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Dynamic Modeling and Structural Shift: Monetary Transmission Mechanisms in Italy before and after EMS

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Dynamic Modeling and Structural Shift: Monetary Transmission Mechanisms in Italy before and after EMS.

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Abstract

The focus is on nominal transmission mechanisms in Italy with special reference to monetary effects and how they have changed with the increased economic integration in Europe and the increased independence of Italian Central Bank. The empirical model investigates the dynamic determination of money, income, prices, and interest rates based on the cointegrated VAR model. The choice of price measurements and its consequences for the empirical results are given special attention. The empirical results provide empirical results on the macroeconomic effects of joining the ERM and of capital deregulation.

Keywords: $I(2)$ Analysis, Regime Shift, Price Homogeneity, Money Demand, $IS-LM$, Monetary Policy.

1. Introduction

The focus of this paper is on nominal transmission mechanisms in Italy with special attention to monetary effects and how they have changed with the increased economic integration in Europe. Italy is particularly interesting in this respect because the central bank became more independent of the Treasury in 1981 with a transition period of a few years. The general theme is similar to Juselius (1998a) where monetary transmission mechanisms in Germany, Denmark, and Italy were compared to uncover similarities and dissimilarities in the functioning of monetary

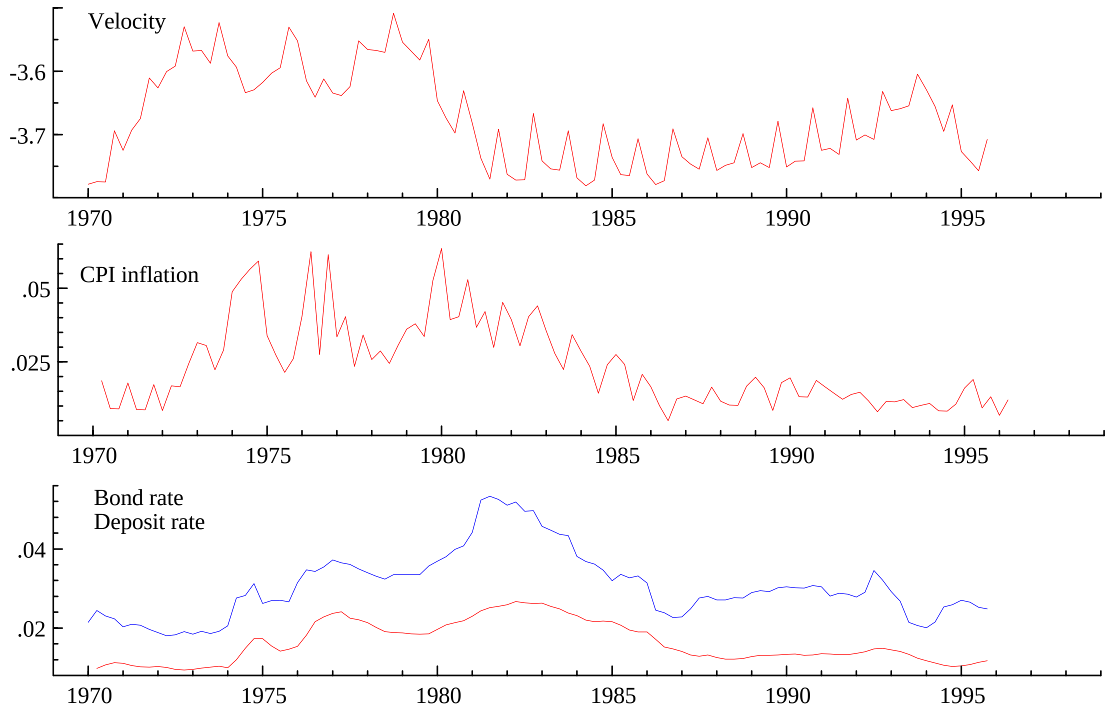

Figure 1.1: Money velocity, CPI inflation, and interest rates

policy between countries and regimes. This paper addresses the measurement problem and presents a detailed analysis of nominal money and its relation to prices and real income. It gives the background and rationale for the real money analysis in Juselius (1998a) and is complementary in the sense that the results reported in Juselius (1998a) are referenced to but not repeated.

As appears from the graphical picture (produced by GiveWin, Doornik and Hendry, 1998) of money velocity in Figure 1.1 the sample period seems to cover two transition periods. The first is from the previous Bretton Woods system of pegged exchange rates to the more flexible system of the seventies, the other is from 1979 to 1983. The latter coincides with the first frequent realignments phase of the ERM and with the increased independence of the Italian central bank from the Treasury. In this sense the sample offers the possibility to investigate both the effect of increased economic European integration and increased central bank independence. It appears from Fig 1.1. that the strong money velocity growth in the first transition period, 1971-74, cannot be explained by changes in the opportunity cost of holding money as measured by the interest rate spread and inflation. Including these years caused parameter instability and they were, therefore, omitted from the empirical analysis.

Gennari (1998) estimated the demand for money by modelling the transition from one regime to the next using a logistic smooth transition function. However, Juselius (1998a) discovered changes in the cointegration properties and, in particular, in the dynamic adjustment coefficients at around 1981-1983. This was the motivation for splitting the sample into two sub-samples describing different regimes with different dynamic transmission mechanisms.

Many previous studies have demonstrated substantial difficulties finding an empirically stable quarterly money demand relation for Italy (Bagliano and Favero, 1992, Angelini *et al.,* 1994). Considering the transition effects and changes in monetary transmission mechanisms in this period, this may not seem surprising.

In anticipation of the econometric difficulties we started from a general model specification based on nominal money and prices. This model, which was empirically found to be $I(2)$, provided a natural framework for testing price homogeneity hypotheses. Because overall price homogeneity was strongly rejected in both periods, the nominal money model was analyzed in more detail to get an understanding for the econometric consequences of this problem. To investigate whether this problem could be related to the choice of price measurement, we performed a sensitivity analysis based on two different price indices. The analysis showed that the choice mattered for the cointegration results, but also that the main problem of no overall price homogeneity remained unsolved.

Both econometrically and economically the analysis of the Italian data is a major challenge: lack of price homogeneity; many transition periods; measurement problems; difficult identification restrictions. We have adopted the VAR methodology to address these problems as efficiently as possible. For instance, by exploiting the rich structure of the $I(2)$ model, we were able to uncover problems related to the absence of long-run price homogeneity and to suggest an acceptable transformation to the subsequent $I(1)$ model in real terms. By exploiting the cointegration properties we were able to choose between different measurements and find those hypothetical relations for which there were empirical support.

Using the various test procedures within the $I(1)$ model we were able to obtain empirical results demonstrating how the monetary transmission mechanism has changed over the sample period. In particular, we were able to point out how the functioning of the domestic money market has been affected by the increased economic integration within Europe and by the increased independence of the Italian Central Bank.

The organization is as follows: Section 2 discusses Italian institutions, reforms and interventions in some detail. Section 3 discusses the economic model and it relates to the empirical time-series properties of the available data. Section 4 defines the statistical and the empirical models to be used in the analysis. Section 5 reports an $I(2)$ analysis of alternative price indices. Section 6 investigates different aspects of long-run price homogeneity for each of the two price indices using the $I(2)$ model. Section 7 uses cointegration tests as a first step to empirically identify relations in the data which are supposed to describe an aggregate money relation, a real income relation, and a relation between inflation and the short-term and long-term interest rate. Section 8 reports a fully identified long-run structure for each period and Section 9 summarizes the major differences in the monetary transmission mechanisms between the two periods.

2. Institutional background

Italian money market has experienced fundamental changes over the present sample period. These involve the instruments used in the monetary policy, the relationship between the central bank, the government, the debt management and the more general economic environment where the money market is operating.

In 1973, the Bank of Italy introduced credit ceilings and a security investment constraint for private banks. Although both instruments were subsequently modified in various ways, they were nevertheless partly in use until approximately 1986 (see Bollettino Statistico della Banca d'Italia, 1979-1987). Since then, '...Italian monetary policy has relied mainly on 'indirect' instruments: intervention in the primary and secondary markets for Treasury paper, foreign exchange operations, commercial bank financing and discount rate changes...' (see Angeloni, 1994, p.388).

In the first few years after the birth of the *ERM* in 1979 Italy maintained many restrictions on credit and capital mobility and the central bank was thus able to pursue a monetary policy without having to consider short run effects in the exchange rate market. Only in the mid 80's, with the gradual lifting of credit and capital restrictions, the monetary policy became more dependent on the exchange rate market (see Angeloni, 1994, Sarcinelli, 1995).

The so-called 'divorce' in July 1981 between the central bank and the Treasury can be considered the most fundamental change in the money market during the sample period. With this agreement the Bank of Italy was no longer obliged to act as a residual buyer in the auctions of Treasury Bills and the overdraft on the Treasury's account was set at a maximum of 14% of Treasury's total anticipated expenditures. To avoid the risk of excessive monetization of the public debt, the Bank of Italy, however, continued for a couple of years more to guarantee a full subscription of Treasury bills in the auctions. Only in 1983 it appeared for the first time as a net seller (see Passacantando, 1996).

The independence of the central bank from the Treasury was finally enforced in

1992-93 by two important laws: in February 1992 the governor of the central bank was assigned the right to set the discount rate and the base rate on current account and fixed-term advances; in November 1993 the overdraft facility of the Treasury with the Bank of Italy was suppressed and the outstanding credit converted into bonds.

In the seventies and the eighties the Italian economy experienced three major problems: high inflation, instability of the exchange rate and, in the second part of the period, a large public deficit. Inflation was rising all through the seventies and reached a maximum of 22% after the second oil shock in 1979. At the beginning of the eighties inflation started falling and in 1987 it was barely above 4%.

The years preceding the entrance of Italy in the ERM in 1979 were characterized by frequent devaluations followed in the period 1979-86 by frequent realignments of the ERM parity . These did not fully offset the growth of prices so that the real exchange rate appreciated. From 1987 to 1991 Italian lira was quite stable and in 1990 Italy adopted the narrow bands (2.25%) of the ERM. However, the public sector deficit grew all too fast in this period and the need to finance government expenditures, combined with the need to defend the exchange rate parity, pushed up the level of the interest rate. In 1990-91 inflation started again to rise with a consequent appreciation of the real exchange rate. The pressure on the interest rates became gradually unmanageable and, in September 1992 speculative attacks forced Italian lira out of the ERM (see Baldassarri, 1994).

In the period following the devaluation Italy experienced an improvement in the terms of trade, a reduction in the public deficit and in inflation but high unemployment rates.

3. Theoretical and empirical model properties

The historical overview suggests several regime changes of which the most important are the change in central bank independence and the change of exchange rate regime. A priori one would expect monetary transmission mechanisms to be strongly influenced by these changes.

3.1. Methodological considerations

The purpose is to study the dynamics of "excess money" and how it affects the domestic economy through its effects on prices, income and interest rates. 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 omission of important foreign variables such as the real exchange rate, a variable measuring export demand, and a foreign interest rate, means that some questions cannot be addressed. To give the reader an idea of the importance 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 the domestic monetary mechanisms, the labor market mechanisms, and the foreign mechanisms separately using cointegration analysis and then to combine the results of the sub-systems into a more complete model. For a similar approach, see for instance Juselius (1992), Metin (199) Ericsson and Iron (1998). The foreign effects have been studied in detail in Juselius and Marcellino (1998), the labor market effects in Marcellino and Mizon (1998) but the combined analysis is still left for future research.

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 prior hypothesis is that the dynamics differ in different regimes. How the adjustment structure changes is left for empirical investigation. In this sense there is a large exploratory element in the 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 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 Italy has maintained restrictions on capital movements in most of the sample period, domestic money demand is not likely to be much influenced by this variable.

The "domestic" central bank policy rule is supposed to be:

$$R_{m_t} = R_{bt} + b_3(\Delta p_t - \pi_0) + R_0 + u_{CB_t} \tag{3.2}$$

where R_0 is a constant, π_0 is the target inflation rate, $b_3 > 0$ and $u_{CB_t} \sim I(0)$ is a residual.

Including foreign indicator variables in the analysis such as the exchange rate, s, foreign inflation rate, Δp^*_t, and the foreign short-term interest rate, $R^*_{s_t}$, leads to the following hypothetical central bank policy rule:

$$R_{s_t} = R^*_{s_t} + b^*_3(\Delta p_t - \Delta p^*_t) + b^*_4(s_t - s^*_t) + R^*_0 + u^*_{CB_t}.$$

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 (3.2) if $u^*_{CB_t} \sim I(0)$. Both are likely to have explanatory power, but possibly with different weights in different periods and regimes.

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:

$$y_t = b_4 * trend + b_5 R_{b_t} + b_6 \Delta p_t + u_{y_t} \tag{3.3}$$

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 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 the real income determination in Italy and (3.3) is, therefore, likely to provide only a partial explanation.

Interest rates. 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 the inflation rate and the 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. Over the sample period, Italy maintained restrictions on capital movements until the beginning of the nineties. In addition Italy adopted the broad bands of the ERM except for 1990-92 when it adopted the narrow bands after several years of stable exchange rates. After the exchange crisis in 1992 Italy left the ERM. Therefore, we find it plausible that the Italian bond market has not been strongly exposed to the influence of the foreign bond market until very recently.

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 Central Bank policy is effective we expect inflation to fall when monetary policy is strict and rise when it is loose. In terms of cointegration (3.1)-(3.4) contain these hypotheses as special cases.

4. The statistical and empirical model

Section 4.1 defines briefly the cointegrated $I(1)$ and $I(2)$ models as parameter restrictions on the unrestricted VAR model and discusses the consequent implications on the data generating process (hereafter DGP). Section 4.2 defines the empirical model and discusses the choice of rank and its cointegration and common trends implications.

4.1. 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.

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. $\alpha'_\perp \mu_1 = 0$. The moving average representation is given by:

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

where $C_2 = \beta_{\perp 2}(\alpha'_{\perp 2} \Psi \beta'_{\perp 2})^{-1} \alpha'_{\perp 2}$, $\Psi = f_1(\Theta)$, $\alpha_{\perp 2}$ and $\beta_{\perp 2}$ are the orthogonal complements to $(\alpha, \alpha_{\perp 1})$ and $(\beta, \beta_{\perp 1})$ respectively, 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:

$$x_t = C\sum_1^t \epsilon_i + C\mu_0 t + \widetilde{E}t + C\Phi\sum_1^t D_i + C^*(L)(\varepsilon_t + \mu_0 + \Phi D_t) + B \tag{4.5}$$

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.

4.2. The empirical model

Model (4.1) is estimated with two lags and a linear trend in the cointegration space motivated by the short-run Phillips curve / demand pressure relation (3.3). The variables are defined by:

$$x'_t = [m, p, y, R_m, R_b]_t,\ \ t = \text{1974:1-1994:4}$$

where m is the log of the monetary aggregate $M2$, p is the log of a price index, y is the log of real GDP, R_m is the rate of return on $M2$, 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. A full description of the data set is given in the Appendix. The sample is split into two periods, 1974:1-1983:1 and 1983:1-1994:4. The split is motivated partly by strong econometric evidence of parameter non-constancy at around 1982-84 approximately coinciding with the shift of regime, partly by an *a priori* economic interest in these two periods as argued at some length in Juselius (1998a).

The model includes five impulse dummies, defined as D19xxy = 1 in 19xx, Quarter y, 0 otherwise, to account for the following significant reforms and interventions:

D744 = the break-down of the bond market,
D761 = the closure of the exchange market due to a major currency crises,
D812 = the "divorce" between the central bank and the Treasury,
D862 = the fall of the discount rate with more than 3%,
D923 = the exit of Italian lira from the ERM.

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).

The choice of cointegration rank r, i.e. the decomposition of the data into steady-state relations and common driving trends, was discussed at some length in Juselius (1998a) and will not be repeated here. The final choice, $\{ r = 3,\ p-r = 2\}$ was motivated by statistical as well as economic arguments. The two common trends are assumed to describe the cumulation of permanent shocks to aggregate demand and aggregate supply, respectively. In the nominal model to be analyzed in Section 7 we need in addition to distinguish between the number of $I(2)$ and $I(1)$ trends among the two common stochastic trends. Based on arguments in Juselius (1998b, 1998c) we assume that there is one $I(2)$ trend describing the stochastic nominal trend (the aggregate demand trend) and one $I(1)$ trend describing the real stochastic trend (the aggregate supply trend).

5. The choice of price variable

Long-run price homogeneity is an important concept when analyzing the effects of excess money demand on price inflation. The empirical verification of price homogeneity can, however, be sensitive to the choice of measurement of the price variable. Unfortunately, macroeconomic theory is quite silent on the choice of measurements for the aggregate price level, probably because prices are expected to converge and, hence, different definitions would measure the same price development. This is likely to be the case over long time periods, but not necessarily when the perspective, as here, is the medium long-run. Section 5.1 presents some descriptive measures for the nominal variables and discusses the cointegration implications of choosing one of two possible price indices. Section 5.1 reports the results of an $I(2)$ analysis of the CPI and the implicit price deflator of GDP and concludes that the choice will matter for the subsequent cointegration results.

5.1. A descriptive analysis

The obvious choice of measurements is between the consumer price index (CPI) and the implicit price deflator (IPD) of the selected income measure, here GDP. We will first present a descriptive and graphical analysis of the long-run trend

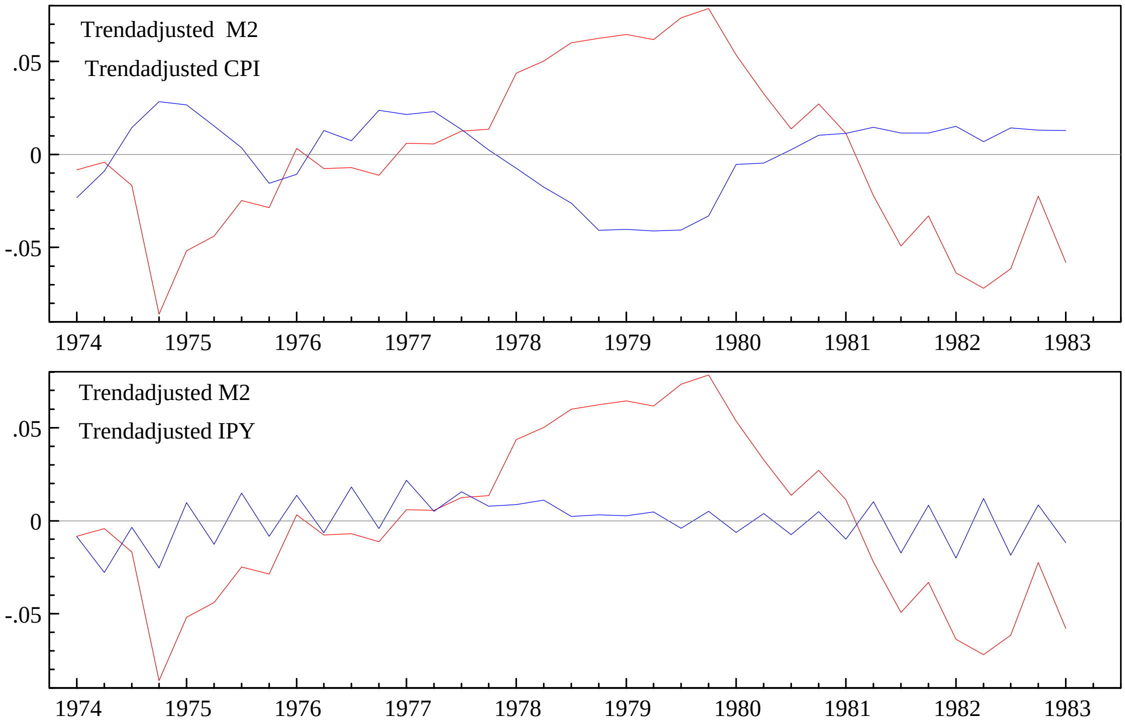

Figure 5.1: Trend-adjusted money and prices in the first period

component of the two price indices. The linear growth rates of the log of nominal money and the two price indices are first estimated by regression and the detrended price index is then used as a first crude approximation of the behavior of the long-run stochastic trend.

The estimates reported in Table 5.1 are calculated for the full sample and the two sub-samples, respectively. They demonstrate large differences in growth rates between the high inflation period of the seventies and the beginning of the eighties and the low inflation period thereafter. As expected, nominal money stock grows faster than prices as a consequence of fairly high real growth rates in this period. The two price indices seem to have experienced somewhat different growth rates, IDP growth exceeds the CPI growth with approximately 0.8% per annum.

The graphs of the detrended money and price variables in Figure 5.1 and 5.2 suggest that the stochastic trends of money stock and prices have developed similarly in the more recent period, whereas this is not the case in the first period. This already gives some support for splitting the sample into two.

Inflation rates are usually found to be $I(1)$, empirically, implying that price

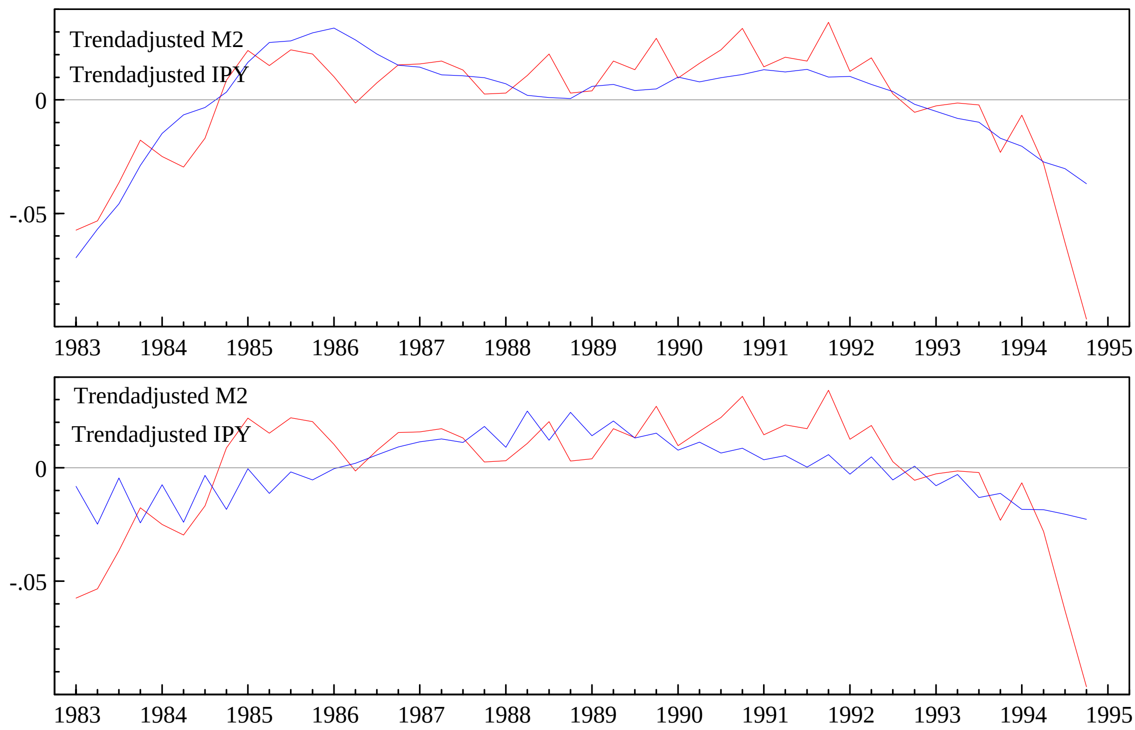

Figure 5.2: Trend-adjusted money and prices in the second period

levels (and nominal money stock) are best approximated as $I(2)$ variables. Assume that $(m, p_1, p_2) \sim I(2)$ where p_1 and p_2 are two price variables. First, if $p_1 - p_2 \sim I(2)$, then the choice between p_1 and p_2 will strongly influence the finding of long-run price homogeneity between nominal money and prices, whereas if $p_1 - p_2 \sim I(1)$ this will not be the case. But even in the latter case the difference between $(m - p_1)$ and $(m - p_2)$ is $I(1)$ and the subsequent cointegration results of real money stock and the remaining variables will be affected. Therefore, the choice of price variable will matter for the cointegration results unless $(p_1 - p_2) \sim I(0)$ which is not very likely. See for instance Jørgensen (1998) and Juselius (1998c). We expect instead that $(p_1 - p_2) \sim I(1)$, which implies that $(\Delta p_1 - \Delta p_2) \sim I(0)$ and, hence, that the stochastic inflation trends are the same independently of the choice of measurement.

This suggests that the choice of measurement for the price variable can potentially influence both the finding of long-run price homogeneity between nominal money and prices, but also the cointegration properties of the empirical model in real terms. Therefore, an analysis of the co-movements of potential price mea-

Table 5.1: Linear growth rates in nominal money and prices

	1974:1-1994:4	*1974:1-1982:4*	*1983:1-1994:4*
$m2$	0.030	0.042	0.022
$p_c(CPI)$	0.026	0.038	0.015
$p_y(IDP)$	0.027	0.040	0.017

surements as well as a sensitivity analysis of the subsequent empirical results are motivated.

5.2. An $I(2)$ analysis of the two price indices

To investigate whether the price differential is $I(1)$ or $I(2)$ we apply model (4.1) with four lags and $\mu_1 = 0, \Phi = 0$. The two reduced rank conditions (4.2) and (4.3) were tested under the restriction $\alpha'_{\perp 2}\mu_0 = 0$.

The test statistics reported in Table 5.2 are based on the joint determination of (r, s_1) as described in Paruolo (1996) for the model with $\alpha'_{\perp 2}\mu = 0$ with the 95% quantiles given in italics. The test procedure starts with the most restricted model $(r = 0, s_1 = 0, s_2 = 2)$ in the upper left hand corner, continues to the end of the first row, and proceeds to the next row until the first acceptance at $\{r = 1, s_1 = 0, s_2 = 1\}$. This procedure delivers a correct size asymptotically but, as demonstrated in Jørgensen (1998), the power is usually low and the six needs to be corrected in small samples. With a small sample correction $\{r = 0, s_1 = 1, s_2 = 1\}$ would probably have been first accepted. Therefore, we briefly discuss the implications of either choice.

The case $\{r = 0, s_1 = 1, s_2 = 1\}$ implies no stationary cointegration relation between the two price indices, but one $CI(2,1)$ cointegration relation. It can be illustrated by the moving average form of the model:

$$\begin{bmatrix} p_{1t} \\ p_{2t} \end{bmatrix} = \begin{bmatrix} c_{2.1}\Sigma\Sigma u_{2i} \\ c_{2.2}\Sigma\Sigma u_{2i} \end{bmatrix} + \begin{bmatrix} c_{1.11}\Sigma u_{2i} \\ c_{1.21}\Sigma u_{2i} \end{bmatrix} + \begin{bmatrix} c_{1.12}\Sigma u_{1i} \\ c_{1.22}\Sigma u_{1i} \end{bmatrix} + \begin{bmatrix} \text{determ. and} \\ \text{stat. comp.} \end{bmatrix} \tag{5.1}$$

where the two stochastic trends are $\sum u_{1i}$ and $\sum\sum u_{2i}$, respectively, and $u_{1t} = f_1(\varepsilon_{p1_t}, \varepsilon_{p2_t})$ and $u_{2t} = f_2(\varepsilon_{p1_t}, \varepsilon_{p2_t})$. If $c_{2.1} = c_{2.2}$ then $(p_1 - p_2) = (c_{1.11} - c_{1.21})\sum u_{1i} + (c_{1.12} - c_{1.22})\sum u_{2i} \sim I(1)$ and, because $r = 0$, there is no $I(0)$ cointegration relation between $(p_1 - p_2)$ and $(\Delta p_1, \Delta p_2)$ consistent with the VAR model.

The case $\{r = 1, s_1 = 0, s_2 = 1\}$ implies $p - r = 1$ stochastic trend and the same stochastic shocks influence the price indices both in the long-run (the levels) and in the medium-run (the changes). The representation then becomes:

Table 5.2: The I(2) test of prices

p-r	$Q(s_2 \cap p-r)$		$Q(r)$
2	65.2	26.1	21.8
	36.1	*22.6*	*15.2*
1	-	**7.1**	4.4
		12.9	*4.0*
s_2	2	1	0

$$\begin{bmatrix} p_{1t} \\ p_{2t} \end{bmatrix} = \begin{bmatrix} c_{2.1}\Sigma\Sigma u_{2i} \\ c_{2.2}\Sigma\Sigma u_{2i} \end{bmatrix} + \begin{bmatrix} c_{1.1}\Sigma u_{2i} \\ c_{1.2}\Sigma u_{2i} \end{bmatrix} + \begin{bmatrix} \text{determ. and} \\ \text{stat. comp.} \end{bmatrix}. \tag{5.2}$$

If $c_{2.1} = c_{2.2}$, then $(p_1 - p_2) \sim I(1)$ and, consistent with $r = 1$, there is one polynomially cointegrating relation: $\{(p_1 - p_2) + (c_{1.1}\Delta p_1 - c_{1.2}\Delta p_2)\} \sim I(0)$. Note, however, that $c_{1.1} \neq c_{1.2}$ as a consequence of $(p_1 - p_2) \sim I(1)$.

In both cases Δp_1 and Δp_2 contain the same $I(1)$ trend. In addition when $c_{2.1} = c_{2.2} = c_2$ i.e. when $(p_1 - p_2) \sim I(1)$, we have:

$$\begin{bmatrix} \Delta p_{1t} \\ \Delta p_{2t} \end{bmatrix} = \begin{bmatrix} c_2 \sum u_{2i} \\ c_2 \sum u_{2i} \end{bmatrix} + \begin{bmatrix} \text{determ. and} \\ \text{stat. comp.} \end{bmatrix}. \tag{5.3}$$

i.e. the inflation differential is $I(0)$. Therefore, the choice of price index as a proxy for inflation rate Δp in the subsequent model analysis in Section 7 based on $x_t = [m - p, y, \Delta p, R_m, R_b]$ should not matter for the cointegration results. Nevertheless, the choice of price index as a deflator of nominal money does matter when $(p_1 - p_2) \sim I(1)$. If the case (5.1) is true it is likely to influence the subsequent cointegration results more than if (5.2) is true. Although, the tests in Table 5.2 gave some support to the first case, the case consistent with one cointegrating relation $(p_1 - \beta p_2) \sim I(1)$ seemed preferable. The test of price homogeneity, i.e. $\beta = 1$, produced a test statistic of 2.18, approximately $\chi^2(1)$ and the hypothesis that $p_1 - p_2 \sim I(1)$ is well supported by the data. The next section reports a sensitivity analysis of the effects on the empirical results of either choice.

6. Analyzing long-run price homogeneity

Figure 5.1 and 5.2 demonstrated visually the lack of long-run convergence between nominal money and prices, particularly in the first period. Section 6.1 investigates the $I(2)$ model based on $x_t = [m, p, y, R_m, R_b]$ with p measured by the consumer

Table 6.1: Estimates of the β directions in the nominal model

	First period									
	p_c			p_y			p_c		p_y	
	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_{\perp 1}$	$\hat{\beta}_{\perp 2}$	$\hat{\beta}_{\perp 1}$	$\hat{\beta}_{\perp 2}$
m	1.0	1.0	1.0	1.0	1.0	1.0	3.3	-3.1	0.1	-2.6
p	0.5	2.3	4.3	1.4	4.3	-4.1	-3.5	0.7	-2.8	0.1
y	-1.7	-0.0	-0.2	-1.5	-0.5	2.1	-12.4	-1.0	-0.3	-0.7
R_m	-9.7	-21.6	-2.1	-13.2	-19.3	-39.3	-2.9	-0.0	-0.7	-0.1
R_b	6.8	7.7	-0.5	4.8	1.6	31.6	-7.4	0.1	-1.2	0.0
	Second period									
	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_{\perp 1}$	$\hat{\beta}_{\perp 2}$	$\hat{\beta}_{\perp 1}$	$\hat{\beta}_{\perp 2}$
m	1.0	-0.1	1.0	1.0	-0.5	1.0	9.5	-3.3	-4.0	-3.9
p	-2.3	0.4	-1.0	-0.5	0.1	-0.9	-10.6	-5.5	4.0	-2.7
y	1.2	1.0	-0.8	0.5	1.0	-0.7	17.9	-1.6	4.1	-1.3
R_m	24.0	8.2	-2.0	0.9	5.8	-21.6	-2.5	-0.2	-2.7	-0.2
R_b	-4.3	-6.1	-1.4	-3.4	-2.9	17.8	-0.2	0.0	-3.0	-0.2

price index and the implicit price index, respectively. The results provided little support for overall long-run price homogeneity and Section 6.2 investigates, therefore, several additional hypotheses with the purpose of uncovering the causes of the lack of overall homogeneity.

6.1. $I(2)$ analysis of nominal model

For the investigation of price homogeneity only the β directions of the $I(2)$ model are relevant. 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. Under assumption that only nominal money and prices are affected by the $I(2)$ trend, the hypothesis of long-run price homogeneity can be formulated as:

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

See for instance the discussion in Juselius (1998c). The estimates in Table 6.1 are based on the case $\{r = 3, s_1 = 1, s_2 = 1\}$ and reported for both of the two price indices.

For the first period the hypothetical restrictions (6.1) do not seem to have any empirical support. Except for $\hat{\beta}_2$ in the case of p_c and $\hat{\beta}_3$ in the case of p_y the coefficients of m and p in $\hat{\beta}_i$, $i = 1, ..., 3$, are not even of opposite signs, suggesting that the stochastic trends in nominal money and prices are moving in opposite directions. This effect can also be noticed in the graphs of Figure 5.1.

For $\hat{\beta}_{\perp 1}$ the homogeneity restriction (7.2) between m and p seems to be satisfied for p_c, but not for p_y. Since $\beta_{\perp 1}$ defines a $CI(2,1)$ relation which can only become stationary by differencing but not by cointegration, these results suggest that Δm and Δp_c move together in the medium run without satisfying a long-run sustainable homogeneous steady-state relation between m and p. At this stage we do not attempt to explain this finding, but note that the first period is problematic in many respects. As illustrated by the graphs in Figure 1.1, this is possibly because of the transition from a fairly closed and regulated economy to a more modern welfare economy.

The estimates of $\beta_{\perp 2}$, determining how the $I(2)$ trend affects the variables of the system, are very similar for the two price indices. The long-run homogeneity restriction (6.3) does not get much empirical support and real income has a large coefficient against the hypothetical zero coefficient. As expected, the two interest rates do not seem to be affected by the $I(2)$ trend.

For the second period the estimates of $\hat{\beta}_i$ are more consistent with the hypothetical restrictions (6.1). In particular, $\hat{\beta}_3$ satisfies the homogeneity restriction almost exactly for both price variables. The coefficients of $\hat{\beta}_1$ suggest that prices have followed nominal money and real income almost homogeneously for both prices. This suggests that other factors than those related to Italian monetary policy have influenced the Italian price level. The coefficients of m and p in $\hat{\beta}_2$, though quite small and probably not significant, do not support price homogeneity.

The coefficients of $\hat{\beta}_{\perp 1}$ suggest strong support for the homogeneity restriction (6.2) between m and p and inflation and money growth seem to follow each other in the medium run. The coefficients of m and p in $\beta_{\perp 2}$, though not equal, are much more consistent with restriction (6.3) than the coefficients in the first period. As in the first period, the coefficient of real income is quite large and the two interest rates are not influenced by the $I(2)$ trend. For the implicit price index the first three coefficients describe almost exactly $m - p - y$, i.e. velocity.

Altogether, overall long-run price homogeneity does not seem to get much empirical support. In the first period there is hardly any evidence of convergence between nominal money and prices, whereas in the second period there is much more support for price homogeneity in some of the directions of β. For both periods, the quite large coefficients of real income in $\beta_{\perp 2}$ motivates further investigation.

The above empirical results point to the need for testing the following hypotheses:

(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 $I(1)$?

6.2. Hypotheses testing

We now turn to a formal testing of the hypotheses discussed above. Technically the testing can be done using the 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 $\mathcal{H}_2 - \mathcal{H}_5$ are of the form $\beta = \{H\phi, \psi\}$, i.e. they test restrictions on a single vector and leave the other vectors unrestricted. $\mathcal{H}_2$ tests whether trend-adjusted real money stock is $I(1)$, $\mathcal{H}_3$ whether trend-adjusted real income is $I(1)$, $\mathcal{H}_4$ whether trend-adjusted velocity is $I(1)$, and $\mathcal{H}_5$ whether trend-adjusted real money and real income are cointegrating. The results are presented in Table 6.2.

As expected, the hypothesis $\mathcal{H}_1$ of long-run price homogeneity in the cointegration space is clearly rejected for both periods and both price indices. Also, the hypothesis $\mathcal{H}_2$, that trend-adjusted real money stock is $I(1)$, is rejected. In the second period real money based on the implicit price deflator can be borderline acceptable as $I(1)$. The hypothesis $\mathcal{H}_3$, that trend-adjusted real income is $I(1)$, is rejected except for the p_y case of the first period. This implies that real income is approximately $I(2)$, i.e. that the real income coefficient of $\hat{\beta}_{\perp 2}$ in Table 6.1 is significant.

The finding that both real income and real money stock are approximately $I(2)$, empirically, suggest that $(m - p - ay)$ might be $CI(2,1)$. The unrestricted relation is tested by $\mathcal{H}_4$. In the first period it is rejected for p_c, but not for p_y with a large income coefficient. This suggests a real income relation with real money effects instead of a velocity relation. In the second period the results are the opposite: cointegration is accepted for p_c, but not for p_y. The estimated income coefficient is close to one in the former case, but small in the latter case. The velocity hypothesis $\mathcal{H}_5$ is rejected in the first period, strongly accepted in the second period for p_c but only borderline accepted for p_y.

Altogether, the results in this section do not unambiguously favor one of the price indices rather than the other. In the first period p_y might have performed slightly better, whereas in the second period p_c seems preferable. The differences are, however, not large. This is consistent with the results in section 5.2 demon-

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

	Hypotheses		p_c			p_y	
			First period 1974:1-1983:1				
	$\beta = \{H_i\phi\}$		$\chi^2(\nu)$	*p-val.*		$\chi^2(\nu)$	*p-val.*
$\mathcal{H}_1$	$H_1\phi_j = [a_j, -a_j, *, *, *, *]$		28.0(3)	0.00		25.6(3)	0.00
	$\beta = \{H_i\phi, \psi\}$		$\chi^2(\nu)$	*p-val.*		$\chi^2(\nu)$	*p-val.*
$\mathcal{H}_2$	$H_2\phi = [1, -1, 0, 0, 0, *]$		9.3(2)	0.01		11.4(2)	0.00
$\mathcal{H}_3$	$H_3\phi = [0, 0, 1, 0, 0, *]$		9.7(2)	0.01		2.2(2)	**0.33**
$\mathcal{H}_4$	$H_3\phi = [1, -1, -1, 0, 0, *]$		8.8(2)	0.01		6.8(2)	0.03
$\mathcal{H}_5$	$H_4\phi = [1, -1, -a, 0, 0, *]$	**a=4.3**	6.2(1)	0.01	**a=4.7**	0.4(1)	**0.51**
			Second period 1983:1-1994:4				
	$\beta = \{H_i\phi\}$		$\chi^2(\nu)$	*p-val.*		$\chi^2(\nu)$	*p-val.*
$\mathcal{H}_1$	$H_1\phi_j = [a_j, -a_j, *, *, *, *]$		14.6(3)	0.00		10.3(3)	0.02
	$\beta = \{H_i\phi, \psi\}$		$\chi^2(\nu)$	*p-val.*		$\chi^2(\nu)$	*p-val*
$\mathcal{H}_2$	$H_2\phi = [1, -1, 0, 0, 0, *]$		13.5(2)	0.00		5.0(2)	0.08
$\mathcal{H}_3$	$H_3\phi = [0, 0, 1, 0, 0, *]$		6.1(2)	0.05		7.1(2)	0.03
$\mathcal{H}_4$	$H_4\phi = [1, -1, -1, 0, 0, *]$		0.7(2)	**0.72**		5.2(2)	0.07
$\mathcal{H}_5$	$H_5\phi = [1, -1, -a, 0, 0, *]$	**a=0.8**	0.3(1)	**0.58**	**a=0.2**	4.1(1)	0.04

strating that the price differential between consumer price index and the implicit price index was $I(1)$, i.e. was similarly affected by the $I(2)$ trend. Therefore, the crucial difference is not likely to be found in relations between nominal money stock and prices, but instead in relations involving the other determinants of the system. Among these, the real income variable is of special importance. Because, trend adjusted velocity was $I(1)$ in the second period with the consumer price index but not with the implicit price deflator, we have decided to use the former variable as a proxy for prices in the subsequent model analysis.

7. Cointegration analyses in a real money model

Further inference in the $I(2)$ model is complicated by the lack of appropriate software. Therefore, transforming to the $I(1)$ model is preferable. Under assumption of long-run price homogeneity the following transformation would produce $I(1)$ variables without loosing any information:

$$x_t = [m - p, y, \Delta p, R_m, R_b] \tag{7.1}$$

Unfortunately, the data did not support overall long-run homogeneity. Moreover, trend adjusted real income was only borderline acceptable as $I(1)$. As reported in Juselius (1998a) using (7.1) leads to a vector error correction model with a few fairly large roots in the characteristic polynomial. For the first period the largest root was 0.88, whereas for the second period it was 0.82.

Alternatively, the data vector could have been transformed according to: $x_t = [m-p-y, \Delta p, \Delta y, R_m, R_b]$. This solution was adopted in a similar analysis based on Spanish data in Juselius and Toro (1998) where the velocity transformation was strongly supported by the data. The drawback of using the velocity transformation is that the IS / demand pressure relationship of (3.3) cannot be properly addressed. Therefore, we will continue the analysis based on the transformed vector (7.1) in spite of the rather large roots in the characteristic polynomial.

Based on the real money data vector (7.1) we will take a closer look at the theoretical relations of the $IS-LM$ model discussed in section 3. We perform a comparative analysis of cointegration properties between the two periods with the purpose of uncovering changes of the aggregate demand for money relation (Section 7.1), of interest rates and inflation relations (Section 7.2), and of the IS relation (Section 7.3).

The hypotheses reported in Table 7.1-7.3 are of the form $\beta = \{H\phi_1, \psi_1, \psi_2\}$, i.e. they 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. For a technical derivation of the test procedures, see Johansen and Juselius (1992).

7.1. Comparing velocity and real income relations in the two periods

In Table 7.1 $\mathcal{H}_6 - \mathcal{H}_8$ tests hypotheses on the money velocity relation (3.1) and $\mathcal{H}_9 - \mathcal{H}_{12}$ on the real income relation (3.3). $\mathcal{H}_6$ imposes two just identifying restrictions on β_1 and, hence, there is no testing involved. For the first period the coefficients are consistent with a money demand interpretation with strong own yield effects and negative bond rate effects. In the second period, the coefficient of the short interest rate has become much smaller and the coefficient of the bond rate is essentially zero. $\mathcal{H}_7$ tests the spread as a measure of the opportunity cost of holding money relative to bonds. It is only weakly supported in both periods. $\mathcal{H}_8$ is a relation between velocity and inflation and is accepted in both periods. The estimated coefficients, which differ considerably between the periods, show that inflation and velocity are positively related. Hence, $\mathcal{H}_8$ cannot be interpreted as a demand for money relation.

The coefficient estimate of real interest rate in $\mathcal{H}_9$ is not consistent with the

Table 7.1: Specification of velocity and real income relations

	m-p	y	Δp	R_m	R_b	*trend*	$\chi^2(v)$	*p.val.*
				First period				
$\mathcal{H}_6$	1	-1	0	-30.9	14.9	0.005	(0)	-
$\mathcal{H}_7$	1	-1	0	-11.6	11.6	0.001	3.62(1)	0.06
$\mathcal{H}_8$	-0.05	0.05	1.0	0	0	0.000	2.84(2)	**0.24**
$\mathcal{H}_9$	0	1.0	3.0	-3.0	0	-0.004	6.46(1)	0.01
$\mathcal{H}_{10}$	0	1.0	-3.8	0	0	-0.008	5.80(1)	0.02
$\mathcal{H}_{11}$	0	1.0	0	2.6	-2.6	-0.008	5.61(1)	0.02
$\mathcal{H}_{12}$	-0.4	1.0	0	2.7	-2.7	-0.005	(0)	-
				Second period				
$\mathcal{H}_6$	1.0	-1.0	0	-4.73	-0.02	-0.004	(0)	-
$\mathcal{H}_7$	1.0	-1.0	0	-0.5	0.5	-0.002	2.76(1)	0.10
$\mathcal{H}_8$	-.40	0.40	1.0	0	0	0.001	0.91(1)	**0.34**
$\mathcal{H}_9$	0	1.0	-6.0	6.0	0	-0.006	3.65(1)	0.06
$\mathcal{H}_{10}$	0	1.0	-1.5	0	0	-0.006	5.48(1)	0.02
$\mathcal{H}_{11}$	0	1.0	0	7.0	-7.0	-0.006	0.56(1)	**0.45**

IS curve in the first period, is plausible in the second period but with a small p-value. The short-run Phillips curve / demand pressure hypothesis $\mathcal{H}_{10}$ has plausible coefficients, but is rejected in both periods. Finally, $\mathcal{H}_{11}$ tests whether trend-adjusted real income is cointegrated with the interest rate spread. This hypothesis is strongly supported by the data in the second period, but not in the first.

Thus, specification (3.3) does not obtain much support in the first period, whereas the results are slightly more promising in the second period. When output gap is related to the interest rate spread, as in $\mathcal{H}_{11}$, instead of the real interest rate, as in $\mathcal{H}_9$, the result is much more satisfactory in the second period, whereas a stationary relation for real income in the first period only was found by including real money as shown by $\mathcal{H}_{12}$.

These are interesting results. In the first period, which coincides with the expansion of the government sector as an important part of the Italian welfare state, the development of real aggregate income was positively related to real money expansion (central bank monetizing government debt), negatively to the short-term rate and positively to the long-term government bond rate. This is likely to be a consequence of the expansion of government expenditure being financed partly by the issuing of government bonds, partly by monetizing government debt. Increasing the supply of government bonds increases their yield, hence the positive coefficient.

In the second period the monetization effect is no longer there. Instead, the interest rate effect has increased. This is consistent with government debt being financed predominantly by issuing bonds.

7.2. Comparing inflation and interest rate relations in the two periods

In table 7.2 we report the cointegration properties of inflation and interest rates as an indication of how the mechanisms (3.4) and (3.5) may have changed over the two periods. $\mathcal{H}_{13}$ tests for cointegration between inflation and the short interest rate. In the first period it can be accepted but with a "wrong" sign. In the second period cointegration is only borderline accepted, but now with a plausible coefficient close to one. The stationarity of the real short-term interest rate, $\mathcal{H}_{14}$ is clearly rejected in the first period, and weakly accepted in the second. Similar results are found when testing the same hypotheses for the medium-term bond rate. $\mathcal{H}_{17}$ tests whether the two interest rates are cointegrated. The hypothesis is rejected in both periods, but in the second period the ML estimate is quite close to the hypothetical minus one. When testing the stationarity of the spread the additional degree of freedom leads to weak acceptance in the second period.

Altogether, there is little evidence of just one common trend between the interest rates and the inflation rate consistent with the $I(0)$ version of (3.4) and (3.5). The finding of two stochastic trends is consistent with only one cointegration relation between inflation and the two interest rates. Two hypotheses are of special interest: $\mathcal{H}_{19}$, the central bank policy rule (3.2) and $\mathcal{H}_{20}$, a homogeneous relation between interest rates and inflation. For the first period both the central bank policy rule and the homogeneity of the short-term interest rate relative to inflation and the medium-term bond rate were strongly accepted. For the second period $\mathcal{H}_{19}$ shows that the spread does not cointegrate with inflation and $\mathcal{H}_{20}$ was only weakly supported.

The outcome of $\mathcal{H}_{19}$ and $\mathcal{H}_{20}$ together with $\mathcal{H}_{11}$ and $\mathcal{H}_{12}$ in the previous section is quite interesting: The interest rate spread is strongly cointegrated with inflation in the first period but with the output gap in the second period. Because output gap and inflation do not cointegrate, the latter result cannot be directly interpreted as evidence of the effectiveness of monetary policy.

All this suggests quite interesting differences between the dynamic transmission mechanisms in the two periods to be further investigated in the next section.

Table 7.2: Cointegration properties of inflation and interest rates

	m-p	*y*	Δp	R_m	R_b	*trend*	$\chi^2(v)$	*p.val.*
				First period				
$\mathcal{H}_{13}$	0	0	1.0	0.83	0	0	4.72(2)	0.09
$\mathcal{H}_{14}$	0	0	1.0	-1.0	0	0	15.92(3)	0.00
$\mathcal{H}_{15}$	0	0	1.0	0	0.38	0	2.68(2)	0.26
$\mathcal{H}_{16}$	0	0	1.0	0	-1.0	0	16.63(3)	0.00
$\mathcal{H}_{17}$	0	0	0	1.0	-0.41	0	7.99(2)	0.02
$\mathcal{H}_{18}$	0	0	0	1.0	-1.0	0	17.16(3)	0.00
$\mathcal{H}_{19}$	0	0	1.0	-0.67	0.67	0	1.63(2)	**0.44**
$\mathcal{H}_{20}$	0	0	-0.42	1.0	-0.58	0	2.45(2)	**0.29**
				Second period				
$\mathcal{H}_{13}$	0	0	1.0	-1.24	0	0	6.64(2)	0.04
$\mathcal{H}_{14}$	0	0	1.0	-1.0	0	0	7.93(3)	0.05
$\mathcal{H}_{14}$	0	0	1.0	0	-1.13	0	5.12(3)	0.08
$\mathcal{H}_{16}$	0	0	1.0	0	-1.0	0	6.19(3)	0.10
$\mathcal{H}_{17}$	0	0	0	1.0	-0.92	0	6.72(2)	0.03
$\mathcal{H}_{18}$	0	0	0	1.0	-1.0	0	6.86(3)	0.08
$\mathcal{H}_{19}$	0	0	0.08	1.0	-1.0	0	6.64(2)	0.04
$\mathcal{H}_{20}$	0	0	-0.67	-0.33	1.0	0	5.78(2)	0.06

8. A identified long-run structure for the two periods

In this section we discuss different specifications of the long-run structure. The hypotheses are 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. We present an identified structure of long-run relations for the first period in Section 8.1, and for the second period in Section 8.2, and discuss the basic changes that have taken place over the full sample period in Section 8.3.

8.1. The first period 1974:1-1983:1

In Table 8.1 we report two alternative specifications of the long-run structure, $\alpha_r\beta_r'$, for the first period. The first alternative imposes two overidentifying restrictions which are accepted with a p-value of 0.44, whereas the other imposes three restrictions accepted with a p-value of 0.35. Hence, both restricted models correspond to almost the same value of the likelihood function and $\hat{\Pi}_r = \hat{\alpha}_r\hat{\beta}_r^{'}$ is almost identical to the unrestricted $\hat{\Pi}$ in both cases. The latter is reported in Table 8.2.

Specification I contains a money demand relation (3.1) with plausible opportunity cost properties, a relation between real income, real money stock, and inflation, and the monetary policy rule (3.2).

The money demand relation, $\hat{\beta}_1^{'}x_t$, is dominated by the opportunity cost variables, and velocity has in fact a fairly small weight as can be seen from the first row of the Π matrix: Neither money nor income enters with significant coefficients. Econometrically this can be explained by the absence of long-run price homogeneity and the "odd" behavior of the monetary aggregate in this period as already discussed at some length in section 7. The coefficient $\hat{\alpha}_{11}$ show that real money stock is strongly error-correcting to this relation, $\hat{\alpha}_{31}$ that inflation rate goes up with "excess money", and $\hat{\alpha}_{51}$ that the medium-term bond rate increases with excess money (the demand pressure effect).

The second cointegration relation, $\hat{\beta}_2^{'}x_t$, is a relation between real income, real money, and inflation. The strong positive empirical relationship between real income and real money was already demonstrated in $\mathcal{H}_5$ in the previous section. The negative relationship between real income and inflation is related to the cointegration results of $\hat{\beta}_3x_t$. It shows that inflation and the spread essentially contains the same stochastic trend and, therefore, can be interchanged as will be demonstrated in Specification II. The adjustment coefficient $\hat{\alpha}_{22}$ shows that real income is significantly error-correcting to this relation, whereas $\hat{\alpha}_{12}$ shows that money stock is affected but not error-correcting. This confirms again the puzzling behavior of money stock in this period and supports the interpretation of $\hat{\beta}_2^{'}x_t$ as a real income relation. In addition $\hat{\alpha}_{32}$ and $\hat{\alpha}_{52}$ shows that both inflation and the medium-term bond rate adjusts positively. This seems a priori plausible, because expansion of government expenditure by issuing new bonds and by monetizing should increase both the yield of long-term government bonds and inflation.

The third relation, $\hat{\beta}_3^{'}x_t$, describes the central bank policy rule (3.2) as a relation between inflation and the interest spread. The negative coefficient $\hat{\alpha}_{23}$ shows that narrowing the spread relative to inflation (contractionary monetary policy) has a negative effect on GDP growth. The coefficient $\hat{\alpha}_{33}$ shows that inflation is error-correcting, i.e. inflation adjusts to changes in the interest rate spread. Finally, both the long-term and the short-term interest rate are error-correcting to this relation.

Specification II tells essentially the same story but from a slightly different perspective. Instead of a money demand relation we now have a relation describing inflation adjusting to excess velocity. Money stock and inflation are both

Table 8.1: Two alternative long-run structures: 1974:1-1983:1

	$m-p$	y	Δp	R_m	R_b	*trend*
			Alternative specification I			
β_1'	**1.0**	**-1.0**	0	**-30.7**	**15.0**	**0.005**
				(6.1)*)	(4.0)	(2.5)
β_2'	**-0.4**	**1.0**	**5.5**	0	0	**-0.005**
	(13.3)		(6.1)			(10.)
β_3'	0	0	**-1.5**	**1.0**	**-1.0**	
			(7.5)			
	$\alpha_{.1}$		$\alpha_{.2}$		$\alpha_{.3}$	
m-p	**-0.17**	(-4.7)	**-0.42**	(-2.4)	-0.77	(-0.9)
y	0.02	(1.2)	**-0.26**	(3.4)	**-0.78**	(-2.1)
Δp	**0.11**	(5.0)	**0.36**	(3.4)	**2.00**	(3.9)
R_m	0.00	(0.6)	-0.01	(-1.7)	**-0.10**	(-2.3)
R_b	**0.01**	(2.6)	**0.08**	(4.0)	**0.35**	(3.6)
			Alternative specification II			
β_1'	**-0.09**	**0.09**	**1.0**	0	0	**0.000**
	(5.0)	(5.0)				()
β_2'	**-0.5**	**1.0**	0	**4.3**	**-4.3**	**-0.005**
	(12.0)			(7.1)	(7.1)	()
β_3'	0	0	**-0.4**	1.0	**-0.6**	0
			(6.7)		(10.1)	
	$\alpha_{.1}$		$\alpha_{.2}$		$\alpha_{.3}$	
(m-p)	**2.65**	(-3.7)	**-0.58**	(-3.0)	**8.06**	(6.6)
y	-0.08	(0.3)	**-0.31**	(-3.6)	0.17	(0.3)
Δp	**-2.20**	(5.2)	**0.40**	(3.5)	**-2.92**	(-4.1)
R_m	0.02	(-0.7)	-0.01	(-1.6)	-0.10	(-1.8)
R_b	**-0.23**	(2.8)	**0.09**	(3.9)	**-0.34**	(-2.5)

*) approximate t-values are given in paretheses

Table 8.2: The estimate of the unrestricted π: 1974:1-1983:1

	$m-p$	y	Δp	R_m	R_b	*trend*
$\Delta(m\text{-}p)$	-0.00	-0.24	**-1.15**	**4.67**	**-1.89**	0.001
	(-0.0)	(-1.6)	(-2.6)	(4.9)	(-2.7)	(1.5)
Δy	**0.13**	**-0.28**	-0.24	**-1.37**	**1.09**	**0.002**
	(4.2)	(-3.6)	(-1.0)	(-2.9)	(4.7)	(3.9)
$\Delta^2 p$	-0.04	**0.25**	**-1.04**	**-1.45**	-0.31	**-0.001**
	(-1.0)	(2.6)	(-3.9)	(-2.5)	(-0.7)	(2.6)
ΔR_m	**0.007**	**-0.015**	**0.07**	**-0.13**	**0.11**	**-0.000**
	(2.4)	(-2.0)	(3.1)	(-2.7)	(3.3)	(2.0)
ΔR_b	**-0.022**	**0.068**	**-0.10**	0.02	**-0.19**	**-0.000**
	(-3.2)	(3.8)	(-2.1)	(0.2)	(-2.4)	(-3.8)

Approximate t-values are given in paretheses

significantly error-correcting, whereas bond rate increases with "excess velocity". The second relation is similar to $\hat{\beta}_2^{\prime} x_t$ in Specification I but relates real income and real money to the interest spread instead of inflation. The adjustment coefficients are similar to specification I. The third relation describes a homogeneous relation between the short-term interest rate and the medium-term bond rate and inflation instead of the domestic monetary policy rule in Specification I. It is strongly significant in the money stock equation, where it essentially describes the opportunity cost of holding money. Inflation is strongly error-correcting to this relation as is the medium-term bond rate, whereas the short-term rate is only weakly adjusting.

Specification I gives the hypothetical monetary relations (3.1) and (3.2) as much empirical scope as possible, but at the price of obtaining an income relation which is not directly interpretable. Specification II, by relaxing the theoretical restrictions to some extent, tells a more interesting empirical story. Both specifications have their merits, but in terms of overall empirical consistency we prefer specification II. Unless otherwise stated, we will relate to this as the identified structure of the first period.

8.2. The second period: 1983:1-1994:4

In Table 8.3 we have reported a fully specified long-run structure for the second period. The two overidentifying restrictions were clearly acceptable based on a test statistic of 0.57 (p-value 0.75) asymptotically distributed as $\chi^2(2)$.

The first relation, $\hat{\beta}_1^{\prime} x_t$, describes velocity relative to the short-term interest rate. Consistent with the results of Table 7.1 any attempt to obtain a significant effect for the medium-term bond rate failed. Therefore, the relation cannot be given a straightforward interpretation as a money demand relation. An inspection of the corresponding adjustment coefficients shows that real money stock is error-correcting to this relation, but not significantly. Inflation rate is positively related, implying that "excess money" tends to be inflationary. The adjustment coefficient in the short-term interest rate equation is negative, i.e. the short-term interest rate tends to fall with excess liquidity, whereas the opposite is the case with the medium-term bond rate. The latter can be consistent with long-term inflationary expectations as a result of monetary expansion.

The second relation, $\hat{\beta}_2' x_t$, corresponds to $\mathcal{H}_{11}$ and was already discussed at length in Section 7.1. The adjustment coefficients show that real income is error-correcting, i.e. a widening of the spread will have contractionary effects on real growth. The adjustment coefficient in the inflation equation is positive, i.e. inflation is positively related to the output gap and the spread.

The third relation, $\hat{\beta}_3' x_t$, describes essentially the medium-term bond rate and its relation to domestic inflation and the output gap. The adjustment coefficients show, however, that the bond rate is not significantly error-correcting to this relation, and that both real income and inflation are negatively affected by "excess" increases in the medium-term bond rate. Because capital markets are much more integrated in this period, a plausible steady-state relation for the Italian medium-term bond rate should also include the corresponding foreign rate. Since this is not part of the present information set, the third relation should not be interpreted as a steady-state relation for the bond rate (consistent with the insignificant error-correction coefficient). Instead it gives some empirical evidence of a domestic "risk premium" for the Italian bond rate as measured by the level of domestic inflation and output gap. Similar results are reported in Knot (1998).

9. Changes in monetary transmission mechanisms: Summary and conclusions.

The aim of this empirical study was to uncover major changes in Italian monetary transmission mechanisms associated with the change in central bank independence and the increased economic integration within Europe. The approach was to split the sample into two periods that approximately coincided with these two regimes and carry out a detailed VAR analysis of both periods and then compare the results. Two related issues had to be addressed before the actual analysis could be performed: (1) the absence of overall long-run price homogeneity and (2) the sensitivity of the long-run results to the choice of price variable.

Table 8.3: An identified long-run structure: 1983.1-1994:4

	$m-p$	y	Δp	R_m	R_b	$trend$
β_1'	**1.0**	**-1.0**	0	**-4.4**	0	**-0.003**
				(4.4)		(5.)
β_2'	0	**1.0**	0	**7.0**	**-7.0**	**-0.006**
				(11.7)	(11.7)	(10.)
β_3'	0	**-0.07**	**-0.54**	0	**1.0**	0
		(7.0)	(7.0)			
	$\alpha_{.1}$		$\alpha_{.2}$		$\alpha_{.3}$	
m-p	-0.21	(1.4)	0.36	(1.7)	1.99	(1.4)
y	0.07	(1.2)	**-0.24**	(-3.2)	**-2.4**	(-4.6)
Δp	**0.11**	(3.4)	**0.18**	(4.2)	**1.31**	(4.3)
R_m	**-0.01**	(-2.8)	-0.00	(-0.4)	-0.03	(-0.7)
R_b	**0.04**	(2.5)	0.03	(1.4)	-0.11	(-0.6)
	The Π-matrix					
	m-p	y	Δp	R_m	R_b	$trend$
Δ(*m-p*)	-0.21	**0.43**	-1.08	**3.44**	-0.53	-0.000
	(-1.4)	(3.3)	(-1.4)	(2.8)	(-0.9)	(0.3)
Δy	0.07	**-0.15**	**1.30**	**-2.00**	**-0.70**	-0.000
	(1.2)	(-3.1)	(4.6)	(-3.4)	(-3.4)	(0.2)
$\Delta^2 p$	**0.11**	-0.02	**-0.71**	**0.80**	0.04	**-0.001**
	(3.4)	(-0.6)	(-4.3)	(3.1)	(0.3)	(-3.7)
ΔR_m	**-0.01**	**0.01**	0.02	0.04	-0.02	-0.000
	(-2.8)	(3.1)	(0.7)	(1.1)	(-1.0)	(1.4)
ΔR_b	**0.04**	-0.001	0.06	0.05	**-0.33**	**-0.000**
	(2.4)	(-0.1)	(0.6)	(0.4)	(-5.3)	(-3.5)

*) approximate t-values are given in paretheses

To study the impact of different measurements of the price variable on the cointegration results, a sensitivity analysis was performed based on the choice of either the CPI index or the implicit price deflator of GDP. Although the choice did matter, it unfortunately did not solve the problem of no long-run price homogeneity. By using the $I(2)$ model to analyze how nominal money and prices were related between themselves and relative to real aggregate income we learned about its implications for the econometric analysis of the real money model.

Based on the empirical analyses in the nominal and real money models we found the following major changes in the cointegration and dynamic adjustment properties between the two periods:

Money stock: It was difficult to find convincing evidence of a plausible money demand relation in both periods. In the first period the problem seemed to originate from real money growing a lot faster than real income. In the more recent period the insignificant effect on money holdings from changes in the alternative cost of holding money relative to bonds was the problem.

In the first period velocity was essentially $I(2)$ and, hence, could not cointegrate with the opportunity cost of holding money. The reasons for the divergent growth paths of money and income are hard to explain. One possibility, supported by the results in Gennari (1998), is that financial innovations played a substantial role in this period, causing a shift in velocity not easily modeled by a linear trend. Another possibility is the inaccuracy of the GDP measurements in Italy because of presence of the informal economy.

In the second period the lack of empirical support for a stable money demand relation can possibly be explained by the increased central bank independence. Agents' demand for money could in principle have effectively been restricted by the central bank policy decisions. There are arguments in favor of this hypothesis: The last restrictions on capital movements were abolished as late as 1990. Italy maintained the broad 6% bands of the ERM until 1991 and the lira was essentially floating after Italy left the ERM in 1992. On the other hand Sarcinelli (1995) argues that the central bank performance did not significantly improve in this period in terms of actual versus targeted money supply, which is against this hypothesis.

Real aggregate income: The results regarding the changes in the mechanisms determining real aggregate income were quite interesting. Comparing the estimates of the income relation, $\beta_2' x_t$, shows two main differences: (1) the strong real money effect in the first period compared to no effect in the second period; (2) the increased interest rate sensitivity in the second period.

The real money effect is empirically interesting at the background of the strong ties between the Bank of Italy and the Treasury in the first period. It suggests that monetary expansion did produce real growth instead of price increases as theory would predict. The nominal analysis in section 6 supported this interpretation. Nevertheless, expansion of aggregate demand in this period had also to some extent inflationary effects.

The interest rate effect on real aggregate income shows that changes in the spread, i.e. increases in the short-term rate relative to the long-term rate have had contractionary effects on real activity and more so in the second period.

Altogether, the monetary effects on real income have been quite different in the two periods with strong positive effects from real money expansion in the first period and strong interest rate effects in the second period.

Inflation: The first two relations describing excess money and excess aggregate demand (although based on somewhat different specifications) have positive and similar effects on inflation in both periods. This demonstrates that independently of the regime the excess demand effect has been inflationary, albeit monetary expansion caused by the monetization of government debt has also produced real effects, particularly in the first period. Not surprisingly, the short-run interest rate effect on inflation is less clear-cut. This is probably so because the time lag before inflation is affected by a change in central bank interest rate can be assumed long and varying.

The interest rates: The mechanisms behind the determination of the short-term and medium-term interest rates have clearly changed in this period. The demand effect of issuing bonds to finance government expenditure has as expected increased the bond rate and this effect became more pronounced in the second period. In the first period there was some evidence of the liquidity effect on the short rate and in the second period the bond rate seemed affected by a risk premium. In the first period there was little evidence of convergence between the short and the medium long interest rate whereas in the second period with a more efficient capital market there was more convergence.

To conclude: The effect of "excess money" on domestic price inflation seemed quite modest in both periods, but particularly so in the first period. The accommodative monetary policy of Italian central bank in the first period, but also to some extent in the second period, seemed to have facilitated real growth at least in the medium-long run. The effect of the short interest rate seemed more important than excess money, but its dynamic transmission effect on price inflation was not clear-cut. Altogether, it seems plausible that the Italian prices have been more affected by other than monetary factors, for instance by domestic wage and foreign price determination.

These conclusions are similar to Juselius (1996, 1998b) based on similar data sets and to Hendry (1998) based on century-long data for UK.

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10. Appendix

The definition of the data:

Variable	Data description	Source
m	Money supply M2 definition. Non public sector Not seasonally adjusted. Current prices.	OECD DATASTREAM
p	Consumer price index. Not seasonally adjusted.	OECD DATASTREAM
p_y	Implicit price deflator of the GDP. Not seasonally adjusted.	ISTAT
y	Gross domestic product. Seasonally adjusted. Constant prices.	OECD DATASTREAM
i_B	Bond yield. Credit Institutions. Net of taxes.	Bank of Italy