state relations to describe the long-run structure in the data, and reports the estimates of the long-run impact matrix. Section 8 reports an identified short-run adjustment model for each period, and discusses the basic findings based on a comparative analysis of the pre and post EMS period. Section 9 summarizes and concludes.

2. The monetary procedure in Spain 1973-95

Before moving to the empirical analysis we discuss the historical development of the monetary aggregates based on a graphical analysis in Section 2.1 and give an overview of monetary reforms and changes in monetary procedure in Section 2.2.

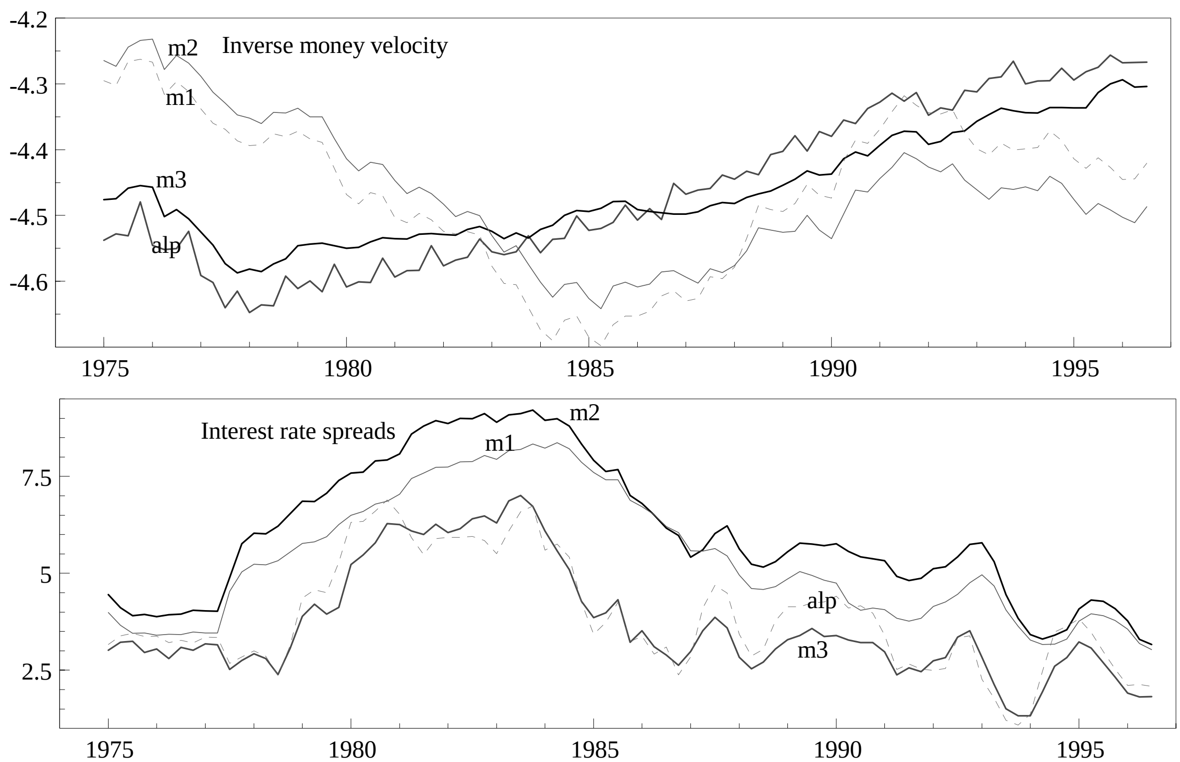

Figure 2.1: The graphs of inverse velocity for M1, M2, M3, and ALP (upper panel) and the corresponding interest rate spreads (lower panel).

Section 2.3 briefly comments on capital deregulation and financial innovations.

2.1. Graphical review

As a background to the empirical analysis we first present the graphs of the inverse velocity (hereafter money velocity) of various components of aggregate money stock and their most important determinants.

Figure 2.1. reports the log of the velocity of M1, M2, M3, and ALP, where lower case letters stands for logarithmic values. It appears that the velocity of M1 and M2, and of M3 and ALP exhibit similar trending behavior within the pairs, but distinctly different between the pairs. The spread between the interest rates graphed in the lower panel of Figure 2.1 is defined as the differential between the average interest rate on outside assets (bonds) and the interest rate yield on the money aggregate in question. The graphs show that interest rates hardly

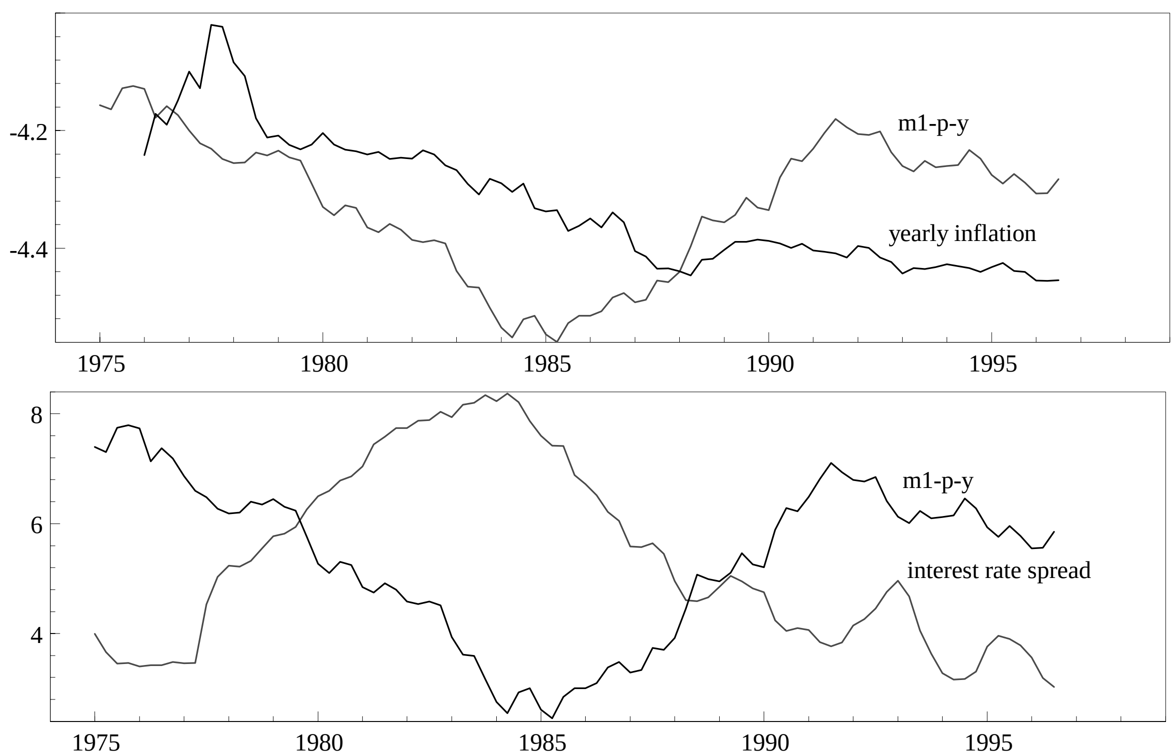

Figure 2.2: The graphs of M1 inv. velocity compared to inflation (upper panel) and interest rate spread (lower panel).

change at all in 1975-77, whereas from 1977 onwards the spread increases quite dramatically for M1 and M2 to be followed by M3 and ALP a few years later. As expected, the spreads for M1 and M2 are much larger than for M3 and ALP. Some of the more important dates are the start of the EMS in 1979, the agreement to stop the frequent realignments within the EMS in 1983, Spain joining the EMS in 1989, Spain adopting the very broad bands of the EMS after the speculative attack on the peseta in late 1992.

In the upper panel of Figure 2.2 the velocity of M1 is compared to the yearly inflation rate and in the lower panel to the interest rate spread. There seems to be a strong negative relationship between M1-velocity and the spread (the opportunity cost of holding money) as theory would suggest, but hardly any relationship to inflation. Figure 2.3 shows that the opposite behavior seems to characterize the M3-velocity, suggesting a strong negative relationship with inflation, but hardly any relationship with the interest rate spread.

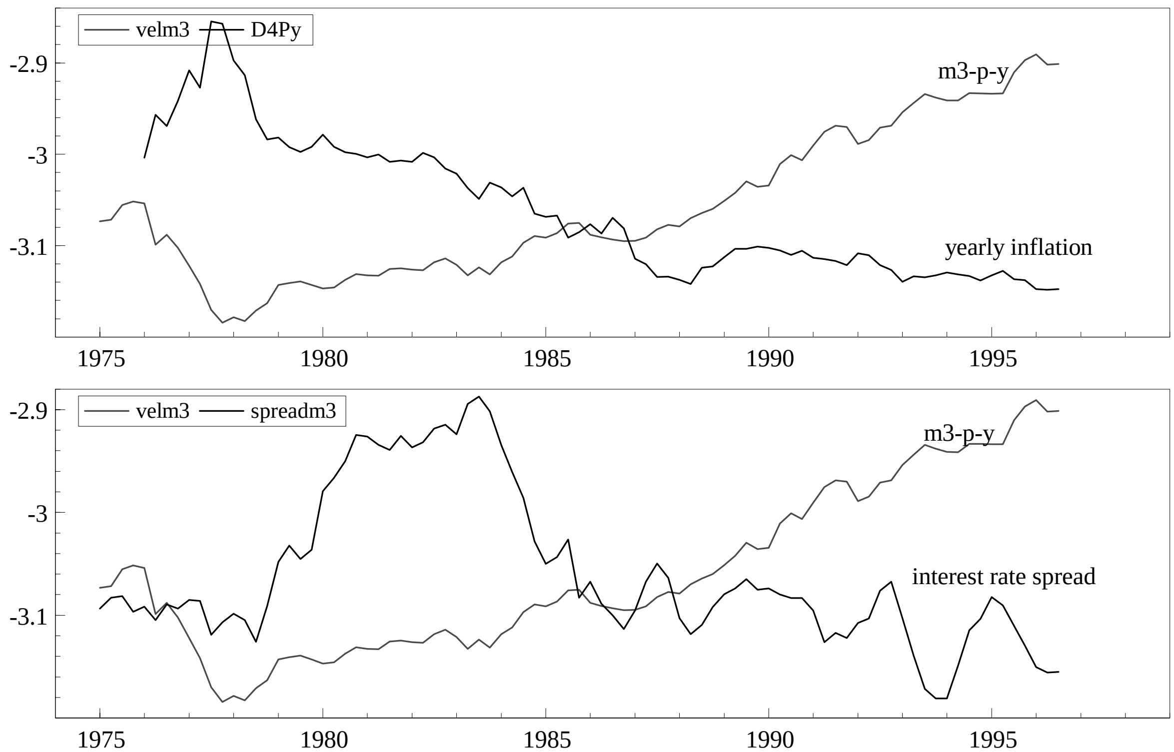

Figure 2.3: The graphs of inverse m3 velocity compared to inflation (upper panel) and interest rates (lower panel).

Thus, based on a visual inspection it seems possible to find empirical support for a demand for M1 (or M2) relation as a function of the interest rate spread but not for M3 (or ALP).

2.2. Changes in monetary procedure[1]

Ortega (1996)Spain has actively pursued monetary policy all since 1973. The monetary target has generally been specified in terms of an monetary aggregate, but since 1995 it has been replaced by a target inflation rate. At the beginning of the period monetary procedure relied on an intermediate target defined by M3, later it was redefined in terms of ALP (liquid assets held by the public). The monetary aggregate $M3$ was chosen because of its insensitivity to portfolio reallocations between savings and time deposits. The latter were the most common

[1] This section draws strongly on Sanz and Val (1993) and Cabrero, Escriva and Ortega (1996).

means of payment in the seventies and the beginning of the eighties. However, the demand for private assets transfer certificates as well as bonds issued by the banking system and other official credit institutions started to grow with a peak in 1983. High yields and favorable tax treatment made them good substitutes for time deposits. The latter experienced also hard competition from other financial innovations, such as insurance transactions and repos on notes and bills. All this led the monetary authorities to redefine the intermediate monetary instrument in 1984 by the liquid assets in the hands of the public (ALP). It was then believed that ALP would have good properties in terms of controllability. This was defined as a stable relationship between the growth of the money aggregate and the main instruments of the central bank, and the inflation and output growth, the final goal variables.

However, the relatively high Spanish inflation prevalent in the seventies and eighties prevented the Treasury to rely exclusively on the Bank of Spain for financing the large government deficits. The appearance of short-term government debt, Treasury bills, as well and repos on bills and notes, together with a market for them that increased their liquidity, induced significant portfolio readjustments. This led again to a redefinition of the monetary aggregate ALP to include these new assets.

Though this aggregate covered essentially the whole money market, there were some serious drawbacks associated with it. First, a great proportion of assets included in the aggregate yielded return not very different from assets outside the aggregate. Consequently, the opportunity cost of holding money became almost zero. Second, the demand for a great proportion of the assets included in the aggregate was linked to demand associated with deficit financing. This lead to periods of instability because part of the demand for ALP depended on the timing of the government's financing. requirements. Third, because Treasury bills where not included in the reserve requirements, the money multiplier became quite unstable.[2]

Financial integration as well as commitments due to the membership of the EMS led to further changes in the monetary operating procedure. Since 1987 short-term interest rate control became increasingly important for the implementation of monetary policy. The following three reforms of the monetary procedure in Spain are of particular interest:

<u>The 1987 reform</u> increased the reserve requirement from a maximum level of 7% to 19%. The purpose was to drain excess liquidity originating from the increase in public deficit and the increase in foreign reserves, but also to obtain a cheap way of financing government deficits due to the low interest rates on reserve requirements.

[2] Based on these arguments our empirical analysis will focus in the agreggate M3.

The 1990 reform took place after the financing need of the government had been reduced and stated that future government borrowing from the BoS could not exceed the position at the end of 1989. The commitment of the government to reduce its borrowing from the Bank of Spain permitted a more flexible liquidity control. This lead to a modification of the reserve requirements which were set at 3% and later reduced to 2%. The reserve differential was transformed to certificates of the Bank of Spain with a gradual amortization from 1993 to 2000.

The 1993 reform was motivated by large shifts in the monetary aggregates related to uncertainty on the exchange rate movements (after the speculative attack on the peseta). The large portfolio shifts from bank accounts to investment funds and the large scale substitution of deposits across borders strongly affected the informative content of the growth of the monetary aggregate (ALP).

2.3. Capital deregulation

The process to deregulate the Spanish capital market was initiated in 1987 with the final aim of incorporating the Spanish peseta in the ERM. The purpose was to improve monetary as well as fiscal credibility and discipline by forcing price decisions to be consistent with those of the foreign trading partners. The intention was to borrow the low inflation reputation of the EMS countries and to break the vicious circle that the large inflows of foreign capital had started. The latter was a result of the large interest differential between Spain and the outside world and the consequent appreciation of the Spanish peseta and loss of competitiveness in the export sector.

Although the main decision to deregulate capital movements took place in 1987 the actual reforms became effective from 1989 onwards as a result of Spain joining the EMS with the Spanish peseta in the broad 6% ERM bands. At the same time quantitative limits on investment in securities issued on foreign markets were lifted and deposits denominated in ecus were authorized. In 1990 the purchase of securities issued in foreign money markets were liberalized which started a fierce competition among the Spanish banks. In 1992 residents were allowed to hold accounts denominated either in pesetas or foreign currencies at non-residents banks.

However, the decision in 1989 to join the ERM regime was not sufficient to decrease core inflation (nominal wage growth), which was growing at a rate incompatible with target inflation rates of the other ERM countries. This led the BoS to impose restrictions on credit and capital movements which prevailed until 1990. Nevertheless, the external (and internal) imbalances of the Spanish economy were too large and in 1992 the peseta became subject to a major speculative attack which caused a first devaluation of 5% in September 1992 and a further devaluation of 6% in November 1992.

3. Theoretical relations and their cointegration implications

The historical overview suggested several regime changes of which the most important seems to be the change of exchange rate regime and the associated capital liberalization. A priori we expect monetary transmission mechanisms to be strongly influenced by this, resulting in changes in both the dynamic adjustment coefficients and the cointegration properties of the data. As a background, Section 3.1 discusses some methodological aspects of the adopted approach and Section 3.2 considers possible cointegration relations given the data set and their macroeconomic interpretation.

3.1. Methodological considerations

The main purpose is to study the dynamics of "excess money" and "excess short-term interest rates" and how they affect the domestic economy through their effects on prices, income and long-term interest rate. The absence of foreign variables in the analysis to account for the additional effects of changes in the balance of payments (BP) does not, in general, invalidate the econometric interpretation of the results. The reason is that the cointegration property is invariant to changes in the information set. Therefore, if cointegration is found within the presently used set of variables the same cointegration relation would be found in an extended analysis.

Nevertheless, the cost we pay for not including of important foreign variables such as the real exchange rate, a variable measuring export demand, and a foreign interest rate, is that some questions cannot be addressed. To let the reader assess the implications of this choice, we extend the domestic $IS - LM$ model (Laidler, 1985) with BP effects and discuss how the hypothetical relations would have been modified correspondingly.

The motivation for focusing exclusively on the domestic mechanisms is related to the choice of econometric methodology. The VAR approach is very powerful for a detailed analysis of smaller systems, but becomes unmanageable in larger systems. Therefore, the idea is first to study separately the domestic monetary mechanisms, the labor market mechanisms, and the foreign mechanisms using cointegration analysis and then to combine the results of the sub-systems into a more complete model. Examples of this approach can be found for example in Juselius (1992) and Metin (1998). The approach of Ericsson and Iron (1998) is similar but they estimate a long-run relation based on a combined approach.

The hypothetical relations discussed below describe how the long-run structure of the model can be related to the cointegration properties of the data. A necessary condition for empirical support for a hypothetical steady-state relation is that the corresponding cointegration relation is stationary with estimated cointegration coefficients of the expected sign. The short-run adjustment parameters on the other hand describe the dynamic transmission mechanisms of monetary policy. A priori we expect the dynamics to differ in the two regimes without having a strong prior for how. Hence, the short-run adjustment dynamics will be empirically determined by the econometric analysis. In this sense there is a large exploratory element in the empirical analysis.

3.2. Steady-state relations

All through the paper lower cases denote logarithmic values and upper cases levels.

Money demand, m^d, is assumed to be the sum of the transactions, precautionary, and speculative demand for money and is given by:

$$m_t^d = y_t + p_t + b_1(R_{m_t} - R_{b_t}) + b_2\Delta p_t + u_{m_t} \tag{3.1}$$

where y is real income, p is price, $R_b - R_m$ is the opportunity cost of holding money relative to bonds, Δp is the opportunity cost relative to real stock, u_{m_t} is a residual. The condition for (3.1) to qualify as a demand for money relation is that $b_1 > 0,\ b_2 < 0$ and $u_{m_t} \sim I(0)$.

In addition, the opportunity cost of holding money relative to foreign bonds, $(R_{m_t} - R^*_{b_t})$ might potentially influence demand for money. Since Spain has maintained restrictions on capital movements in the pre-EMS period, domestic money demand is not likely to be much influenced by the foreign interest rate in this period. In the second period the influence is likely to be greater.

As discussed in Section 2.2 the Bank of Spain used predominantly money stock as their policy instrument for controlling inflation in the first period, but interest rates in the second period. This motivates the specification of two different central bank policy rules.

The first describes a *money stock rule*:

$$m_t - p_t - y_t = f(\Delta p_t - \pi_0) + u_{CB1_t} \tag{3.2}$$

where u_{CB1_t} is a stationary residual error. According to (3.1) we expect BoS to contract money stock as a result of inflation being above the target inflation rate π_0. A prerequisite for this rule to be effective is long-run homogeneity between nominal money and prices and causality from money to prices rather than the other way around.

The second describes an *interest rate rule*:

$$R_{m_t} = R_{bt} + b_3(\Delta p_t - \pi_0) + R_0 + u_{CB2_t} \tag{3.3}$$

where R_0 is a constant, $b_3 > 0$, and u_{CB2_t} is a stationary residual error.

Foreign indicator variables, such as the exchange rate, s, foreign inflation rate, Δp_t^*, and the foreign short-term interest rate, $R_{s_t}^*$, are potentially important determinants of the BoS decisions, suggesting a policy rule such as:

$$R_{s_t} = R_{s_t}^* + b_3^*(\Delta p_t - \Delta p_t^*) + b_4^*(s_t - s_t^*) + R_0^* + u_{CB_t}^*.$$

According to this rule the central bank would change the short-term interest rate R_{s_t} relative to the foreign rate $R_{s_t}^*$ when domestic inflation exceeds foreign inflation and when the exchange rate has moved away from its target value. From an econometric point of view the "foreign" reaction rule is complementary to (3.3) if $u_{CB_t}^* \sim I(0)$. In this case we might explain more of the changes in short-term interest rates by adding the foreign determinants, but (3.3) would remain a valid cointegrating relation. We expect the foreign determinants to have become more relevant in the EMS period.

Interest rate relations. The Fisher parity predicts that the short-term interest rates depends on expected inflation and the expectations hypothesis that short interest rate determines the long interest rate, *i.e.* :

$$R_{m_t} = \mathcal{E}_t(\Delta p_{t+1}) + u_{Rm_t} \tag{3.4}$$

and

$$R_{b_t} = R_{m_t} + u_{Rb_t}, \tag{3.5}$$

where $\mathcal{E}_t(\Delta p_{t+1})$ is the expected change in inflation at time t. Empirical support would generally require that $u_{Rm_t} \sim I(0)$, and $u_{Rb_t} \sim I(0)$ implying one common stochastic trend driving both inflation rate and interest rates. However, the finding that $(R_m - R_b)_t \sim I(1)$, can be consistent with the predictions from the expectation's hypothesis or the Fisher parity, if $E_t(\Delta p_{t+b} - \Delta p_{t+m})$, is an $I(1)$ process, where $E_t(\Delta p_{t+b})$ is the expected future inflation at the maturity of the bond and $E_t(\Delta p_{t+m})$ is the expected short-term inflation rate.

In a small capital deregulated economy one would expect the foreign (world) level of interest rates to essentially determine the domestic level, albeit with the addition of a country specific risk premium. Because central banks can affect the short-term interest rate, but not (or to a much lesser extent) the long-term interest rate, one would expect the long-term bond rates to be market determined through the UIP:

$$R_{b_t} = R_{b_t}^* + E_t\Delta s_{t+b} + u_{Rb_t}^*.$$

where $E_t \Delta s_{t+b}$ is the expected change in the spot exchange rate at the maturity of the bond. In the pre-EMS period Spain maintained restrictions on capital movements, adopted the 6% bands of the ERM in 1989, but was forced to devalue the pesetas twice as a result of the exchange crisis in late 1992, which in 1993 resulted in an increase of the ERM currency bands to 15%. Based on this we expect the Spanish bond market to have been strongly exposed to foreign competition only after the entrance in the EMS.

Aggregate income. The IS relationship predicts that trend-adjusted real aggregate income is negatively related to the long-term real interest rate. In addition, trend-adjusted real income can be cointegrated with inflation in a short-run Phillips curve relationship, alternatively demand pressure relationship. See for instance Hendry and Mizon (1993) and Juselius (1996). The following specification accounts for both alternatives:

$$y_t = b_4 * trend + b_5 R_{b_t} + b_6 \Delta p_t + u_{y_t} \tag{3.6}$$

where $b_4 \geq 0$, $b_5 < 0$, $b_5 = -b_6$ and $u_{y_t} \sim I(0)$ would be consistent with the IS curve, whereas $b_5 = 0$ and $b_6 > 0$ would be consistent with the short-run Phillips curve. With foreign variables included in the analysis the following hypothetical relation would need to be added to the analysis:

$$y_t = b_4^* y_t^* + b_5^* ppp_{b_t} + u_{y_t}^*$$

describing the effect of export demand on domestic income as a function of foreign real activity, y_t^*, and the level of competitiveness ppp_t. The demand for export is clearly important for real income determination in Spain and (3.6) is, therefore, likely to provide only a partial explanation.

Prices. In the empirical analysis we find that $\Delta p \sim I(1)$ and, hence, $p \sim I(2)$. This gives the rationale for distinguishing between the long-run determination of the price level and the medium-run determination of the inflation rate. The quantity theory of money predicts that the price level is related to $m - y$, *i.e.* to monetary expansion in excess of real productive growth. If $m - p - y \sim I(1)$, we expect the inflation rate to adjust to deviations from this steady state. According to the short-run Phillips curve, inflation increases with excess aggregate demand. Finally, if the BoS policy rule (3.2) is effective we expect inflation to fall when monetary policy is strict and rise when it is loose. In terms of cointegration (3.1)-(3.5) contain these hypotheses as special cases.

4. The statistical model

The baseline VAR model is given by:

$$\begin{gathered}\Delta^2 x_t = \Gamma_1 \Delta^2 x_{t-1} + \Gamma \Delta x_{t-1} + \Pi x_{t-1} + \Phi D_t + \mu_0 + \mu_1 t + \varepsilon_t, \\ \varepsilon_t \sim N_p(0, \Sigma\ ),\ t = 1, ..., T\end{gathered} \tag{4.1}$$

where x_t is a $p \times 1$ vector of variables in the system, t is a deterministic trend, and the parameters $\Theta = \{\Gamma_1, \Gamma, \Pi, \Phi, \mu_0, \mu_0, \Sigma\}$ are unrestricted. The vector D_t contains centered seasonal dummies and intervention dummies.

Long-run price homogeneity is important for understanding the effects of excess money demand on price inflation. Because prices and nominal money stock empirically behave as $I(2)$ variables we start with the conditions for the $I(2)$ model.

The hypothesis that x_t is $I(2)$ is formulated as two reduced rank hypotheses (Johansen, 1991):

$$\Pi = \alpha\beta' \tag{4.2}$$

and

$$\alpha'_\perp \Gamma \beta_\perp = \zeta\eta', \tag{4.3}$$

where α, β are $p \times r$ and ζ, η are $p - r \times s_1$ matrices. The linear trend coefficient μ_1 is restricted to $sp(\alpha)$, i.e. $\alpha'_\perp \mu_1 = 0$. We can define the following matrices $\alpha_1 = \alpha_\perp \zeta$ and $\beta_{\perp 1} = \beta_\perp \eta$ and the orthogonal complements of $(\alpha, \alpha_{\perp 1})$ and $(\beta, \beta_{\perp 1})$ respectively. The moving average representation is given by:

$$\begin{aligned} x_t = {} & C_2 \sum_{s=1}^{t} \sum_{i=1}^{s} \varepsilon_i + C_2 \tfrac{1}{2} \mu_0 t^2 + C_2 \Phi \sum_{s=1}^{t} \sum_{i=1}^{s} D_i + C_1 \sum_{s=1}^{t} \varepsilon_s \\ & + C_1 \Phi \sum_{s=1}^{t} D_s + F_0 t + + Y_t + A + Bt,\ t = 1, ..., T \end{aligned} \tag{4.4}$$

with

$$C_2 = \beta_{\perp 2} (\alpha'_{\perp 2} \Psi \beta'_{\perp 2})^{-1} \alpha'_{\perp 2} \tag{4.5}$$

Y_t defines the stationary part of the process, and A and B are functions of the initial values $x_0, x_{-1}, ..., x_{-k+1}$. The linear trend $F_0 t$, $F_0 = f_2(\Theta)$, consists of a component originating from $\alpha'_{\perp 1} \mu_0 \neq 0$, i.e. linear trends in the common trends, and another from $\alpha' \mu_1 \neq 0$, i.e. from a linear trend in β. See Johansen (1992,1995), Rahbek *et.al.* (1999) and Paruolo (1996) for further details.

It appears from (4.4) that the constant term, if unrestricted, allows for quadratic and linear trends in the data. Linear trends would correspond to $E(\Delta p) = \pi_1 \neq 0$, which seems a reasonable assumption, whereas quadratic trends in prices correspond to $E(\Delta p) = \pi_1 + \pi_2 t$, $(\pi_1, \pi_2) \neq 0$. Although a linear trend in inflation rate may work as a local approximation over short periods of time, such an assumption can hardy be justified over longer periods. This is the motivation for imposing the *a priori* restriction $\alpha^{'}_{\perp 2}\mu_0 = 0$. As shown in Rahbek *et.al.* (1999) this model delivers similar inference for the determination of the rank indices.

The hypothesis that x_t is $I(1)$ is formulated as the reduced rank hypotheses of (4.2) and the full rank of (4.3).

The moving average representation of the $I(1)$ model defines x_t as a function of ε_t, the initial values X_0, and the variables in D_t and is given by:

$$x_t = C\sum_1^t \epsilon_i + C\mu_0 t + \widetilde{E}t + C\Phi\sum_1^t D_i + C^*(L)(\varepsilon_t + \mu_0 + \Phi D_t) + B \qquad (4.6)$$

where $C = \beta_\perp(\alpha'_\perp \Gamma \beta_\perp)^{-1}\alpha'_\perp$, $C^*(L)$ is an infinite polynomial in the lag operator L, and B is a function of the initial values.

5. The empirical model

Model (4.1) is estimated with two lags and a linear trend restricted to lie in the cointegration space motivated by the short-run Phillips curve / demand pressure relation (3.6). The variables are defined by:

$$x'_t = [m, p, y, R_m, R_b]_t, \ \ t = 1974{:}4\text{-}1994{:}4$$

where m is the log of the monetary aggregate $M3$[3], p is the log of the CPI, y is the log of real GDP, R_m is the rate of return on $M3$, R_b is the yield on medium-term bonds. Both interest rates are divided by 400 to make the estimated coefficients comparable with logarithmic quarterly changes.

The model includes two transitory impulse dummies defined as Dixxy = 1 in 19xx Quarter_y, -1 in 19xxQuarter_y*+1, 0* otherwise, and three permanent impulse dummies defined as Dxxy = 1 in 19xxQuarter_y, *0* otherwise, to account for the following significant reforms and interventions:

Di763 = The large impact of the monetization of government debt on money stock.

Di791 = The start of the EMS with 9 participating countries

D872 = The removal of the ceiling on interest rates that credit institutions could pay on sight deposits.

[3]The empirical analysis is based on $M3$ instead of ALP because of the very close substitutability between assets inside and outside ALP discussed in Section 2.1.

D924 = The devaluation of the peseta in September and November 1992.

The sample is divided into two periods, 1974:4-1989:1 and 1989:1-1996:3. The motivation for the split is partly econometric: strong evidence of parameter nonconstancy at around 1989, and partly economic: did monetary mechanisms change (and how) after Spain joined the EMS. We will investigate this empirically by distinguishing between (i) changes in the long-run coefficients β and (ii) changes in the adjustment coefficients α. Of particular interest are zero, nonzero parameter changes, i.e. changes in cointegrating properties that signal changes in the functioning of the markets.

5.1. Specification tests

As a general check of the statistical adequacy of the model we report both multivariate and univariate misspecification tests for each sub-sample in Table 5.2. A significant test statistic is given in bold face.

For both periods all misspecification tests are acceptable, except for some indication of ARCH effects in nominal money in the first period. Since cointegration results are generally robust to heteroscedastic residuals, we conclude that the empirical models are acceptable descriptions of the data. The R^2 are generally high and compared with the small values of $\hat{\sigma}_\varepsilon$ suggests that the model can explain most of the variation in the data.

The significance of a regime change at the entrance in the EMS was tested with an LR test approximately distributed as $\chi^2(\upsilon)$, where υ is the total number of estimated parameters in the cointegrated VAR model under the null of constant parameters. Because the VAR model is based on two lags, the effective sample size for the conditional data vector $\{x_t \mid x_{t-1}, x_{t-2}\}$ is two observations less than for x_t. When splitting the sample at 1989:1 we can either use 1989:1-2 as initial values or condition on 1988:3-4. The sum of the effective sample size of each subperiod is $T-2$ in the first case, but T in the second case, where T is the effective size of the full sample. The test statistics reported in Table 5.2 is based on the second case. It appears that the null of parameter constancy is strongly rejected.

5.2. Integration and cointegration rank

The cointegration rank can be seen as an indication of how well markets adjust and, therefore, of market deregulation. Based on the arguments in Juselius (1998a, 1999b) we expect that at least two common stochastic trends are driving this system of money, prices, income and interest rates; one trend associated with permanent nominal shocks and the other with permanent real shocks. This hypothesis is more plausible in a deregulated than a regulated economy. Therefore,

Table 5.1: Misspecification tests and characteristic roots

Spain I					
Multivariate tests:					
Residual autocorr. LM_1	$\chi^2(25)$	=	37.23	p-val.	0.05
LM_4	$\chi^2(25)$	=	22.78	p-val.	0.53
Normality: LM	$\chi^2(10)$	=	12.21	p-val.	0.27
Univariate tests:	Δm	Δp	Δy	ΔR_m	ΔR_b
ARCH(2)	0.98	2.08	0.88	1.63	0.06
Jarq.Bera(2)	**9.62**	0.18	2.06	1.59	0.48
$\hat{\sigma}_\varepsilon$	0.0041	0.0050	0.0089	0.0002	0.0009
R^2	0.80	0.90	0.78	0.67	0.46
Eigenvalues of the Π-matrix:	0.71	0.61	0.40	0.24	0.14
Modulus of 5 largest roots					
Unrestricted model:	0.97	0.97	0.93	0.93	0.52
$r = 3$	1.00	1.00	0.98	0.81	0.57
$r = 2$	1.00	1.00	1.00	0.98	0.69
Spain II					
Multivariate tests:					
Residual autocorr. LM_1	$\chi^2(25)$	=	38.0	p-val.	0.05
LM_4	$\chi^2(25)$	=	19.8	p-val.	0.76
Normality: LM	$\chi^2(10)$	=	9.6	p-val.	0.47
Univariate tests:	Δm	Δp	Δy	ΔR_m	ΔR_b
ARCH(2)	0.89	1.14	0.71	1.49	3.54
Jarq.Bera(2)	0.85	1.15	0.94	4.41	1.17
$\hat{\sigma}_\varepsilon$	0.0046	0.0024	0.0053	0.0002	0.0005
R^2	0.80	0.80	0.89	0.86	0.80
Eigenvalues of the Π-matrix:	0.86	0.65	0.60	0.55	0.12
Modulus of 5 largest roots					
Unrestricted model:	0.97	0.92	0.92	0.87	0.75
$r = 3$	1.0	1.0	0.89	0.89	0.88
$r = 2$	1.0	1.0	1.0	0.84	0.84

Table 5.2: Testing for a regime shift

-log$\mid \hat{\Sigma} \mid \times T_i$	-log$\mid \hat{\Sigma} \mid \times T_i$	-log$\mid \hat{\Sigma} \mid \times T_i$	$\chi^2(\upsilon)$	*95%.conf.bands*
First period	*Second period*	*Full sample*		
52*61.705	30*67.997	82*61.44531	212(105)	75-135

our preferred hypothesis is $\{r = 3, p - r = 2\}$, but in the first more regulated period r might be lower.

The roots of the characteristic polynomial of the VAR model provide useful information when there are $I(2)$ or near $I(2)$ components in the data. The number of unit roots in the characteristic polynomial is $s_1 + 2s_2$, where s_1 and s_2 are the number of $I(1)$ and $I(2)$ common trends, respectively. If there are no $I(2)$ components in the data the number of unit roots (or near unit roots) is $p - r$. In table 5.1. the characteristic roots are reported for the unrestricted VAR and the VAR restricted to $r = 2$ and 3. In the first period there remains one large roots and in the second period two large roots whatever value of r is chosen. This is strong evidence of at least one stochastic $I(2)$ trend in the first period and possibly two in the second.

The order of integration and cointegration can be formally tested in the $I(2)$ model using the likelihood procedure. Johansen (1995) derived a LR test for the determination of s_1 conditional on r. Paruolo (1996) extended the test procedure to the joint determination of (r, s_1) and simulated the nonstandard asymptotic distributions for the model with different restrictions on the constant term. Rahbek, Kongsted, and Jørgensen (1998) derive the nonstandard asymptotic distributions for trend stationarity in the I(2) model.

The test statistics reported in Table 5.3 are based on the VAR model with a trend in the cointegration space and, therefore, based on the tables in Rahbek, Kongsted, and Jørgensen (1998)[4]. The test procedure is based on the joint determination of (r, s_1) for the model with $\alpha'_{\perp 2}\mu = 0$, i.e. quadratic trends are not allowed in the model. The 95% quantiles are given in italics. Note that the tabulated values are generated for a model without dummies and without small sample corrections. Therefore, the size of the tests is not likely to be accurate and the results should only be considered indicative. The conventional test procedure starts with the most restricted model $\{r = 0, s_1 = 0, s_2 = 5\}$ in the upper left hand corner, continues to the end of the first row, and proceeds similarly row-wise from left to right until the first acceptance.

As discussed above our prior hypothesis is $\{r = 3, p - r = 2\}$ and, unless there is strong evidence for more than two stochastic trends in the data, we will base the subsequent analysis on this choice.

First period: It appears that the case $\{r = 3, s_1 = 1, s_2 = 1\}$ cannot be rejected. It also corresponds to the first strongly acceptable case and to four unit roots in the characteristic polynomial, consistent with the number of unit roots and near unit roots in Table 5.1. The $\alpha_{3.1}$ and $\alpha_{3.5}$ coefficients of the third cointegration vector were strongly significant, suggesting significant mean

[4]The estimates of the $I(2)$ model have been calculated with a procedure developed by C. Jorgensen within the software package CATS for RATS, Hansen and Juselius (1994).

Table 5.3: Testing the joint hypothesis H(s_1,r)

p-r	r	$Q(s_1, r)$					$Q(r)$	$Q(s_1, r)$					$Q(r)$
		First perod						Second period					
5	0	344	256	225	195	169	162	282	230	197	166	149	140
		198	168	142	120	101		198	168	142	120	101	
4	1		237	172	138	108	97		188	138	105	88	84
			137	113	92	75	63		137	113	92	75	63
3	2			118	84	52	48			124	75	57	54
				87	68	53	42			87	68	53	42
2	3				40	**24**	22				75	**29**	27
					48	34	25				48	34	25
1	4					*14*	*8*					38	8
						20	12					20	12
s_2		5	4	3	2	1	0	5	4	3	2	1	0

reversion. Because the choice of cointegration indices is crucial for all subsequent results and we have checked the sensitivity of our results (not reported here) for the choice of $\{r = 2, s_1 = 2, s_2 = 1\}$. The latter case generally performed worse on all criteria.

Second period: Since the sample is less than 10 years, the results should be interpreted with some caution. Our prior hypothesis $\{r = 3, s_1 = 1, s_2 = 1\}$ cannot be rejected and, again, is the first acceptable case when using the standard procedure. It corresponds to four unit roots in the model which is consistent with the four near unit roots in Table 5.1. Again the α coefficients of the third cointegrating relation are very significant. However, when two unit roots are imposed three fairly large roots remain in the model. Based on sensitivity analyses (not reported here) we find that $\{r = 3, s_1 = 1, s_2 = 1\}$ is nevertheless the best choice.

6. Testing for long-run price homogeneity

The frequent practise of imposing long-run price homogeneity a priori without proper testing can be hazardous in empirical modelling. This is so for two reasons: First, because the analysis of nonstationary real variables, such as $m-p$ and y^n-p, implies that both nominal money and nominal income have to cointegrate with prices from $I(2)$ to $I(1)$, i.e. $m-p$ and y^n-p have to be $CI(2,1)$. Second, because a valid transformation of the $I(2)$ nominal system to a real $I(1)$ system requires the inclusion of the inflation rate. This will be demonstrated in Section 7. Section 6.1.

Table 6.1: Estimates of the β directions of x_t and the weights of the common stochastic I(2) trend.

	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_{\perp 1}$	$\hat{\beta}_{\perp 2}$	$\hat{\alpha}_{\perp 2}$
The period 1976-1988						
m	1.0	1.0	1.0	-5.0	-1.6	-0.036
p	-0.7	-0.1	-0.1	1.9	-2.6	0.005
y	-0.7	-2.4	-0.2	-2.9	0.9	-0.004
R_m	-16.3	-16.3	-24.1	-0.2	-0.1	0.317
R_b	4.9	-11.3	2.1	0.4	-0.2	-0.237
The period 1989-1996						
	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_{\perp 1}$	$\hat{\beta}_{\perp 2}$	$\hat{\alpha}_{\perp 2}$
m	1.0	1.0	1.0	-7.3	-6.5	-0.021
p	-2.5	-1.2	-0.5	0.8	-3.4	0.020
y	-0.9	-0.5	-0.4	-8.4	5.3	-0.001
R_m	-21.3	-6.1	-36.7	-0.2	-0.2	-0.190
R_b	15.3	-19.5	15.8	-0.2	-.2	0.195

reports some estimates of the $I(2)$ model and discusses three different formulations of the hypothesis of long-run price homogeneity and Section 6.2. reports the test results.

6.1. Restrictions on the I(2) model

It is natural to express the hypothesis of price homogeneity as restrictions on the β components of the vector process, i.e. $[\beta, \beta_{\perp 1}, \beta_{\perp 2}]$ (Juselius, 1999b). The estimates of β and $\beta_{\perp 1}$ define the $CI(2,1)$ relations and $\beta_{\perp 2}$ define the variables which are affected by the $I(2)$ trends. The hypothesis of long-run price homogeneity can be formulated as:

$$\beta_i' = [a_i, -a_i, *, *, *],\ i = 1, ..., r, \tag{6.1}$$
$$\beta_{\perp 1}' = [b, -b, *, *, *], \tag{6.2}$$
$$\beta_{\perp 2}' = [c, c, 0, 0, 0]. \tag{6.3}$$

Restriction (6.3) is valid under assumption that nominal money and prices alone are affected by the $I(2)$ trend. See for instance the discussion in Juselius (1999a).

In table 6.1 we report the estimates of $\{\beta, \beta_{\perp 1}, \beta_{\perp 2}, \alpha_{\perp 2}\}$. For both periods the estimates are based on $\{s_1 = 1, s_2 = 1\}$. Based on the estimates $\hat{\beta}$, the long-run homogeneity hypothesis (6.1) does not get much empirical support. In the

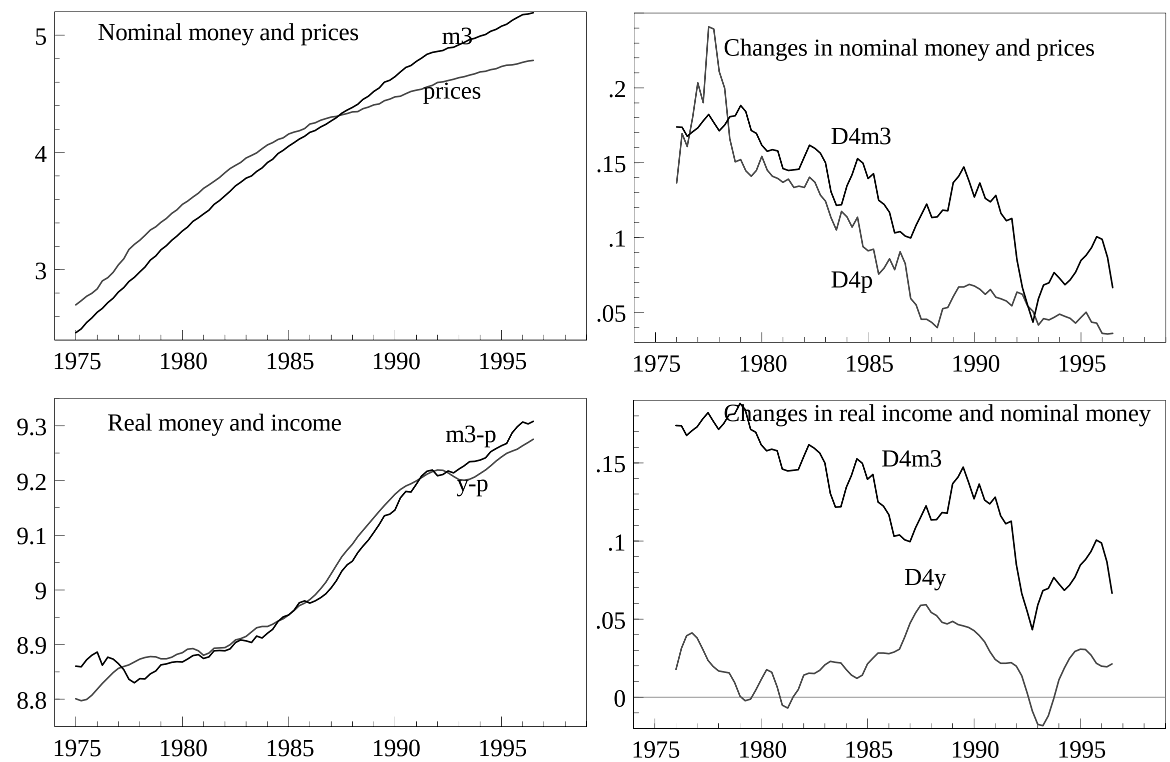

Figure 6.1: The graphs of nominal m3 and implicit price deflator (upper lhs), yearly changes in nominal m3 and prices (upper rhs), real GDP and real m3 (lower lhsl), and yearly changes in real GDP and m3 (lower rhs).

first period only $\hat{\beta}_1$ is somewhat close to price homogeneity, whereas the price variable is more or less absent in both $\hat{\beta}_2$ and $\hat{\beta}_3$. In the second period only $\hat{\beta}_2$ is approximately consistent with price homogeneity. The coefficients indicate that M3 money stock has grown much faster than prices in the first period. This is supported by the graphical display in the upper panels of Figure 6.1 showing that, except for the first few years after the oil crises, money stock (M3) has grown faster than prices over the whole sample period.

The hypothetical homogeneity restriction (6.2) of $\beta_{\perp 1}$ does not seem to have much empirical support in the two periods. Instead, the estimates suggest a relation between nominal money and real income. Note, however, that $\beta_{\perp 1}$ defines a $CI(2,1)$ relation and, hence, both m and y have to be $I(2)$ for $\beta'_{\perp 1}x_t$ to be $CI(2,1)$ econometrically. Since $\beta'_{\perp 1}x_t$ can only become stationary by differencing, the result suggests that Δm and Δy have moved in opposite directions. The graphical picture of the yearly growth rates in the lower r.h.s. panel of Figure 6.1 support this finding. A possible interpretation is that the BoS has reduced money stock to curb excess real income growth over the business cycle.

Consistent with the above results, the long-run homogeneity restriction (6.3) does not seem to be empirically satisfied. Furthermore, real income has a large coefficient (particularly in the second period) against the hypothetical zero coefficient. Since the estimates of $\beta_{\perp 2}$ determine the loadings of the $I(2)$ trend to the variables of the system, this suggests that real income is empirically $I(2)$ in this period. As a first check of this hypothesis we investigate whether the money velocity transformation is able to cancel the $I(2)$ trends, i.e. whether velocity is $CI(2,1)$. The result for the first period is given by:

$$m - p - y = (-1.6 + 2.6 - 0.9)\alpha'_{\perp 2}\Sigma\Sigma\varepsilon_i + I(1) \text{ and } I(0) \text{ components}$$

and for the second period by:

$$m - p - y = (-6.5 + 3.4 - 5.3)\alpha'_{\perp 2}\Sigma\Sigma\varepsilon_i + I(1) \text{ and } I(0) \text{ components.}$$

In the pre-EMS period the coefficients add approximately to zero suggesting that velocity is $I(1)$. In the EMS period the coefficients do not add to zero and the velocity transformation does not seem to be $CI(2,1)$. The sensitivity of this result has been carefully checked for different choices of r and s_1, but the conclusion remains. The graphical picture of real M3 and real GDP in the lower l.h.s. panel of Figure 6.1 supports this interpretation.

From (4.5) it can be seen that $\alpha_{\perp 2}$ determines the common stochastic trends defined by $\alpha'_{\perp 2}\Sigma\Sigma\varepsilon_i$. The estimates in Table 6.1 show that the twice cumulated disturbances from the two interest rates have the greatest weights in the $I(2)$ trend. Similar results have been found for Denmark (Juselius, 1998b) and for Italy (Juselius and Gennari, 1999). Because the coefficients are approximately equal with opposite signs, the result indicates that the twice cumulated shocks to the spread have a major impact on the long-run stochastic nominal trend in this period. Note, however, that the sign have changed between the two periods.

Altogether, the conventional explanation of long-run trends in prices being caused by excess money does not seem appropriate to explain the development of nominal money and prices in this period. In the first period there is evidence of convergence between nominal money, prices and real income, whereas in the second period this is more questionable. The empirical result that real income is needed (in addition to nominal M3) to account for the long-run trend in prices suggests that the fast expansion of the government sector and the obligation of the central bank to monetize government debt played an important role for the rapid growth of GDP, particularly in the first period.

Table 6.2: Long-run price proportionality tests in the first period

	Hypotheses	*Period I*		*Period II*	
	$\beta = \{H_i\phi\}$	$\chi^2(\nu)$	*p-val.*	$\chi^2(\nu)$	*p-val.*
$\mathcal{H}_1$	$H_1\phi_j = [a_j, -a_j, *, *, *, *]$	13.5(3)	0.00	8.8(3)	0.03
	$\beta = \{H_i\phi, \psi\}$	$\chi^2(\nu)$	*p-val.*	$\chi^2(\nu)$	*p-val.*
$\mathcal{H}_2$	$H_2\phi = [1, -1, 0, 0, 0, *]$	11.2(2)	0.00	3.0(2)	**0.23**
$\mathcal{H}_3$	$H_3\phi = [0, 0, 1, 0, 0, *]$	12.8(2)	0.00	2.2(2)	**0.33**
$\mathcal{H}_4$	$H_3\phi = [1, -1, -1, 0, 0, *]$	0.9(2)	**0.64**	2.6(2)	**0.27**

6.2. Hypotheses testing

For both periods, the quite large coefficients of real income in $\beta_{\perp 2}$ motivates further investigation. Three hypotheses will be formally tested:

(i) Can real money stock be considered $I(1)$?

(ii) Can real aggregate income be considered $I(1)$?

(iii) Can velocity or any combination between real money and real income be considered $I(1)$?

The tests are based on standard test procedures developed for the $I(1)$ model. Acceptance of hypotheses, however, implies cointegration from $I(2)$ to $I(1)$ (possibly $I(0)$), i.e. the cointegrated relations are $CI(2,1)$ (or possibly $CI(2,2)$).

The first hypothesis $\mathcal{H}_1$ tests formally whether price homogeneity can be imposed on all cointegration vectors. It is of the form $\beta = \{H\phi\}$. The hypotheses $\mathcal{H}_2 - \mathcal{H}_4$ are of the form $\beta = \{H\phi, \psi\}$, i.e. they test restrictions on a single vector and leave the other vectors unrestricted. See Johansen and Juselius (1992) for further detail. The results are presented in Table 6.2.

As expected, the hypothesis $\mathcal{H}_1$ of overall long-run price homogeneity in the cointegration space is clearly rejected for both periods, but less strongly so for the second period. The hypotheses $\mathcal{H}_2$ and $\mathcal{H}_3$, that trend-adjusted real money stock and real income are $I(1)$, are rejected in the first period, but not in the second. The velocity hypothesis $\mathcal{H}_4$ is not rejected in the first nor the second period. Altogether the results are in accordance with the results in Table 6.1 for the first period, but accepting real money, real income, and velocity to be $I(1)$ in the second period is more surprising. However, the very small sample size in the second sample might have produced a large variance of the test statistic.

7. The I(1) model

In the ideal case of overall long-run price homogeneity and real income being $I(1)$, the model can be transformed into the $I(1)$ model without loosing any data information by using either of the following data vectors:

$$\begin{aligned} x_t' &= [m-p, y, \Delta p, R_m, R_b]_t \\ x_t' &= [m-p, y, \Delta m, R_m, R_b]_t \end{aligned}$$

However, overall long-run homogeneity was rejected in both periods and real income was found to be $I(2)$ at least in the first period. Based on the results of Table 6.2, eq. (7.1) would correspond to an $I(1)$ model for the second period, but some data information would be lost, in particular the information relevant for explaining the non-homogeneous movements in nominal money and prices. For the first period (7.1) would still be $I(2)$. Only the velocity transformation will lead to an $I(1)$ model. This can be achieved by either of the following transformations:

$$\begin{aligned} x_t' &= [m-p-y, \Delta p, \Delta y, R_m, R_b]_t \qquad (7.1) \\ x_t' &= [m-p-y, \Delta m, \Delta y, R_m, R_b]_t, \\ x_t' &= [m-p-y, \Delta m, \Delta p, R_m, R_b]_t. \end{aligned}$$

The data vector (7.2) was chosen for the subsequent model analysis for the first period. For the second period the model analysis was performed based on both (7.1) and (7.2). Because the major findings were unaffected in both cases we have chosen to report the results based on (7.2) to facilitate the comparative analysis. Because the likelihood function of the velocity transformed model is no longer equivalent to the nominal model of Section 5 we have recalculated the misspecification tests. No sign of misspecification remained. For the first period the largest unrestricted root in the model based on (6.2) was 0.84, for the second it was 0.83.

Note that the choice of the velocity transformation (7.2) imposes *a priori* a unit long-run income coefficient in the money demand relation and, hence, excludes the possibility to test the BoS estimate of 1.7. In this sense we have from the outset chosen to explain money velocity, inflation and real growth instead of real money, real income, and inflation.

7.1. Absence of long-run feed-back

We report the results of testing the absence of long-run feed-back (i.e. long-run weak exogeneity) both for $r = 2$ and 3 as a sensitivity check. The tests, formulated

Table 7.1: Testing for weak exogeneity

r	*m-p-y*	Δp	Δy	R_m	R_b	$\chi^2(r)$
			Spain 1975-88			
2	47.2	48.6	42.6	0.2	1.0	6.0
3	65.7	63.8	59.8	7.3	**3.5**	7.8
			Spain 1989-96			
2	4.4	16.1	11.0	0.4	2.6	6.0
3	8.9	19.9	13.0	**1.6**	**2.8**	7.8

as $R\alpha = 0$ where R is a unit vector, are approximately distributed as $\chi^2(r)$. The results are reported in Table 7.1 where insignificant test values are indicated with bold face.

The bond rate is found to be weakly exogenous for the long-run parameters β in both periods, whereas the short-term money interest rate is weakly exogenous in the EMS but not in the pre-EMS period. If $r = 2$, then both interest rates would have been weakly exogenous in the whole period. This is consistent with the strong weights of the interest rates in $\hat{\alpha}_{\perp 2}$ discussed in the previous section. It demonstrates the crucial role nominal interest rates have played in the monetary transmission mechanisms over the last decades. Because the single hypothesis tests in Table 7.1 are not in general independent we also test the hypothesis of the short-term rate and the long-term rate being jointly weakly exogenous. The test, distributed as $\chi^2(6)$, gave a test value of 9.36 (p.value = 0.15) and the null can be accepted.

The result that both interest rates might be weakly exogenous is somewhat surprising. A priori one would expect the short-term and the long-term interest rates to adjust to each other and, hence, only one of them to be weakly exogenous. Because the test statistic increased substantially in the combined test compared to the single tests, it seems likely that some adjustment information would be lost if the joint restrictions are imposed. Therefore, in the subsequent analysis of the long-run structure no weak exogeneity restrictions will be imposed *a priori.* Instead, the significance of the adjustment coefficients will be used as an indication of which interest rate is adjusting and which is driving.

7.2. Cointegration properties

To assess the cointegration properties of the theoretical relations discussed in Section 3 we test alternative specifications of a velocity relation and interest rates / inflation relation. Given two stochastic trends one would generally find cointegration between sets of either two or three variables. The purpose of the empirical testing is to identify where and how strongly cointegration is present.

The hypotheses are of the form $\beta = \{H\phi_1, \psi_1, \psi_2\}$, i.e. we test whether a single restricted relation is in $sp(\beta)$ leaving the other two relations unrestricted. Each hypothesis is tested for both periods. If the hypothetical relations exists empirically, then this procedure will maximize the chance of finding them.

These tests provide information about the direct relationship between, say, a policy instrument variable and a target or a goal variable. For example, if monetary expansion always and everywhere leads to inflation we would expect inflation to cointegrate positively either with the change in real money stock corrected for linear growth or trend-adjusted velocity. But since monetary expansion can be inflationary through increased aggregate demand pressure, positive cointegration between inflation and trend-adjusted real income can also be an indication of monetary transmission effects. These relationships are quite likely to change relative to the degree of openness and regulation of the economies and, therefore, can provide information about the effects of European integration.

In the *velocity* part of Table 7.1. several hypotheses involving velocity are tested:

$\mathcal{H}_5$ tests whether there is evidence of the demand for money relation (3.1). It imposes two just identifying restrictions and hence no testing is involved. The coefficients of the two interest rates suggest a plausible money demand relation for the first period: money holdings increases with increasing yield on money and decreases with increasing yield on alternative assets. In the second period the coefficients of interest rates are both negative suggesting that money holdings increase with increases in both yields. This does not define a plausible money demand relation, but might be explained empirically by the close substitutability between money assets and alternative assets in this period discussed in Section 2.

$\mathcal{H}_6$ tests the hypothetical central bank policy rule (3.2). It is strongly acceptable in both periods, which supports the general conception that Bank of Spain has predominantly relied on money stock control (in particular in the first period). Note, however, that a negative relation between inflation and money velocity also can be evidence of money demand effects. The question whether $\mathcal{H}_6$ empirically describes a money demand relation or a monetary policy rule will be addressed in Section 8.

$\mathcal{H}_7$ is motivated by the strong empirical evidence of co-movements between real income growth and expansion of money stock demonstrated in Section 6. It is strongly supported in the first period but not in the second. The coefficients of the first period suggest that real GDP growth was strongly adjusting to money velocity. This can be interpreted as evidence of real effects from the monetization of government debt. In the EMS period this is no longer the case, supporting the view that real monetization effects are not possible in a deregulated open

Table 7.2: Cointegration properties

	m-p-y	Δp	Δy	R_m	R_b	*trend*	$\chi^2(\upsilon)$	*p.val.*
				The period 1976-1988				
Velocity								
$\mathcal{H}_5$	1	0	0	-7.7	3.0	-0.005	- (0)	-
$\mathcal{H}_6$	1	4.8	0	0	0	-0.002	0.05(1)	**0.82**
$\mathcal{H}_7$	1	0	-1.2	0	0	-0.005	0.08(1)	**0.78**
Interest rates								
$\mathcal{H}_8$	0	0	0	1	-1	0	24.9(3)	0.00
$\mathcal{H}_9$	0	0	0	1	-0.35	0	9.3(2)	0.01
$\mathcal{H}_{10}$	0	-0.53	0	1	0	0	10.1(2)	0.01
$\mathcal{H}_{11}$	0	-2.0	0	0	1	0	11.1(2)	0.00
$\mathcal{H}_{12}$	0	1.7	0	1	-1	0	11.6(2)	0.00
$\mathcal{H}_{13}$	0	-1.04	0	1	0.04	0	10.4(2)	0.01
$\mathcal{H}_{14}$	0	-0.16	-0.35	1	-0.49	0	0.23(1)	**0.63**
				The period 1989-1996				
Velocity								
$\mathcal{H}_5$	1	0	0	-16.9	-11.1	-0.012	- (0)	-
$\mathcal{H}_6$	0.007	1.0	0	0	0	0.000	0.06(1)	**0.80**
$\mathcal{H}_7$	0.080	0	1.0	0	0	0.000	4.48(1)	0.03
Interest rates								
$\mathcal{H}_8$	0	0	0	1	-1	0	24.9(3)	0.00
$\mathcal{H}_9$	0	0	0	1	-0.75	0	7.3(2)	0.03
$\mathcal{H}_{10}$	0	-0.6	0	1	0	0	10.1(2)	0.01
$\mathcal{H}_{11}$	0	-0.8	0	0	1	0	11.1(2)	0.00
$\mathcal{H}_{12}$	0	0.2	0	1	-1	0	1.7(2)	**0.42**
$\mathcal{H}_{13}$	0	-0.4	0	-0.6	1	0	10.2(2)	0.01

economy.

The interest rate relations of Table 7.2 test different hypotheses on stationary relationships between the short-term interest variable (which is closely related to the central bank interest rates) and inflation rate (the goal variable) and long-term interest rate (the target variable).

$\mathcal{H}_8$ tests the stationarity of the interest rate spread. Since it is rejected in both periods, $\mathcal{H}_9$ tests whether any combination of the two interest rates is stationary. It is also rejected in both periods. This is also the case for $\mathcal{H}_{10}$ and $\mathcal{H}_{11}$ which test whether real interest rates are stationary, but without restricting the inflation coefficient. Hence, the interest rates and the inflation rate must be affected by both common stochastic trends, so pairwise cointegration is not possible (Juselius,

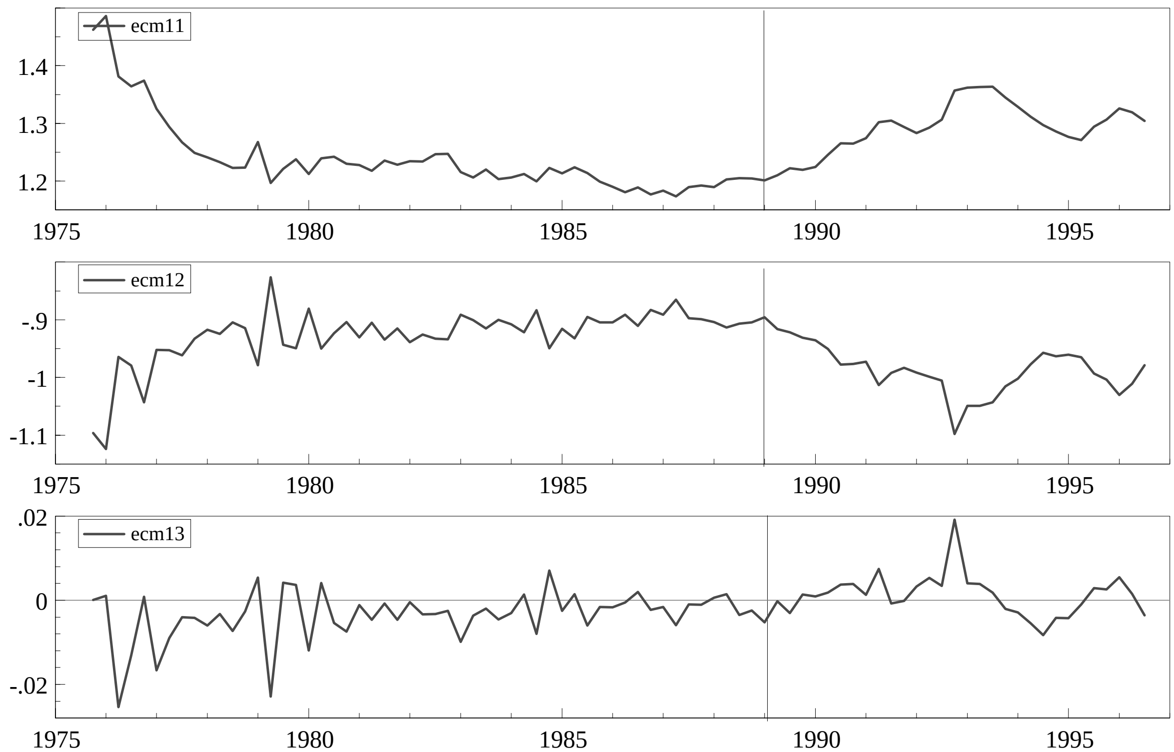

Figure 7.1: The estimated cointegration relations based on the period 1974:3-1989:1, and extrapolated for the period 1989:2-1995:4.

1999a).

$\mathcal{H}_{12}$ tests whether the spread is cointegrated with inflation i.e. policy rule (3.3). In the first period it is rejected, but not in the second. This could be evidence of the increased importance of interest rate control in the EMS period as discussed in Section 2.1. However, the sign of the relationship is not consistent with the monetary policy rule and we leave its further interpretation to the next section.

$\mathcal{H}_{13}$ tests whether there exists a homogeneous relation between the interest rates and the inflation and is rejected in both periods. For the first period we furthermore test $\mathcal{H}_{14}$, a homogeneous relation between the short- and long-term interest rates, inflation, and real growth. It was strongly accepted indicating that all three variables were important for the operating procedure of the BoF.

Altogether, the results of $\mathcal{H}_8 - \mathcal{H}_{14}$ give little support for the stationary version of the Fisher parity (3.5) and the term structure of interest rates (3.6).

7.3. A representation of three long-run relations

The hypothesis of a fully identified cointegration structure is of the form $\beta_r = \{H_1\phi_1, H_2\phi_2, H_3\phi_3\}$, where the design matrices H_i imposes restrictions on each cointegration vector such that a fully identified structure of long-run relations is obtained. The test of overidentifying restrictions is based on the LR test procedure described in Johansen and Juselius (1994) and is asymptotically distributed as $\chi^2(v)$, where v is the number of overidentifying restrictions.

In Table 7.3 we report a specification of the long-run structure for the first period. It essentially consists of $\mathcal{H}_6, \mathcal{H}_7$, and $\mathcal{H}_{14}$ (with the exception that homogeneity restriction of $\mathcal{H}_{14}$ is not imposed here) and imposes one overidentifying restriction which is accepted with a p-value of 0.74. The first relation $\hat{\beta}_1^{\prime} x_t$ corresponds to the money demand relation of Table 7.2. The second relation $\hat{\beta}_2^{\prime} x_t$ describes real growth as being positively and very significantly related to money velocity. By reordering the variables it can be interpreted as a dynamic steady-state relation where real GPD growth adjusts to the deviation between the level of real GDP and real money stock in the following way:

$$\Delta^2 y_t = ... - 0.34[\Delta y_{t-1} + 0.74\{y - (m - p)\}]_{t-1}$$

The adjustment coefficient -0.34 is taken from model (8.1) in Section 8. The cointegration relation within the brackets suggest that real GDP growth has adjusted positively to monetary expansion in the first period. This is consistent with the I(2) analysis in Section 6 and explains why real GDP was needed to cancel the I(2) trends in the data. However, this relationship does not describe a long-run sustainable steady-state relation as can be seen from the graphical display in the middle panel of Figure 7.1. When extrapolated into the EMS period the relationship breaks down. It seems sustainable only as long as capital and trade regulations were effective in the Spanish economy.

The third relation $\hat{\beta}_3^{\prime} x_t$, describes an approximately homogeneous relation between the short-term interest rate and the long-term bond rate, inflation, and real growth. As mentioned above it might be interpreted as a monetary reaction rule for setting the short-term interest rate. The graphical display of Figure 7.1, lower panel, shows that it becomes less stable after 1989. This is an indicating that monetary policy rule has changed, or that the adjustment of the short-term interest rate to the (market determined) bond rate has become increasingly strong. The latter interpretation is consistent with the cointegration estimates of the second period.

In the second period the long-run structure consists essentially of the hypotheses $\mathcal{H}_6, \mathcal{H}_5$, and $\mathcal{H}_{12}$ (with the exception that R_b is restricted to zero in $\mathcal{H}_5$). The first relation, $\hat{\beta}_1^{\prime} x_t$, might either be interpreted as the monetary policy rule (3.2) or

Table 7.3: An identified long-run structure for the EMS period

	$m-p-y$	Δp	Δy	R_m	R_b	$trend$
			First period			
β_1'	1.0	0	0	-5.4	2.5	-0.005
				(12.8)	(12.2)	
β_2'	-0.74	0	1.0	0	0	-0.003
	(124)					
β_3'	0	-0.12	-0.28	1.0	-0.47	0
		(11.0)	(25.7)		(17.3)	
The LR test for overidentifying restrictions: $\chi^2(1) = 0.09\,(p.val. = 0.76)$						
			Second period			
β_1'	0.008	1.0	0	0	0	0.0005
	(1.6)					
β_2'	-0.035	0	0	1.0	0	0.0003
	(11.7)					
β_3'	0	0.22	0	1.0	-1.0	0
		(10.0)				
The LR test for overidentifying restrictions: $\chi^2(4) = 2.16\,(p.val. = 0.71)$						
t-values are given in parentheses						

as money demand relation describing agents' willingness to hold money stock as an alternative to real assets. The second relation, $\hat{\beta}_2' x_t$, might also be interpreted as a money demand relation, but the absence of a plausible alternative cost of holding money is problematic. When R_b is included in β_2 its estimated coefficient obtains the same sign as R_m. It appears from the graph in the middle panel of figure 7.2 that this relation was not stationary in the period before 1985, i.e. before the government facilitated the substitution between less liquid assets with liquid assets in 1985 as mentioned in Section 2.2. The third relation, $\hat{\beta}_3' x_t$, describes the interest rate spread as a function of inflation. The sign of the inflation coefficient suggests that inflation is a proxy for a risk premium added to the price of bonds relative to short-term assets. The graph of the lower panel of Figure 7.2 shows that this relation was probably stationary already from 1985.

Altogether the graphical display suggests that most of the changes in monetary transmission mechanisms took place after the decision to join the EMS, i.e. a few years before Spain became a member of the EMS.

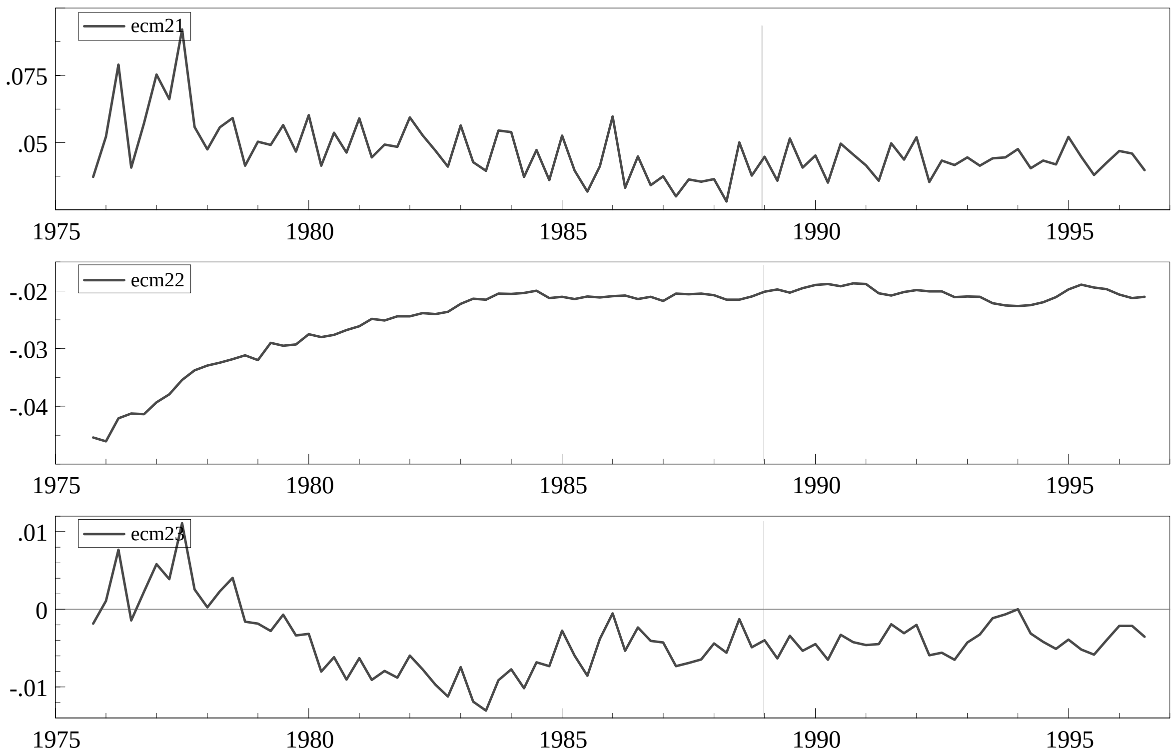

Figure 7.2: The estimated cointegration relations based on the second period 1989:1-1995:4 and extrapolated for the period 1974:4-1988:4.

7.4. The common trends and the long-run impact matrix

Here we will investigate the long-run impact of unanticipated "shocks" to the system. Because the conditional expectation $E_{t-1}\{x_t \mid X_{t-1}\}$ has optimal properties as a predictor of x_t given the information set X_{t-1} available at time t-1, we choose the residuals $\hat{\varepsilon}_{it}$ from (4.1) as estimates of the unanticipated shocks associated with variable x_i. The estimated coefficients of the C matrix in (4.5) reported in Table 7.4 are measuring the final impulse response effects. They are based on non-standardized residuals and their standard errors are, therefore, reported separately. Standard errors of estimates are calculated using results in Paruolo (1997). Significant coefficients with a p-value of 0.05 or less are indicated with bold face. The decomposition into common trends and loadings are based on $C = \widetilde{\beta}_\perp \alpha'_\perp$ where $\widetilde{\beta}_\perp = \beta_\perp(\alpha'_\perp \Gamma \beta_\perp)^{-1}$. Identification has been achieved by imposing the weak exogeneity restriction on the long-term bond rate, i.e. by imposing the restrictions:

$$\begin{aligned}\alpha'_{\perp.1} &= [*,*,*,1,0] \\ \alpha'_{\perp.2} &= [0,0,0,0,1]\end{aligned}$$

The estimated coefficients for the first period are reported in the l.h.s. of Table 7.4. It appears that the first common trend, $\alpha'_{\perp.1}\Sigma\varepsilon_i$, is approximately equal to the short-term interest rate, consistent with the weak exogeneity result of Table 6.1. The remaining coefficients of $\alpha_{\perp.1}$, though small, cannot be jointly restricted to zero and we interpret the first common trend as a domestic monetary trend, and the second, $\Sigma\varepsilon_{Rb}$, as a financial market trend.

The estimates of $\beta_{\perp.1}$ show that the domestic monetary trend, $\alpha'_{\perp.1}\Sigma\varepsilon_i$, has affected velocity, real growth, and the two interest rates positively but inflation negatively. This could be some evidence that monetary policy has been effective in the first period. As expected, the long-term bond trend, $\Sigma\varepsilon_{Rb}$, has affected velocity and real growth negatively, but inflation and the short-term interest rate positively.

The estimates of the C-matrix show that the long-run impacts of shocks to velocity, inflation, and real growth have been quite small, whereas shocks to the interest rates have had a much more significant impact on the variables of the system.

The estimates of the second period are reported in the r.h.s. of Table 7.4. The estimate of $\beta_{\perp.1}$ indicates that the domestic monetary trend, $\alpha'_{\perp.1}\Sigma\varepsilon_i$, has had a very small impact on inflation. This supports the hypothesis that the Spanish inflation has essentially adjusted to the low European inflation level without much reference to the actions of the central bank. The estimate of $\beta_{\perp.2}$ shows in particular a strong positive effect of the bond rate on money velocity supporting the close substitutability between assets inside and outside money stock. As in the first period the bond rate has a negative effect on real GDP growth, but a negative effect on inflation rate. The C-matrix shows significant long-run impact of shocks to the long-term bond rate on essentially all variables of the system.

8. A short-run adjustment model before and after EMS[5]

As discussed in Johansen and Juselius (1994) identification of the short-run adjustment structure can be performed for a given identified $\beta = \beta_r$. The estimates

[5] The estimates are computed with PcFiml (Doornik and Hendry, 1998).

Table 7.4: An identified common trends structure for the pre–EMS period

	First period					Second period				
	The common trends decomposition									
$\hat{\sigma}_\varepsilon$										
	$\Sigma\hat{\varepsilon}_{vel}$	$\Sigma\hat{\varepsilon}_{\Delta p}$	$\Sigma\hat{\varepsilon}_{\Delta y}$	$\Sigma\hat{\varepsilon}_{Rm}$	$\Sigma\hat{\varepsilon}_{Rb}$	$\Sigma\hat{\varepsilon}_{vel}$	$\Sigma\hat{\varepsilon}_{\Delta p}$	$\Sigma\hat{\varepsilon}_{\Delta y}$	$\Sigma\hat{\varepsilon}_{Rm}$	$\Sigma\hat{\varepsilon}_{Rb}$
$\alpha'_{\perp.1}$	0.03	0.02	0.03	1.0	0.0	0.08	0.11	0.07	1.0	0.0
$\alpha'_{\perp.2}$	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0
	vel	$\Delta^2 p$	$\Delta^2 y$	R_m	R_b	vel	$\Delta^2 p$	$\Delta^2 y$	R_m	R_b
$\widetilde{\beta}_{\perp.1}$	1.9	-1.7	3.9	2.0	2.1	-2.3	0.3	10.4	0.1	-0.4
$\widetilde{\beta}_{\perp.2}$	-2.1	0.5	-1.9	0.3	1.7	22.3	-0.2	-3.6	0.8	0.8
	The C-matrix									
	$\Sigma\hat{\varepsilon}_{vel}$	$\Sigma\hat{\varepsilon}_{\Delta p}$	$\Sigma\hat{\varepsilon}_{\Delta y}$	$\Sigma\hat{\varepsilon}_{Rm}$	$\Sigma\hat{\varepsilon}_{Rb}$	$\Sigma\hat{\varepsilon}_{vel}$	$\Sigma\hat{\varepsilon}_{\Delta p}$	$\Sigma\hat{\varepsilon}_{\Delta y}$	$\Sigma\hat{\varepsilon}_{Rm}$	$\Sigma\hat{\varepsilon}_{Rb}$
Δvel	0.05	0.04	0.05	1.86	**-2.07**	-0.18	0.25	-0.17	-2.28	**22.27**
	(0.5)	(0.5)	(0.5)	(1.1)	(4.7)	(0.3)	(0.3)	(0.5)	(0.1)	(2.8)
$\Delta^2 p$	-0.05	-0.04	-0.05	**-1.69**	**0.51**	**0.02**	**0.03**	**0.02**	0.25	**-0.16**
	(1.7)	(1.5)	(1.7)	(3.6)	(4.2)	(3.4)	(3.4)	(6.1)	(1.3)	(2.4)
$\Delta^2 y$	0.11	0.09	0.11	**3.87**	**-1.86**	**0.80**	**1.12**	**0.77**	10.38	-3.58
	(1.2)	(1.1)	(1.2)	(2.6)	(4.8)	(3.9)	(3.8)	(6.9)	(1.5)	(1.5)
ΔR_m	0.06	0.05	0.06	**2.02**	0.32	0.01	0.10	0.00	0.06	**0.77**
	(1.3)	(1.2)	(1.3)	(2.9)	(1.7)	(0.2)	(0.2)	(0.3)	(0.1)	(2.7)
ΔR_b	0.06	0.05	0.06	2.08	**1.71**	-0.03	-0.04	-0.03	-0.40	**-0.40**
	(0.5)	(0.5)	(0.5)	(1.1)	(3.6)	(1.4)	(1.4)	(2.4)	(0.5)	(3.0)

t-values are given in parentheses

of the restricted models reported in Table 8.1 and 8.2 are conditional on the overidentified relations reported in Table 7.3. Because a comparison of the combined long-run relations between the two periods requires similarity in model specification, the restricted short-run adjustment structure in Section 8.1 is based on the VAR. Section 8.2 includes current effects in the model and Section 8.3 compares how the combined steady-state relations have changed between the two periods.

8.1. The restricted short-run adjustment structure based on the VAR

The short-run adjustment structure in Table 8.1 and Table 8.2 has been found by a search procedure where the most insignificant adjustment coefficients have been restricted to zero and tested using a Likelihood Ratio test. The final model for the first period is accepted based on a $\chi^2(9) = 6.31(0.71)$ test for overidentifying restrictions. The short-run adjustment coefficients to the long-run relations show that almost all $ecm-$coefficients are significant in all four equations. This means that the linear combination $\hat{\alpha}\hat{\beta}_r^{\prime}x_t$ is likely to be more relevant as an estimate of the steady-state relation for the variable in question. This is particularly so because the adjustment coefficients in the velocity and the inflation equation are very similar and the $ecm11$ and $ecm12$ coefficients seem to be almost linearly related. The graphs in Figure 7.1 support this interpretation, showing that the fairly large deviations from steady-state in 1976-79 are almost equal with opposite signs. Therefore, the linear combination $\hat{\alpha}_1\hat{\beta}_{r1}^{\prime}x_t + \hat{\alpha}_2\hat{\beta}_{r2}^{\prime}x_t$ is likely to be more stable. Note also that the equations $\Delta^2 p$ and $\Delta^2 y$ are subsets of the first equation $\Delta vel = \Delta m - \Delta p - \Delta y$. Therefore, we let the discussion of the speed of adjustment towards the steady-state relations wait until the discussion of the comparative analysis which is based on the combined effects $\hat{\alpha}\beta_r^{\prime}$.

It appears that most of the short-run adjustment effects to changes in the determinants of the system were insignificant. For example, there were no effects of lagged changes in the interest rates, only current changes in the bond rate were important. We note that the latter has a negative effect on velocity (the alternative cost of holding money), a positive effect on real income (a procyclical demand effect) and on the short-term interest rate (a financial market effect), that the lagged variables show strong autoregressive effects, that the monetization of government deficit in 1976:3 had a significant effect on all variables of the system, and that the start of the EMS increased M3 velocity.

Tabel 8.1: The restricted short-run adjustment structure of the first period.

$$\begin{bmatrix}\Delta vel_t\\ \Delta^2 p_t\\ \Delta^2 y_t\\ \Delta R_{mt}\end{bmatrix} = \begin{bmatrix} \underset{(-2.02)}{-2.35} \\ 0 \\ \underset{(2.51)}{2.84} \\ \underset{(5.91)}{0.17}\end{bmatrix}[\Delta R_{bt}] + \begin{bmatrix} \underset{(3.86)}{0.55} & \underset{(-4.09)}{-0.55} & \underset{(-3.08)}{-0.31}\\ 0 & \underset{(3.22)}{0.26} & 0 \\ 0 & \underset{(3.08)}{0.34} & 0.25 \\ \underset{(2.63)}{0.02} & 0 & \underset{(-2.81)}{-0.006}\end{bmatrix}\begin{bmatrix}\Delta vel_{t-1}\\ \Delta^2 p_{t-1}\\ \Delta^2 y_{t-1}\end{bmatrix}+$$

$$\begin{bmatrix}\Delta vel_t\\ \Delta^2 p_t\\ \Delta^2 y_t\\ \Delta R_{mt}\end{bmatrix} = \begin{bmatrix} \underset{(-2.02)}{-2.35} \\ 0 \\ \underset{(2.51)}{2.84} \\ \underset{(5.91)}{0.17}\end{bmatrix}[\Delta R_{bt}] + \begin{bmatrix} \underset{(3.86)}{0.55} & \underset{(-4.09)}{-0.55} & \underset{(-3.08)}{-0.31}\\ 0 & \underset{(3.22)}{0.26} & 0 \\ 0 & \underset{(3.08)}{0.34} & 0.25 \\ \underset{(2.63)}{0.02} & 0 & \underset{(-2.81)}{-0.006}\end{bmatrix}\begin{bmatrix}\Delta vel_{t-1}\\ \Delta^2 p_{t-1}\\ \Delta^2 y_{t-1}\end{bmatrix}+$$

$$+\begin{bmatrix} \underset{(-5.15)}{-1.5} & \underset{(-3.99)}{-1.6} & \underset{(-5.78)}{-9.6}\\ \underset{(11.81)}{2.3} & \underset{(10.69)}{2.9} & \underset{(11.06)}{10.3}\\ 0 & \underset{(-9.14)}{-0.34} & \underset{(11.06)}{4.2}\\ \underset{(-2.97)}{-0.03} & \underset{(-3.01)}{-0.04} & \underset{(-3.75)}{-0.22}\end{bmatrix}\begin{bmatrix} ecm11_{t-1}\\ ecm12_{t-1}\\ ecm13_{t-1}\end{bmatrix} + \begin{bmatrix} \underset{(6.08)}{0.03} & \underset{(6.19)}{0.05}\\ \underset{(-7.86)}{-0.03} & 0\\ \underset{(-6.10)}{-0.04} & 0\\ \underset{(-4.83)}{-0.0009} & 0\end{bmatrix}\begin{bmatrix} Di76.3\\ D79.1\end{bmatrix}+$$

$$+\begin{bmatrix} v_{mt} \\ v_{\Delta pt} \\ v_{yt} \\ v_{R_{mt}} \end{bmatrix}, \; and \;\; \hat{\Sigma} = \begin{bmatrix} 0.0102^2 & & & \\ -0.17 & 0.0054^2 & & \\ -0.80 & -0.20 & 0.0101^2 & \\ -0.23 & 0.14 & 0.37 & 0.0003^2 \end{bmatrix}$$

where:

$$\begin{array}{rcl} ecm11 & = & (m-p-y) - 5.5R_m + 2.5R_b - 0.005t \\ ecm12 & = & \Delta y - 0.74(m-p-y) + 0.003t \\ ecm13 & = & R_m - 0.47R_b - 0.28\Delta y - 0.12\Delta p \end{array} ,$$

For the second period the LR test for overidentifying restrictions became $\chi^2(14) = 13.87(0.46)$ and, hence, they are clearly data consistent. Based on similar arguments as above we postpone the interpretation of the speed of adjustment of the long-run relations until the combined steady-state analysis below. The short-run adjustment effects of changes in the system determinants are even less significant than in the first period. We note that changes in the bond rate influences M3 velocity negatively (but less strongly than in the first period) and the short-term interest rate positively (the speed of adjustment has increased relative to the first period), that the autoregressive behavior of the variables is now less pronounced (except for inflation), and that leaving the EMS significantly influenced all variables except inflation.

Tabel 8.2 : The restricted short-run structure for the second period.

$$\begin{bmatrix} \Delta vel_t \\ \Delta^2 p_t \\ \Delta^2 y_t \\ \Delta R_{mt} \end{bmatrix} = \begin{bmatrix} \underset{(-2.59)}{-1.91} \\ 0 \\ 0 \\ \underset{(10.33)}{0.29} \end{bmatrix} [\Delta R_{bt}] + \begin{bmatrix} 0 & 0 \\ 0 & \underset{(3.85)}{0.45} \\ \underset{(7.26)}{0.86} & \underset{(-2.56)}{-1.26} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \Delta vel_{t-1} \\ \Delta^2 p_{t-1} \end{bmatrix} +$$

$$+\begin{bmatrix} 0 & \underset{(7.27)}{7.6} & \underset{(-3.4)}{-2.6} \\ \underset{(-6.26)}{-1.7} & 0 & 0 \\ \underset{(3.53)}{2.8} & \underset{(-6.28)}{-9.7} & 0 \\ \underset{(6.13)}{0.08} & 0 & \underset{(-12.55)}{-0.30} \end{bmatrix} \begin{bmatrix} ecm21_{t-1} \\ ecm22_{t-1} \\ ecm23_{t-1} \end{bmatrix} + \begin{bmatrix} \underset{(6.74)}{0.04} \\ 0 \\ \underset{(-4.93)}{-0.05} \\ \underset{(-1.82)}{-0.0003} \end{bmatrix} [D92.4] +$$

$$+\begin{bmatrix} v_{mt} \\ v_{\Delta pt} \\ v_{yt} \\ v_{R_{mt}} \end{bmatrix} \; and \;\; \hat{\Sigma} = \begin{bmatrix} 0.0065^2 & & & \\ -0.78 & 0.0040^2 & & \\ -0.06 & -0.28 & 0.0083^2 & \\ 0.37 & -0.51 & 0.14 & 0.0002^2 \end{bmatrix}$$

where:

$$\begin{aligned} ecm21 &= \Delta p + 0.008(m-p-y) + 0.0003t \\ ecm22 &= R_m - 0.035(m-p-y) + 0.0004t \ , \\ ecm23 &= R_m - R_b + 0.22\Delta p \end{aligned}$$

Including current effects in the model

The estimates of Σ show fairly large residual correlations in both periods, in particular between velocity and the change in real income and inflation. By re-specifying the model with the current change in income and inflation included in the velocity equation we demonstrate below that the correlations are essentially a result of the velocity transformation (7.2) of the data vector. The estimates of the velocity model with current effects are given in (8.1) for the first period and (8.4) for the second period. Because the estimates of the remaining equations were essentially unchanged they are not reported. By rearranging and collecting terms in (8.1) one gets (8.2) which shows that changes in M3 have adjusted dynamically to inflation and real GDP growth and to excess yield on M3 relative to the bond rate and real growth. The solved steady-state solution given in (8.3) demonstrates that in the pre-EMS period the changes in real money stock were essentially determined by the "spread" between the short-term interest rate and the long-term bond rate[6].

$$\begin{gathered} \Delta vel_t = 0.76\Delta vel_{t-1} - 0.75\Delta^2 p_t - 1.10\Delta^2 y_t + \\ -0.26ecm11_{t-1} - 0.35ecm12_{t-1} \end{gathered} \tag{8.1}$$

$$\begin{gathered} \Delta m_t = 0.76\Delta m_{t-1} + 0.25\Delta p_t + 0.34\Delta y_{t-1} + \\ +(1.4R_{mt-1} - 0.36\Delta y_{t-1} - 0.65R_{bt-1}) + 0.0002trend \end{gathered} \tag{8.2}$$

The solved steady-state relation for money growth:

$$\Delta m^* \simeq \Delta p + 5.6(R_m - 0.46R_b) + 0.0008trend \tag{8.3}$$

The results demonstrate that transforming the data either for economic or econometric reasons, can make the interpretation of estimated short-run adjustment effects quite difficult. Econometrically this is an important point, because of the popularity of this kind of transformations in empirical work, sometimes for econometric reasons as in the present study, sometimes for economic reasons.

For the second period it was not possible to obtain significant effects from current changes in any of the variables, except the weakly exogenous bond rate. For the comparative purpose of the study we report the estimates of the velocity

[6] A similar spread, $R_d - 0.48R_b$, was found to be stationary for Danish data in Juselius (1998b).

equation in which we have included current changes in inflation and real GDP growth, though both were insignificant:

$$\begin{aligned}
\Delta vel_t &= 0.34\Delta^2 p_t - 0.01\Delta^2 y_t - 1.89\Delta R_{bt} - 7.62ecm22_{t-1} - 2.63ecm23_{t-1} \\
&= 0.34\Delta^2 p_t - 0.01\Delta^2 y_t - 1.89\Delta R_{bt} + \\
&\quad -0.27(vel + 2.2\Delta p - 18R_m - 10R_b - 0.011trend)
\end{aligned}$$

8.2. Comparison of the steady-state relations:

The steady-state relations estimated as the $\hat{\alpha}_i$ weighted estimates of $\hat{\beta}'_{ri}$ in Table 8.1 and 8.2 are compared for each period. To facilitate the interpretation we have solved the derived steady-state relation for the "dependent" variable. The combined error-correction coefficient is given in curly brackets.

The velocity steady-state relation for the first period:

$$\{-0.34\} \quad vel = 3.4\Delta p + 3.4\Delta y - 4.7R_m + 2.4R_b + trend \tag{8.4}$$

and the second period:

$$\{-0.26\} \quad vel = -2.5\Delta p + 16.9R_m + 11.5R_b + trend \tag{8.5}$$

The speed of adjustment of m3 velocity is similar in the two periods. It is positively related to inflation (the "prices cause money" effect) in the first period, but negatively (the money demand effect) in the second period. In the first period real GDP growth is also positively related to money velocity (monetization effect), but no such effect can be found in the EMS period. Note that the money demand relation in the first period given by $\beta'_1 x_t$ with plausible interest rate effects does not survive in the combined relation. Here, the own interest rate effect is negative and the bond rate effect is positive. This can be explained by the strong negative impact of $\beta'_3 x_t$ which describes the deviation of short-term interest rate from its steady-state value. Positive (negative) deviations of the latter coinciding with contractions (expansions) of money stock could then explain the change of sign of R_m in (8.4). Econometrically this is an illustration of the importance of performing the cointegration analysis within a multivariate system. It might explain the difficulties of finding a plausible money demand for ALP relation in previous studies. In the second period the interest rate effect is positive for both interest rates, a result we have already commented on in previous sections.

These estimates can now be compared with the results obtained when conditioning on the change in inflation and in real GDP growth given by (8.1)-(8.3). In this case the steady-state solution for the change in real $m3$ was found to be positively related to the "spread" between short-term and the long-term interest rate, i.e. a plausible money-demand relation for the growth rates of real money. For the second period the results hardly changed when current effects were included in the model.

The inflation steady-state relation for the first period:

$$\{-1.25\} \qquad \Delta p = 0.07vel - 1.4R_m + 0.6R_b - 0.002trend \tag{8.6}$$

and the second period:

$$\{-1.90\} \qquad \Delta p = 0.008vel - 0.00025trend \tag{8.7}$$

In the first period inflation is adjusting positively to velocity and the long-term bond rate (a cost-push effect) and negatively to the short-term interest rate (the effect of monetary policy), whereas in the EMS period only velocity has a minor effect on inflation. However in both periods there is an additional downward trend in inflation that cannot be explained by the present information set. This trend is probably related to the ongoing adjustment towards the European low inflation level in this period.

Altogether it seems likely that inflation to some extent was influenced by domestic monetary policy in the pre-EMS period, but hardly at all in the EMS-period. Consistent with the results of the C-matrix in Table 7.4 money expansion seems to have had some inflationary effects, but the impact has generally been of minor importance.

The real income steady-state relation is only given for the first period, since real growth was not significantly error-correcting in the EMS period:

$$\{-1.53\} \qquad \Delta y = 0.17vel - 0.33\Delta p - 2.8R_m - 1.3R_b - 0.007trend$$

The positive effect of (trend-adjusted) money velocity demonstrates the effect of money expansion (monetization of government debt) on real GDP growth in this period. The negative effects of inflation and the two interest rates, in particular R_m, suggest quite strong contractionary effects on real growth from tight monetary policy.

The short-term interest steady-state relation for the first period:

$$\{-0.06\} \qquad R_m = 0.5\Delta p + 0.5R_b + 0.4\Delta y \tag{8.8}$$

and the second period:

$$\{-0.30\} \qquad R_m = R_b + 0.05\Delta p \tag{8.9}$$

In the first period the short-term interest rate followed inflation rate and the long-term bond rate homogeneously with some additional effect from real growth, in the second period the short-term interest rate is exclusively adjusting to the exogenous long-term bond. The speed of adjustment has increased quite substantially from the pre-EMS period to the EMS period. Altogether, the results suggest that the interest rate determination has largely been outside domestic control in the period after Spain lifted the restrictions on capital movements. This is also consistent with the results of the C-matrix in Table 7.4.

9. Summary and Conclusions

The purpose of this paper was to compare the dynamic adjustment effects of excess money, excess aggregate demand, and central bank reaction rule on price inflation, money growth, real income growth and changes in interest rates in Spain in the pre-EMS period and after joining the EMS.

The empirical analysis was performed in two stages: in stage one co-movements between nominal money, prices, real income, and two interest rates were investigated in the $I(2)$ model to get an understanding for some of the problems that have plagued previous studies, in stage two money velocity, inflation, real growth, and the interest rates were investigated in the $I(1)$ model to get an empirical understanding for the dynamics of monetary transmission mechanisms and how they have changed from the pre-EMS to the EMS period.

Based on the $I(2)$ model we found:

• *No overall long-run homogeneity between money and prices.* In the first period real money and real income were found to be $I(2)$ but money velocity was found to be $I(1)$. In the second period all of them could be considered $I(1)$. The economic interpretation is that "excess money expansion" did not lead to a corresponding increase in prices in this period. The empirical results showed very strongly that although some of the money growth is correlated with price growth, a major part is associated with real growth. Therefore, the fast expansion of the government sector and the obligation of the central bank to monetize government debt in the first period seem to have increased money stock without a corresponding increase in prices. Similar results were found for Italy in Juselius and Gennari (1999).

Based on the $I(1)$ model we found:

• Empirical support for *a plausible money demand relation* with significant equilibrium error correction of money velocity in the first period. Because money stock also seemed to be significantly affected by money supply decisions by the central bank, a money demand relation could only be identified in a multivariate model. In the second period we were not able to estimate a money demand relation with a plausible coefficient of the alternative cost of holding money. Our interpretation is that the close correlation between the yield of some of the components inside money stock and the yield of alternative outside assets has increased the agents' willingness to hold money in the second period. Again, these empirical results correspond very closely to the results in Juselius and Gennari (1999).

• The *controllability of the short-term interest rate* seemed much greater in the first period, for where the short-term interest rate was found to adjust homogeneously to the long-term bond rate, the inflation rate, and the real income growth. Increasing the short-term interest rate in excess of this steady-state value had a strong short-run impact on both money velocity and inflation rate and a significant long-run impact on inflation rate. In the second period the short-term interest rate adjusted almost exclusively to the long-term bond rate. Because the latter was found to be exogenously given (no long-run feedback) and probably to a large extent internationally given, the results seemed to suggest that market forces rather than the central bank determined the short-term interest rate in the second period. Consistent with this interpretation was the result that the long-run impact of shocks to the short-term interest rate had a small positive but insignificant effect on inflation as compared to the negative and significant effect in the first period.

Measured by cointegration properties the Fisher parity and the term structure of interest rates did not achieve much support. This was particularly so in the first period, when the effect of central bank policy rules on short-term interest rate determination seemed much stronger. In the second period real interest rates and the interest rate spread were found to be $I(1)$ and we interpret the results as being consistent with inflationary expectations being $I(1)$. The lack of evidence of the Fisher parity that inflation affects interest rates was present in the first period but very pronounced in the second period. Altogether, the results supported market determination of the short-term interest rate rather than central bank control.

Finally, the empirical results demonstrated very strongly the crucial role of shocks to nominal interest rates, particularly shocks to the long-term bond rate, for the long-run price development. This evidence can be summarized as follows:

• In both periods the twice cumulated shocks to the interest rate spread were found to have by far the largest impact on the common stochastic $I(2)$ trend which strongly affected the price variable.

• The bond rate was found to weakly exogenous for the long-run parameters in both period, i.e. there was no long-run feed-back from the other variables of the system onto the bond rate.

• The short-term interest rate was shown to adjust increasingly strongly to the long-term bond rate, and not vice versa. This was still more pronounced in the EMS period.

• The long-run impact matrix showed strong and significant effects from permanent shocks to the bond rate in both periods and in the first period from shocks to short-term rate. Permanent shocks to money velocity had altogether very small and insignificant effect on the system. This was more pronounced in the first period.

The increased international impact on the determination of the bond rate, combined with the attempt to maintain small exchange rate variability and downward sticky nominal prices, seems to have caused the conventional dynamics of the $IS-LM$ transmission mechanism to collapse.

Altogether, the empirical results suggest that the increased economic integration within the EU has caused major changes in the macroeconomic mechanisms and substantially decreased the degree of domestic monetary autonomy. The finding that domestic monetary policy when more independent, had a significant long-run impact both on inflation rates and real DGP growth rates, seems to suggest that the macroeconomic costs of giving up monetary independence within the planned EMU can be substantial, in particular if we assume that asymmetric shocks will be frequent and that there will be no compensating fiscal transfer within a near future. The same conclusion was reached based on a similar analysis of Italian data.

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