MONEY DEMAND IN PORTUGAL, 1979.IV-1998.IV

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Resumen

The objective of this work is to analyse the existence of a money demand function (M_2^-) in Portugal along the period 1979/4 - 1998/4. We have studied the stochastic properties of the series involved , the order of integration, and, based on Johansen's cointegration test we have found out a potential equilibrium relationship, understood as a money demand function in the long run. We then proceeded with the estimation of an error correction mechanism model (ECM) for real money and applied techniques of dynamic specification so to analyse the stability and predictability of the demand for money in Portugal, namely the generalized impulse response functions and persistence of profile. On the basis of the practical results we did not find a total agreement between the postulates of economic theory and econometric practice - neither Fischer strict effect, nor the hypothesis about the structure of interest rates in the short and long run were verified.

Palabras clave: Unit Roots, Cointegration, Error Correction Models, Money Demand Function, Portugal.

Area temática: Economía Nacional e Internacional.

1. Introduction

Money demand has been for long decades the object of numerous empirical studies, as well as an area of solid theoretical principles of proven importance even among such competing theories as Keynesianism and monetarism. Its importance lies basically on two major arguments. On the one side, there is its power of predictability for the behaviour of monetary policy. Through the money demand function we can quantify the objectives, regarding either money or interest rates, and assess their impact on real economic activity. On the other side, and after its conventional specification had been questioned, the modelization of money demand and the associated econometric methodology began to be the object of investigation in modern societies. One should here make reference to the paradigmatic article by Goldfeld (1973), which inaugurated an extensive bibliography on the issue of the estimation of a stable money demand function.

The conventional formulation of money demand function (MDF), lying on a partial adjustment mechanism, has revealed itself insufficient to answer to situations of monetary turbulence from the mid-seventies on, caused by high inflation levels, alterations in the liabilities of banks, new financial instruments, which urged the quest for a new econometric reference framework. Cointegration theory and error corrector mechanism models are nowadays econometric techniques used by Central Banks and Federal Reserves for the realization and measurement of the effects of monetary policies. In case there is no cointegration for the monetary aggregate, there are no statistical arguments that may justify its use in the definition and implementation of monetary policy.

The specific objective of this article is to claim that this econometric approach allows us to draw some conclusions about the existence (or not) of a long term relationship between real money, real income, and interest rates in Portugal. The basic hypothesis under observation is that there is a stable MDF, the variation of which in the short run can be appropriately represented by an error corrector mechanism.

This paper is organized as follows: in Section II we present a brief historical framework of the theoretical principles of MDF and respective formulations throughout different epochs to our days, taking into account the two major paradigms of economic theory. We should note here that the monetary experience of the 1980’s is of extreme importance for our understanding of the antecedents of Portugal’s present monetary policy, while giving support to the empirical outcomes.

The following sections present the methodology, data, and empirical results. Thus, in Section III we tried to apply cointegration methodology to the relationship set out by MDF in Portugal, by assuming, for the specific purpose of this work, M_2^- (intermediate monetary aggregate) as representative of the concept of money. We have adopted Johansen's approach in the practical example, as it is, among a valuable set of other alternative methodologies, the one that is more generalized, and because it presents no limitations in what concerns important biases in finite samples or presuppositions of exogeneity that may not be at once verified.

In Section IV, we made an estimation of the dynamic model for real money, which represents a reparameterization of an autoregressive general model for the variables at by imposing the long-term solution, previously obtained, so to give sequence to the proposed investigation of the confrontation between the long-run and the short-run potential equilibrium. The ECM model was validated through the analysis of the behaviour of residuals and, afterwards, through the study of its stability along the sample time period. In the study of the MDF stability and predictability in Portugal we have taken recourse to some techniques of dynamic specification, namely the analysis of the generalized impulse response functions, persistence of the profile, and decomposition of the variance of the prediction error. In Section V we drew some final notes.

2. Historical and methodological framework

2.1. Formulation and Realization of the Monetary Policy in Portugal in the 1980's and 1990's

The historical circumstances associated to a country's economy may to some extent help us understand the statistical aggregates throughout the sample period. In the early 1980's the Portuguese economy was characterized by a deep macro economic unbalance, a low competitiveness in industry, by important distortions in the markets of goods and manufacturers, and by a substantial weight of the public sector in the productive activity, all of which being inherited by the 1974 revolution. The financial market was not sophisticated, and financial institutions, which were decapitalised and inefficient, belonged to the public sector[1].

[1] See the exhaustive portrait of financial innovation in Portugal, in Bação (1997).

Since Portugal joined the European Community the framework of monetary and stock exchange policies has deeply changed. Financial liberalisation in the sphere of the single market had as a corollary the replacement of the mechanisms of direct control of the monetary policy by indirect ones based upon the market. As stabilisation was on focus, Portuguese authorities started to pay more attention to the struggle staged against inflation. It was of particular relevance in the definition and practice of Portuguese monetary policy the establishment of the Organic Law of Banco de Portugal (BP) in October 1990, giving more independence to the central bank. In 1991 BP stopped taking treasury bonds and in mid-1992 those bonds were no longer used as a means of long-term liquidity.

After the escudo entered the Exchange Rates Mechanisms (ERM) of the European Monetary System (EMS) in 1992, the role of the exchange stability was reinforced as a cornerstone of the Portuguese monetary Policy. In the period under analysis, and due to certain turbulence within EMS, the strong appreciation of escudo in the real exchange rates, though contributing to lower inflation, was one of the main causes of economic depression during 1992-1994, and a serious obstacle to the application of a less restrictive monetary policy.

BP Organic Law was altered in September 1995, and, consequently, the treasury counter-stream next to BP was officially suppressed, and the direct acquisition of tickets of public debt by the central bank was forbidden. After 1997 BP started to accept tickets of private public debt as a guarantee in operations of liquidity cession. In early 1998 BP Organic Law was revised again with the objective of permitting a full integration of the bank in the European Centrals Banks System (ECBS), set up on June 1st, 1998. After January 1st, 1999, the beginning of the third phase of European Monetary Union (EMU), with the adoption of a target zone by BP, the autonomy of monetary policy is drastically reduced.

In this context, we should emphasise that structural reforms play a crucial role in the strategies adopted by Portuguese authorities to promote real convergence. In the 1990's Portugal had, among the OECD countries, one of the most comprehensive privatization programmes, both in dimension and depth[2].

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[2] For further details, see, for example, Abreu (2001), and Estudos e Relatórios da Comissão Europeia (Direcção-Geral dos Assuntos Económicos e Financeiros), nº1 (1997).

2.2. Theoretical and empirical Background

It's undeniable that throughout history vigorous debates have taken place among different macro economic schools on the specification of a stable MDF. The theoretical developments of the demand for money (Goldfeld, 1973) have their roots in classical tradition, while the famous "Quantity Theory of Money" belongs to Farlier and Fischer (1911). Later on, the neoclassical approach fundaments the demand for money in some dynamic versions of the classical models, and then come the two major paradigms: the Keynesian-type paradigm and the Monetarist. More recently further theoretical developments have appeared with implications in the empirical results of such models as "Baumol-Tobin inventory" (Baumol (1952) and Tobin (1956)); "cash-in-advance models" approach (Clower (1967)), defending the inclusion of money in a utility function; "consumer demand theory" modelisation (Friedman (1956) and Barnett (1980)), which runs much in the direction of the "Chicago School" adepts, according to which money is a direct extension of the conventional theory of demand of any durable good, being the inflation rate a very strong argument. What is interesting in these various theories is that they analyse the demand for money in different perspectives, but in practice, their results are practically identical. The differences lie basically in the way these alternative theories represent the cost of opportunity of money, and the choice of the scale variable that best represents the real income.

Consequently, there arises a consensus from all this literature: empirical works on money demand are motivated by a combination of various theories. Thus, in the construction and specification of the money demand models some aspects are common to all the methodologies, namely the choice of independent variables (scale variable and cost of opportunity of money), the need to model systems with feed-back effects among the economic variables, and, also the development of appropriate specifications which permit the inclusion of the adjustments towards the long-term equilibrium, which are relevant in the monetary policy (distinguish the different temporal horizons).

In the analysis of MDF it is undeniable that any theory must start by defining the monetary aggregate that is to be evaluated. Yet, the correct definition of money is an issue that has not always generated consensus (Laidler, 1993); it must take into consideration the country under study, its institutional characteristics or even some arbitrary decisions (Boughton, 1992).

As for the scale variable, transaction theories emphasise current income, whereas speculative theories consider wealth instead. Most studies consider the Gross National

Product (GNP) the most relevant scale variable due to the existence of statistical information and because it is a measure that satisfies, directly or indirectly, the criteria both of income and of wealth. According to several studies the reason why only one interest rate is used to measure the cost of money opportunity lies in co-linearity. Yet, the combination of a set of variables (expected inflation rate, external interest rate, exchange rate) depends fundamentally on the level of macro economic development, the status of the domestic financial sector, the degree of liberalization of interest rates, the degree of openness of the economy, and the collection and evaluation of statistical information.

In what concerns functional forms and the specification of money demand models, there is no doubt that partial adjustment models gained most popularity up to the 1970's. In an attempt to meet the objectives of the money demand equilibrium, in this kind of modelization the behaviour of the economic agents targeted at getting a permanent adjustment between actual and desired levels in the long-run[3] .

After 1973, however, previsions based on such models started to systematically overestimate real monetary balances, and the instability of money demand got to be known as "The case of missing money" (Goldfeld, 1976). The time there was a dislocation of MDF was associated to important monetary and financial developments. The problems about the specification of the traditional MDF were due to the omission of important variables and/or to an incomplete dynamic structure in the conventional models. According to Baba, Hendry and Starr (1992) the inclusion of new variables or the redefinition of those already existent did not bring about per se significant improvements to MDF, which evidences the need to review the theoretical framework or the need to find out a better dynamic specification.

New econometric approaches have so far been applied such as ECM models, so as to combine a more complex dynamic structure with a long-run solution similar to the conventional one. This kind of approach does not involve previous conditions, either about the shocks that can disturb the equilibrium relationship in the long-run, or about the equilibrium restoration through an adjustment in one or in a set of determined variables. Here we want to consider that cointegration implies the existence of a dynamic, in the form of an error corrector, in relation with the stability of the system (Engle and Granger, 1987), refuting the criticisms of a partial adjustment. Recent developments have

[3] The inclusion of the lagged money of the demand for money was an important mark in the models of partial adjustment, for it considers incomplete the adjustment mechanism in the short run (Chow, 1966). Later, Goldfeld and Sichel (1990) proposed an enlarged version of the previous models.

demonstrated an increase in the application of cointegration theory in MDF, (with or without ECM)[4]. ECM methodology contributes to restore MDF stability, yet it is no longer a simple function of a few variables, at least at the specification level in the long run.

3. The long-run money demand function (MDF) in Portugal

3.1. Variables used in the model

In an attempt to define an MDF for Portugal, we have taken recourse, for empirical purposes, to quarterly-frequency data with reference to the years 1979/4–1998/4 (T=77) [5]. As the choice of the monetary aggregate that best fits our purposes is of crucial importance, we consider that M_2^- aggregate (intermediate monetary aggregate) is representative of the money concept, thus contributing to the discussion on the difficulty in establishing the frontier of the definition of money, placed between a narrow aggregate (which could be M1 in Portugal) and a broad aggregate, namely L[6]. This option has taken into consideration the historical background of the Portuguese monetary policies in the decades prior to EMU. The scale variable used in our study was Gross Domestic Product (GDP), deflated by the general level of prices (through the series of the index of the consumer's prices), as a measure of real income, and the series related to the rentability rates of treasury bonds issued at the variable rate, and at the assets rates of time deposits, reflect the structure of long and short term interest rates, respectively, measuring the cost of money opportunity.

It must be noted here that the GDP series, at the 1997 prices, is presented from the point of view of the expenses, previously corrected to seasonability. We must also refer that there was a change of the basis for the year 1997, as the GDP series had formerly been deflated to the prices of 1995 (this basis is relative to the deflator of private consumption). Likewise, the values referring to the monetary aggregate used in this study case are presented after correction to seasonability. Our main source of information was Banco de Portugal, who generously provided me with their long statistical series, the

[4] Among the major contributors in the implementation of these techniques were Sargan (1964), Davidson et al. (1978), Banerjee et al. (1986), Granger (1986), Hendry (1986), Engle and Granger (1987), Johansen (1988), Phillips and Perron (1988), and Johansen and Juselius (1990), among others.
[5] Data set was provided by the Department of Economic Studies of Banco de Portugal. The sample finishes in December 1998, as with the single currency the objectives of the economic policy lost relevance, which at the time EMU was created.
[6] For further details see Marques and Lopes (1992).

production of which results from a hard process of compatibilisation between the Normalised System of National Accounts until 1976 and the European System of Integrated Economic Accounts. Hence, the relevant variables for the study of MDF are as follows:

M: monetary aggregate M_2^- (values previously corrected to seasonability);

Y: gross domestic product at 1997 prices (from the point of view of the expenses and previously corrected to seasonability);

r: nominal interest rate of government bonds, before tax, issued at a variable rate;

i: nominal interest rate of time deposits (181 days to 1 year), before tax;

P: general level of prices/consumer price index (basis 1997=100).

The long-term relationship assumes the conventional specification

$$\frac{M}{P} = Y^{\beta_2} \exp^{\beta_3 r + \beta_4 i} \text{, or in log-linear form } (m-p) = \beta_2 y + \beta_3 r + \beta_4 i$$

in which the variables m, p, and y are given in logarithms, as this transformation appears to be appropriate to linearise the respective original exponential trend, thus making no sense in the interest rates. Unlike Friedman (1956), who proposed the expected inflation rate as an important variable in MDF, we didn't consider it statistically significant in the long-term relationship, though it is important in the adjustment structure towards equilibrium, as we demonstrate in section IV.

According to economic theory it is expected that elasticity-income (β_2) assumes a positive value, below or equal to the unit, and that semi-elasticities relative to interests rates (β_3 and β_4) are respectively negative and positive, since *r* stands for the return of the assets outside the monetary aggregate, and *i* the return of liabilities included in it.

Based upon the observation of the graphs of the variables m, p, (m-p), y, r and i, which suggest non-stationarity of the series (see Figure 1), a stable long-run function will only exist if the variables are cointegrated. An equilibrium relationship between real money stock, real income and interests rates implies to investigate whether these series are individually integrated in the same order, and in a later phase, whether or not they are cointegrated.

3.2. Study of the Series Stationarity (Integration Order)

We've restricted our analysis to traditional unit roots tests by Dickey-Fuller and Augmented Dickey-Fuller (ADF). Critical points can be seen from the table constructed by MacKinnon for various types of regressions (with or without an independent term and with or without a linear trend)[7].

Before presenting the contrasts of unit roots for the variables of interest, we must note that the series of prices and of the monetary aggregate have demonstrated to be individually controversial. The analysis of ADF tests does not allow concluding that these variables follow a 1st order integrated process, and the results are of difficult interpretation. Yet, the correlation function of the first differences series suggests the existence of stationarity, furthermore the ADF tests are little potent to the presence of eventual outliers. In this context, the homogeneity of prices[8] is postulated with reference to the clear results in that direction, since this restriction was accepted and subsequently imposed on the analysis, being the empirical study led on a basis of real stock of money (m-p). In order to reinforce the conclusions drawn upon the tests outcomes, we should now see the chronograms plotted in Figure 2.

The results shown in Table 1 denote the rejection of the hypothesis that the series in differences have a unit root, indicated that level variables must be integrated of order 1. According to the strategy of ADF tests, and in all the cases, the constant did not prove to be statistically significant. Whenever a trend was introduced, we noticed that it was significant for all the series individually, though less clearly for income. Thus, evidence goes in the sense of trend stationarity, since real money and income strongly denote a strong upward linear trend, and interest rates denote a softer dropping trend. We must refer that for the series Δi we had to apply an ADF(2) test, so as to remove the serial correlation problem.

In this specific study, the tests that postulate the existence of a unit root as a null hypothesis have not been rejected, thus giving evidence that real money, real income and interest rates are integrated variables of order 1.

[7] For more details see MacKinnon (1991).

[8] In the cointegration static model we tested the homogeneity of prices through the restriction $\beta_{11} = -\beta_{12}$, hence $\chi^2_{obs}(1) = 0{,}694 < \chi^2_{5\%}(1)$. There's some statistical evidence to conclude for the neutrality of money in the long-run.

3.3. Optimum order of the VAR model

A previous question is raised about the determination of the order of the vector autoregressive process that best represents the data set, since the determination of *k* may affect the value of the statistics test and consequently the determination of the cointegration space. Let x_t follow a VAR of *k* order (unknown) with the following representation with an error correction mechanism:

$$\Delta x_t = \mu + \theta_1 \Delta x_{t-1} + ... + \theta_{k-1} \Delta x_{t-k+1} + \Pi x_{t-1} + \Psi D_t + \varepsilon_t ,$$

where, in the present case $\boldsymbol{x} = \begin{bmatrix} (m-p) \\ y \\ r \\ i \end{bmatrix}$ with $\theta_{4\times4}$ and $\Pi_{4\times4}$, $\varepsilon_t \sim IN(0, \Lambda)$ designating, respectively, the vector of the variables of the model, the matrices of the unknown parameters, and finally, the Gaussian residual variable. Note that the exposed model differs from a traditional VAR in the first differences as it includes the term Πx_{t-1}. Matrix Π, of size (4×4), is known as long-run matrix or cointegrant matrix, since the number of cointegration linearly independent vectors, say *r*, is given by the rank of Π .

The hypothesis of interest to test is given by $\Pi = \alpha\beta'$, with $\alpha_{4\times r}$ $\beta_{4\times r}$, that is, the variables are cointegrated, with *r* cointegration vectors corresponding to the columns of matrix β. Given x_t~I(1), the linear combinations $\beta' x_t$, will be stationary, where β corresponds to the vector of the error corrector terms and α to the matrix of the correspondent coefficients of adjustment or weight matrix.

The selection of *k* was made according to the hypotheses about residuals, so we came to the conclusion that two lags would be enough to make the equations residuals turn into non-autocorrelated, approximately with a normal distribution. To verify the absence of autocorrelation we've used statistical LM=$TR^2 \sim \chi^2(k)$, where (k) stands for the number of the endogenous variables of the system. The test of the normality of residuals proposed by Bera and Jarque in 1980, which is based on biased properties and on kurtosis, is extremely sensitive to the presence of abhorant values (outliers) of the estimated residuals. We've used White's heteroscedasticity test, an extension of White's test (1980), to support the selected model, as it is one of the potentials correctly specified.

Thus, note the development of the residuals of each equation of the VAR(2) system, shown in Figure 3.

3.4. Cointegration Tests

Since the variables under observation are integrated of the same order, in this case I(1), it is now relevant to analyse if there is one or more linear combinations among them, integrated of inferior order, in this case I(0). In practice, Johansen's cointegration test is one with the characteristics of matrix Π. The estimation of the maximum likelihood of the selected model, submitted to the restriction contained in the null hypothesis, allows to estimate the eigenvalues $\lambda_1 > \lambda_2 > \lambda_3 > \lambda_4$, permitting the construction for *r*=0, 1, 2, 3, the trace and maximum eigenvalue stastistics.

Bearing in mind the previous study of the series behaviour, we've opted out for the free estimation of the autonomous term, presupposing a linear trend in the series at levels, but considering that this trend does not exist in the data generator process (Case 3 - table 1.1* by Osterwald-Lenum (1992)).

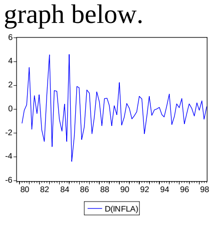
The cointegration tests from this model are shown in Table 2, at the 5% and 1% significance level, denoting that the proper vectors are all normalised in the (m-p) coefficients. By testing the hypothesis *r*=0 (p-*r* = 4) *vs* *r*≥1, the trace statistic is significant, both at the 5% and the 1% significance level, thus giving evidence of a cointegration relationship at both levels. The max-eigenvalue test denotes the presence of two cointegration equations, at the 5% significance level. Thus, statistical evidence is that there is at least one potential long-run relationship among such variables. So far we've tested the accepted hypothesis of the inexistence of a trend in order to analyse if it is (or not) consistent with the data. Let be H^* the hypothesis that $\alpha'_\perp \mu_0 = 0 \ (\mu = \alpha m_0)$, *versus* alternative H of the presence of a linear trend, the value of the statistic test is given by $\chi^2_{obs} = 6{,}812 < \chi^2_{5\%}(3) = 7{,}815$. We can conclude for the inexistence of a linear trend in the cointegration vector.

Before proceeding with our analysis, it should be noted that one of the most consensual, well established facts of economic theory is the relationship between money growth rate and inflation rate. The inclusion of inflation rate (Δp_t) wouldn't be empirically inconsistent, as the first differences of the variable follow a stationary process, i.e., inflation is an I(1) series[9]. This variable was also introduced in an initial phase, as a proxy variable for the cost of detaining money, but as it did not prove to be statistically significant in the cointegration relationship, it was left out of our analysis, though it is of real importance in the explanation of the short term dynamic for the specification of the MDF through an ECM model.

3.5. Estimation of the cointegration vector

For the specific purpose of the present study, there are at least two restrictions imposed upon the parameters of β, which are worth studying at the light of the economic theory: a long-run unit elasticity between money demand and real income, and equal coefficients of opposed sign for interest rates. In practice this constrains is based on the hypothesis $H_0 : \beta_1 = -\beta_2$, allowing to construct the likelihood ratio, a statistical outcome that has an asymptotic distribution of χ^2 with *r*(p-s) degrees of freedom. Test statistic is relevant at the 5% significance level ($\chi^2_{obs} = 5{,}764 > \chi^2_{5\%}(1) = 3{,}841$), calling for the rejection of null hypothesis. Like this, it would be too risky for our economy that the competent authorities led their monetary policy upon the restriction of the unit income elasticity, as there is no guarantee that there is a high correlation between the monetary aggregate and the ultimate objective of the economic policies (to exert control over the inflation rate), a property that should be possessed by an efficient intermediate objective. By working out the second constraint, which implies that the cost of detaining money may be measured by the difference between the interest rate of government bonds and interest rate of time deposits, represented by $H_0 : \beta_3 = -\beta_4$, the value of the likelihood ratio after estimating the restrict model is given by $\chi^2_{obs} = 5{,}373 > \chi^2_{5\%}(1)$.Once the test is significant, we can't accept that the coefficients of the interest rates are equal and of opposed sign. It should be noted, however, that during the sample period, Portugal was under a severe administrative control of interest rates, and it was not until 1991 that credit limits were abolished, a fact

[9] Variable Δp_t (inflation rate) was subjected to the ADF test. The first differences of the variable show a stationary process which is evidenced in the graph below.



that would later help to reinforce competition in the banking sector, which would also lead to a smaller margin of financial intervention.

Thus, we take the following relationship of long run equilibrium as representative

$$(m-p)_t = 0.4395\ y_t - 0.0241\ r_t + 0.0059\ i_t$$

the deviations of which, or error corrector term, are defined by

$$\hat{z}_t = \hat{\beta}' x_t = [(m\text{-}p) - 0.4395\, y + 0.0241\, r - 0.0059\, i]$$

representing a stationary linear combination among the variables, according to the definition of cointegration, the deviations related with the equilibrium must be limited and temporary. Deviations are represented in Figure 4, giving evidence of the cointegration relationship, and making reference to two periods of big dislocations, namely the period 1982-1984 (programmes of IMF adjustment and stabilization) and 1992-1994 (time of strong changes and economic recession).

3.6. Testing for exogeneity

As no there was no particularly relevant hypothesis to test matrix α, we applied the weak exogeneity test, which is a mere likelihood ratio test. After estimating the model and imposing the joint restriction for the first cointegration equation, symbolized by $\mathrm{H}_0 : \alpha_{i1} = 0$ (i= 2, 3, 4), we obtained the test statistic of likelihood ratio -2 ln($\mathrm{H}_0 / \mathrm{H}$) = 2.812 < 7.814 = $\chi^2_{5\%}$(3). Statistical evidence is in the sense of rejection of null hypothesis at a 5% significance level, concluding for the weak exogeneity of the variables under analysis, real income and interest rates, towards real money, i.e., the cointegration vector has no weight in the corresponding equation.

Considering the selected VAR(2), we present in Table 3 Granger's causality test which was used to verify whether the endogenous variables of the system may be treated as exogenous, that is, as independent. Since all the statistics are clearly nonsinificant, evidence points to a non-rejection of null hypothesis, thus making us conclude there is a strong exogeneity of y, r, and i, towards real money stock, and, consequently, real money does not cause a la Granger the other variables. This outcome allows to make previsions about the money real stock, based on a conditional model (in which the equation of money will be totally specified), by taking recourse to the previsions of the other variables obtained by the marginal model (equations of Δy, Δr and Δi, only in function of their own lags).

3.7. Persistence Profiles and Generalised Impulse Response (GIR) of the cointegration relationship

The persistence profile function, presented in Figure 5, contains information about the convergence rate in the long-run equilibrium (and respective speed of adjustment) of the effect of a shock in the system upon the cointegrant vector. In the limit, when time horizon tends to infinite, the persistence of profile function will tend to zero, thus reflecting the long-run properties of the relationship between the different variables of the system. We should note that even in case there is a stable long-run function (cointegration), it is important to analyse whether or not the adjustment is too slow in relation to equilibrium through the persistence of profile functions. Provided the adjustment is too slow we can conclude that the economic agents are too often out of equilibrium (balance). They may be, however, not willing to eliminate such deviations at once, so as “to keep in a money reserve” (compatibility with Buffer-Stock theory, in Laidler’s (1983) broad sense).

In this context, it is important to analyse how the cointegration relationship responds to the shocks of specific equations, reflecting the long-run elasticities. Thus, Figure 6 shows the GIR functions corresponding to the shocks in the equations of (m-p), y, r, and i, respectively and, with more or less speed, the impact of each shock on the long-run equilibrium tends to dissipate, reflecting the stability of the system.

4. Dynamic relationships in the short-run

By reviewing specific literature it has become possible to confirm the fact that new modelization strategies have contributed to restoring MDF stability, even though this is no longer a simple function with just a few variables, at least at the short-run specification level. From among new econometric approaches we should focus on ECM model, since it combines a more complex dynamic structure along with a long term solution much like the conventional one, which allows explaining the short-run deviations towards the equilibrium and respective speed of adjustment, through an EC term.

To complement the long-run analysis presented in Section III, we shall proceed by implementing the dynamic specification of real money in Portugal, based on an ECM model. After its estimation we shall study the model stability throughout the sample extensive period.

4.1. Estimation of an ECM for short-run real money demand

The assumed dynamic specification is of the type:

$$\Delta(m-p)_t = \mu + \sum_{j=1}^{k-1} a_j \, \Delta(m-p)_{t-j} + \sum_{j=1}^{k-1} b_j \, \Delta(p)_{t-j} + \sum_{j=1}^{k-1} c_j \, \Delta(y)_{t-j} + \sum_{j=1}^{k-1} e_j \, \Delta(r)_{t-j}$$

$$+ \sum_{j=1}^{k-1} f_j \, \Delta(i)_{t-j} + \alpha \, \hat{z}_{t-1} + \phi \, d_t + \varepsilon_t \quad \text{where} \quad \hat{z}_{t\text{-}1} = (\hat{\alpha\beta}') \, x_{t-1}$$

which represents a reparameterization of a general autoregressive model for the level variables, imposing the long-run solution obtained by cointegration, but freely estimating the adjustment coefficient (α) in relation to equilibrium. The autonomous inclusion of the price change or inflation rate can be accounted for as the admission of some short-run money illusion, together with motivations already referred to in previous sections in this work.

The model was estimated by ordinary least squares, initially obtaining the following dynamic specification:

$$\Delta(m-p)_t = \underset{(9.258)}{0.0407} + \underset{(0.515)}{0.0380}\,\Delta(m-p)_{t-1} + \underset{(1.704)}{0.1218}\,\Delta(m-p)_{t-2} - \underset{(-1.692)}{0.1638}\,\Delta(y)_{t-1} - \underset{(-0.481)}{0.0492}\,\Delta(y)_{t-2}$$

$$+ \underset{(1.698)}{0.0025}\,\Delta(r)_{t-1} + \underset{(1.221)}{0.0017}\,\Delta(r)_{t-2} - \underset{(-0.864)}{0.0017}\,\Delta(i)_{t-1} + \underset{(0.829)}{0.0016}\,\Delta(i)_{t-2}$$

$$- \underset{(-9.587)}{0.0109}\,\Delta(p)_t - \underset{(-8.184)}{\mathbf{0.1909}}\,\mathbf{z_{t-1}} + \varepsilon_t$$

with $R^2 = 0.7275$.

In a first phase of evaluation of the EC model, we started to analyse the residuals of the model variables (depicted in Figure 7), by improving the cointegration restriction, and suggesting a development favourable to its correct specification. In Table 4 we can observe the tests outcomes about the residuals for the system globality, namely autocorrelation, homocedasticity, and normality. We present the univariant statistics in the first differences of the variable (m-p), since the rest of the variables that form the ECM model have been considered exogenous.

The model was estimated by eliminating the less significant terms, hence the relationship:

$$\Delta(m-p)_t = \underset{(1.913)}{0.0397} + \underset{(1.1576)}{0.1365}\,\Delta(m-p)_{t-2} - \underset{(11.209)}{0.1630}\,\Delta(y)_{t-1} + \underset{(2.072)}{0.0023}\,\Delta(r)_{t-1} + \underset{(-1.772)}{0.00138}\,\Delta(r)_{t-2}$$

$$- \underset{(-10.516)}{0.0107}\,\Delta(p)_t - \underset{(-8.725)}{\mathbf{0.1869}}\,\mathbf{z_{t-1}} + \varepsilon_t$$

with $R^2 = 0.7203$

revealing itself as a more parsimonious model, and not altering the previous conclusions. The option of not excluding the associated terms to $\Delta(m-p)_{t-2}$ and $\Delta(r)_{t-2}$, though not being statistically significant, meets the postulates of economic theory, i.e., in the Portuguese case the dephasement of real money demand and the interest rate of the titles of public debt, are relevant factors in the monetary policy management (importance of the mechanism of the formation of expectations, which is not immediate).

As we proceed with our analysis, it is worth mentioning the importance of the inflation rate, a regressor with a high explanatory capacity, facing monetary deviations in relation to long-run equilibrium, as the monetary policy acts with a temporal dephasement about economic activity and about inflation.

In a second phase of assessment of the diagnostic testing of ECM model, we shall analyse its stability along the sample range. In order to test the existence of cointegration we might analyse the model stability. Thus, the estimate resulting from the error corrector coefficient must be found in the interval [-1, 0], which is valid for the case under observation.

In Table 5 we present the values of more significant statistics of tests for the estimated residuals of the equation of Δ(m-p) for ECM model. The outcomes allow concluding for homoscedasticity, through ARCH test and White's heteroscedasticity. Residual autocorrelation tests of an order higher than "*k*" revealed the inexistence of the problem. As for normality, according to BJ test, statistical evidence allows to conclude for a normal behaviour of the residuals of the equation of Δ(m-p) for ECM model.

So being, it is still important to analyse the stability of the model throughout the long sample period. By the reading of the graphs of the actual and fitted values of Δ(m-p) and of the recursive residuals (see Figure 8), four suspected points were observed corresponding to the observations 1985:4, 1986:2, 1991:1 e 1995:1, especially the last point which runs over in absolute value the double of the regression standard error, suggesting some instability of the parameters[10].

Yet, CUSUM and CUSUMQ tests (graphically shown in Figure 9) do not reveal any instability of the parameters, i.e., they don't allow detecting any relevant change at the 5% level, in the regression coefficient. The structural stability of the model can still be observed from the development of the recursively estimated coefficients (Figure 10).

To complete this study we applied Chow's test which denoted the inexistence of structural breaks. By the reading of the outcomes in Table 6 there is statistical evidence of no structural breaks, except for the periods of 1991: 1 and 1995:1, in which the statistic of test is significant at the 5% level[11]. The analysis of the predictive capacity of the model was based on Chow's prediction test, which permits to know if a given model derived from a sample is also suitable to post-sample data. The results depicted in Table 7, denote the structural stability of the model, with some occasional predictive failures due to outliers, especially in the period 1991:1, though with no real structural change. Emphasis should be put on the idea already stressed in Section II of the modernization of the Portuguese monetary policy, especially after 1991 with the intervention of Banco de Portugal. Still in the context of the stability tests, we used the Reset specification test to try the null hypothesis of the correct specification of the original model, against the alternative hypothesis of the inexistence of specification error (absence of significant variables). Statistical assessment is favourable to the correct specification of the model at 1% and 2,5 % of significance ($\chi^2_{(1)} = 4,87$ e $\chi^2_{(2)} = 6,82$).

4.2. Study of the Generalised Impulse Responses

Seen from the perspective of economic theory the assessment of the performance of a certain monetary policy in the short-run implies the analysis of the potential effects of the monetary policy in the frequency on focus, thus being quite relevant the question "What are the effects of the monetary policy in the short-run?." A good answer lies in the GIR functions, which define the effect of a shock of an exogenous variable, or of an random disturbance upon the values (present and past) of the endogenous variables of the system (to obtain dynamic multipliers), which can be calculated in a cointegrating ECM model.

[10] By establishing a parallel between the graphs (Figure 8), we can detect that it is in those points that the differences between the estimated and the observed values of the variable $\Delta(m-p)$ are bigger.

[11] In the period 1991:1 the statistical significance of the test is obtained in a frontier zone, since $F_{5\%}(7,60) = 2,17$. The null hypothesis in test is not, however, rejected at 1 % of significance.

We just focused our attention on the responses of the variable (m-p), since we accepted the weak exogeneity of the remnant variables. These functions are shown in Figure 11, with the three-month periods represented in the X-axis and the inter-quarterly first differences of each of the restrict VAR variables in the Y-axis. By conjugating the empirical data with the conduction and practice of monetary policies in Portugal, we are led to conclude that the Banco de Portugal led in the 1990s a gradual monetary policy, giving cause to a response behaviour on the part of the monetary policy itself to changes in the economic activity, the movements of which have been of little amplitude throughout times, and the inversion of sense is only given in the very short run, being the response of Δ(m-p) to innovations of the variable Δ(y) of little significance in the Portuguese economy in the sample time.

On the other hand the return of the assets outside the monetary aggregate contributes to the explanation of the temporary deviation (short-run dynamic) of real money against the equilibrium estimated by the cointegration equation, and the negative sense of the response meets the postulate for the economic theory. One can observe that the bonds interest rate shock produces a much stronger impact upon the temporary deviation of MDF towards equilibrium with an effect superior, in absolute value, to the one of the variation of the interest rates of time deposits, and most significantly, in statistical terms, is the fact that it meets the objective of the specification of the selected ECM. By the way, one should here recall the fact that before joining the EC, Portugal had gone through a time of very few financial instruments available for the application of savings in alternative to long-term deposits.

4.3. Analysis of GIR functions with the Inflation Rate

We proceed now to the analysis of the magnitude of the shock effects of the inflation rate on real money demand through GIR functions. Even though this variable did not appear to be significant in the cointegration static relationship, it is fundamental in the estimated ECM adjustment, so to explain the dynamics of the model. This is a structurally exogenous variable[12] in the selected model, a concept that is particularly relevant in

[12] According to this concept the system of equations to be estimated is given by:

$$\Delta Y_t = c_0 + \Lambda \Delta X_t + \Psi_1 \Delta Z_{t-1} + \Pi_Y Z_{t-1} + \mu_t$$
$$\Delta X_t = a_{x_0} + \Gamma_{x_1} \Delta Z_{t-1} + \varepsilon_{X_t}$$

Where X_t is a subset of structurally exogenous variables (Pesaran, Shin and Smith, 1999).

macro-economic analyses of open small economies, where it is plausible to assume that some variables I(1) force other variables to be treated as exogenous.

By the reading of the graphs in Figure 12, one can detect along the temporal horizon the persistence of the response-to-impulse between Δ(m-p) and Δ(p), giving evidence of a relationship of causality of the inflation rate for real money demand, thus contributing to the explanation of the temporary deviations towards the equilibrium in the long-run. The inflation short-run determiners help to explain the absence of convergence in the short-run of the GIR from real money face its based line. The slowness of the impact after an inflation shock can be explained by the existence of some rigidity in the entrepreneurial mechanism of price fixation, by frictions in the work market, or even by learning processes on the part of the economic agents.

4.4. Decomposition of the variance of the prediction error

In this kind of approach the variance percentage is explained by the different disturbances in the system “s” periods ahead. If the dispersion of the prediction error of any variable is explained by its own disturbances, in high percentages, then we can say it is a highly exogenous variable.

In what concerns the asset’s return outside the monetary aggregate, Δ(r), it is a variable that assumes a high importance in the middle / long-run, which can be explained by the big changes the Portuguese financial market was subject to. We should also refer that the behaviour of the decomposition of the variance of real money demand through the innovations in “r” and “i” is inverse along the time (see respective curves in Figure 13). This outcome seems to indicate that monetary authorities can control this aggregate through the manipulation of interest rates, since their change, though identical, will have in *ceteris paribus* conditions, permanent effects on real money demand.

5. Final remarks

Though we are too aware of the presence of many conditioners to the “ideal” modelling of the phenomenon under analysis, we can conclude there’s a stable money demand function in Portugal in the sample time, according to cointegration methodology. Statistical evidence led to the structural stability of the model, hence real money growth rate can be adequately specified in the short-run through an ECM model, without questioning its predictability.

In the case under observation, we have not observed Fischer strict effect[13], which can be explained by historical inflationism in Portuguese economy and by the non-inclusion of the inflation rate in the cointegration static equation. Likewise, the relationship suggested by the economic theory “Expectation Hypothesis of the Term Structure”[14] (EHTS), which corresponds to the efficient functioning of the financial market, was not verified either. Again we note that the restriction imposed upon MDF cointegration relationship in what concerns the symmetry of interest rates was rejected (i.e., the rate difference produces a negative net effect on the M_2^- monetary aggregate), which can also account for the fact that this aggregate is not clearly legible for the definition of the monetary policy, especially after the 1990’s a decade during which Portugal suffered important changes in the conduction of the monetary policy.

Finally, we should note that the adjustment coefficient facing long-run equilibrium, measured by the error corrector term, is relatively low, thus justifying that the adjustments in the interest variables will only be done slowly as long as money stock variations are understood as permanent, implying a certain gradualism in the realization of the monetary policy in Portugal (which is not contrary to the theoretical approach of *Buffer-Stock* money).

The final outcomes suggest the possibility of further workings on our study, namely the possibility of a subset of variables as integrated of order 2, or as seasonably integrated. It would also be interesting to investigate the concept of “super exogeneity” (of regressors in the face of money), which consists in an extension of the weak exogeneity that includes the structural invariance of the parameters. In order to improve the quality of the estimated model, we could consider the effects of the financial innovations in Portugal, or, in other words, if there is a correlation between real money stock and the developments of the financial innovations, it would be of great interest to endogenise these effects by introducing some additional variables in the model.

[13] Being the Fischer relationship given by: $r_t + \beta(\Delta p_t) = \varepsilon_t$, with $\beta = -1$ and $\varepsilon_t \sim I(0)$. Though there is a cointegration relationship between the interest rates in the long run and the inflation rate, we can’t accept that the coefficients associated to these variables are equal and of opposed sign.

[14] This relationship is specified by $r_t + \beta(i_t) = \varepsilon_t$, with $\beta = -1$ and $\varepsilon_t \sim I(0)$. The inexistence of an equilibrium relationship the two types of interest rates (short / long term) was tested for the present study case.

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APPENDIX I. TABLES

Table 1. Unit Root Tests for first differences of Variables

$(H_0 : \delta = (\rho - 1) = 0$ *versus* $H_1 : \delta = (\rho - 1) < 0)$

Variables	*Lags*	***Test Statistic***	*Critical Value (1%)*	*Critical Value (5%)*	*Critical Value (10%)*	*DW Statistic*
Δ(m-p)	**ADF(1)**					
	(a.)	-1.9467	-4.0836	-3.4696	-3.1615	2.0258
	(b.)	-0.0267	-3.5188	-2.9001	-2.5871	1.9868
	(c.)	2.7778	-2.5937	-1.9446	-1.6180	1.9857
Δy	**ADF(1)**					
	(a.)	-1.5739	-4.0836	-3.4696	-3.1615	2.0201
	(b.)	0.1444	-3.5188	-2.9001	-2.5871	2.0259
	(c.)	4.6507	-2.5937	-1.9446	-1.6180	2.0258
Δr	**ADF(1)**					
	(a.)	-2.1436	-4.0836	-3.4696	-3.1615	2.0268
	(b.)	0.2594	-3.5188	-2.9001	-2.5871	2.0049
	(c.)	-1.1431	-2.5937	-1.9446	-1.6180	2.0471
Δi	**ADF(2)**					
	(a.)	-2.9327	-4.0853	-3.4704	-3.1620	2.1120
	(b.)	-0.7604	-3.5200	-2.9006	-2.5874	2.0525
	(c.)	-1.1431	-2.5941	-1.9447	-1.6180	2.0471

(a.) – Model specification: $\Delta y_t = \delta y_{t-1} + \varepsilon_t$

(b.) – Model specification: $\Delta y_t = \mu + \delta y_{t-1} + \varepsilon_t$

(c.) – Model specification: $\Delta y_t = \mu + \beta t + \delta y_{t-1} + \varepsilon_t$.

Table 2. Johansen Cointegration Test

Trace Test: $TR = LR(r/p) = -2(L_{CR} - L_{SR}) = -T \sum_{i=r+1}^{4} \ln(1 - \hat{\lambda}_i)$

Max-eigenvalue Test: $\hat{\lambda}_{max} = L(r/r+1) = -2[L(r) - L(r+1)] = -T \ln(1 - \hat{\lambda}_{r+1})$

Eigenvalue λ	*Hypothesis* H_0 *vs* H_1	***Trace Statistic***	*Critical Value (5%)*	*Critical Value (1%)*	***Max-Eigen Statistic***	*Critical Value (5%)*	*Critical Value (1%)*
λ_4 =0.0012	$r \leq 3$ vs r=4	0.0894	3.76	6.65	0.0894	3.76	6.65
λ_3 =0.0829	$r \leq 2$ vs $r \geq 3$	6.5871	15.41	20.04	6.4977	14.07	18.63
λ_2 =0.2579	$r \leq 1$ vs $r \geq 2$	28.9576	29.68	35.65	22.3705	20.97	25.52
λ_1 =0.3136	r=0 vs $r \geq 1$	57.1851	47.21	54.46	28.2274	27.07	32.24

Table 3. Test of Granger Causality for the Unrestricted VAR(2)

Dependent Variable: Δ(m-p)		
Exclude	*Test Statistic*	*Critical Value* (5%)
Δ(y)	2.8737	$\chi^2(2)$ =5.992
Δ(r)	3.1655	
Δ(i)	1.1582	
All	8.7662	$\chi^2(6)$ =12.591

Table 4. Residuals Tests of the Error Correction Model (ECM)

Multivariantes Test		
LM Test	*Test Statistic*	*Critical Value* (5%)
LM(1)	24.015	$\chi^2(16) = 26.296$
LM(2)	18.449	
LM(3)	15.797	
Skewness Test	*Test Statistic*	*Critical Value* (5%)
Skewness	13.140	$\chi^2(4) = 9.487$ [(a)]
Kurtosis Test	*Test Statistic*	*Critical Value* (5%)
Kurtosis	56.316	$\chi^2(4) = 9.487$
BJ Test	*Test Statistic*	*Critical Value* (5%)
BJ	69.457	$\chi^2(8) = 15.507$

(a) The critical values at the 2,5% and 1% level of significance was $\chi^2(2) = 11.143$ and $\chi^2(2) = 13.2767$, respectively.

Univariantes Test $\Delta(m\text{-}p)$				
Standard-Error	*Skewness*	*Kurtosis*	*BJ Test*	*Critical Value (5%)*
$\hat{\sigma} = 0.0105$	-0.0782	2.5930	0.5863	$\chi^2(2) = 5.9914$

Table 5. Residuals Tests of the Error Correction Model (ECM)

Test Equation $\Delta(m\text{-}p)$,of the ECM		
ARCH Test	*F-Statistic*	*χ^2- Statistic*
ARCH(2,72)	0.1985	0.4119
ARCH(4,70)	0.1028	0.4401
ARCH(6,69)	0.1587	0.8587
White Test		
W(26)	0.7349	21.390
LM Test (Breusch Godfrey)		
LM(1)	0.0961	0.1076
LM(2)	0.8775	1.9456
LM(4)	0.8581	3.8235
LM(6)	0.8509	5.7151
Q-Statistics Test		
Q(4)	--	2.9413
Q(8)	--	10.131
Q(12)	--	11.626
Jarque-Bera Test		
BJ(2)	--	1.1431

Note: The mayor of the test statistic follows in the limit χ^2 distributions.

Table 6. Chow Breakpoint Test

Breakpoints (structural change)	***Chow Test (F-Statistic)***	***Chow Test (LR Ratio)***
1985:4	**Chow** (7,60)=1.0030	**Chow** (7)=8.1890
1986:2	**Chow** (7,60)=1.0347	**Chow** (7)=8.4339
1991:1	**Chow** (7,60)=2.1998	**Chow** (7)=16.9051
1995:1	**Chow** (7,60)=1.4497	**Chow** (7)=11.5637
1991:1, 1995:1	**Chow** (14,53)=2.0548	**Chow**(14)=32.0860

Table 7. Chow Forecast Test

Period of Prediction	***Chow Test (F-Statistic)***
1985:4 to 1998:4	**Chow** (53,14) =1.1274
1986:2 to 1998:4	**Chow** (51,16) =0.8979
1991:1 to 1998:4	**Chow** (32,35) =0.9697
1995:1 to 1998:4	**Chow** (16,51) =0.7644

APPENDIX II. FIGURES

Figure 1. Representation of the Variables (in levels)

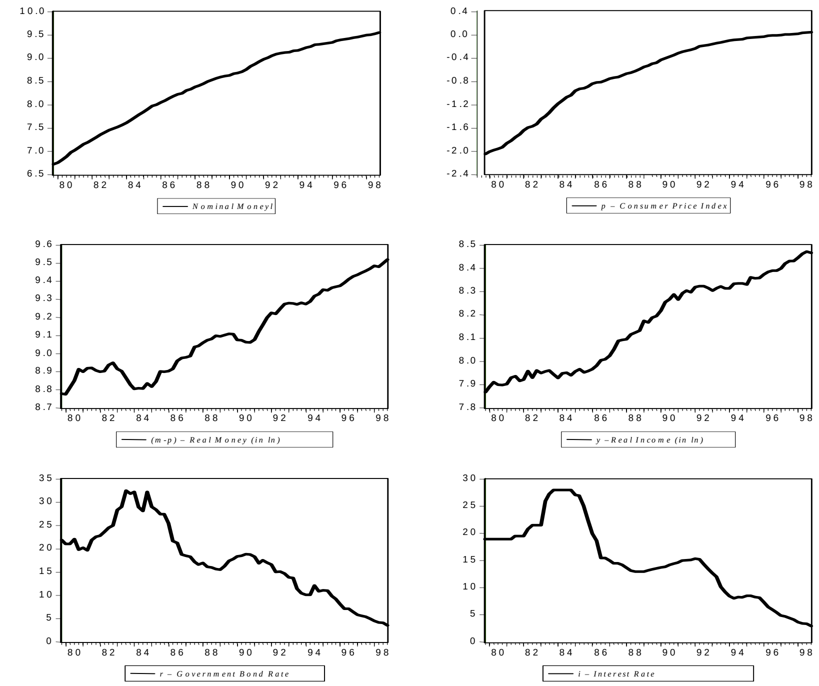


Figure 2. Representation of the First Differences Series

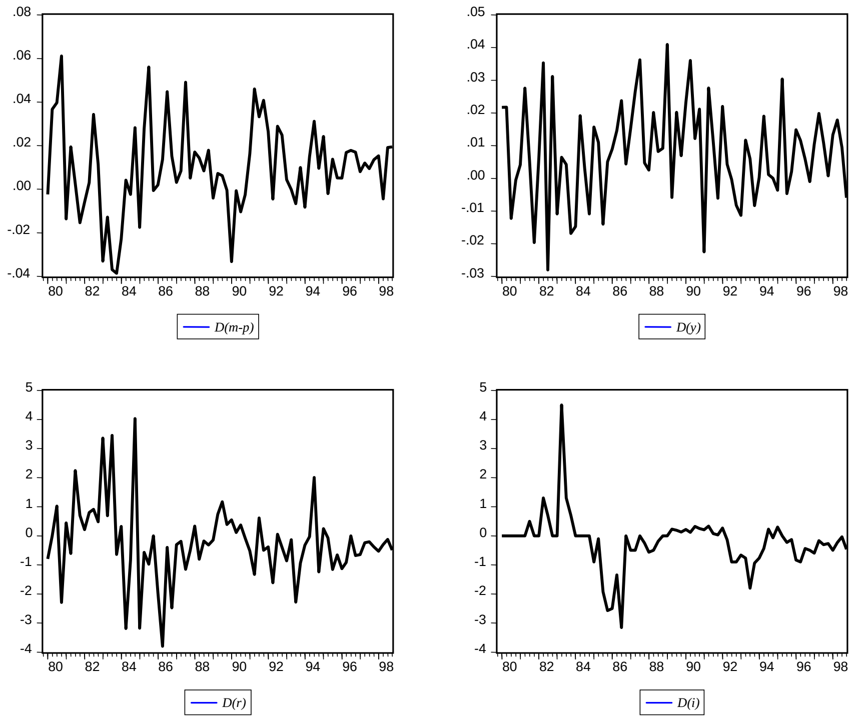


Figure 3. Residuals of the Unrestricted VAR(2)

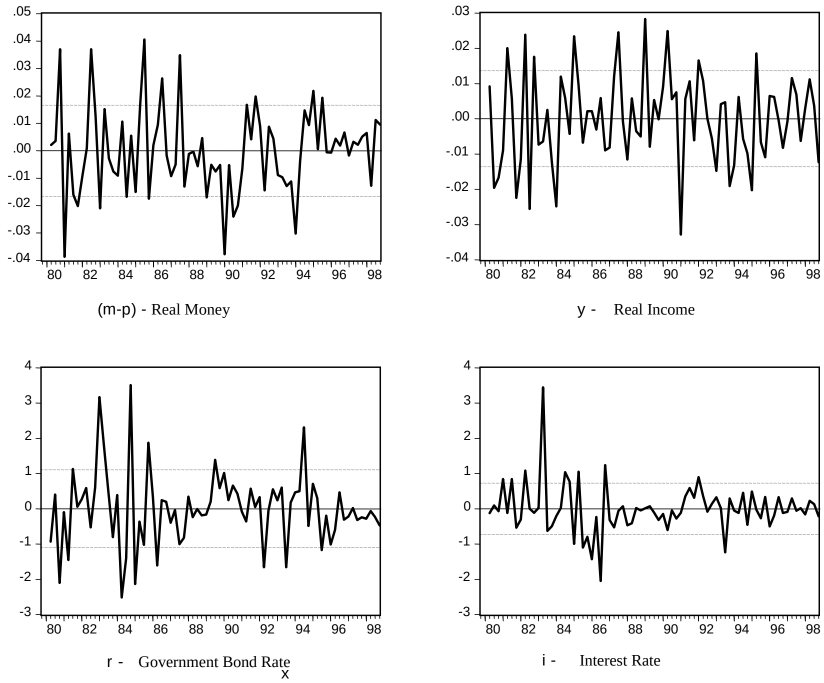


Figure 4. Cointegration Relation ($\hat{z}_t = \hat{\beta}' x_t$)

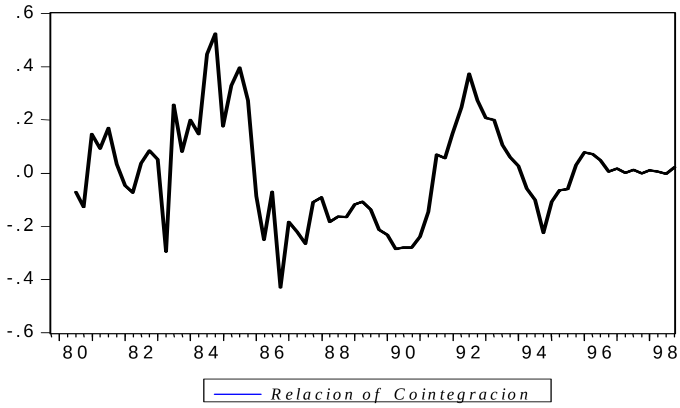


Figure 5. Persistence Profile of the effect of a system-wide shock to CV

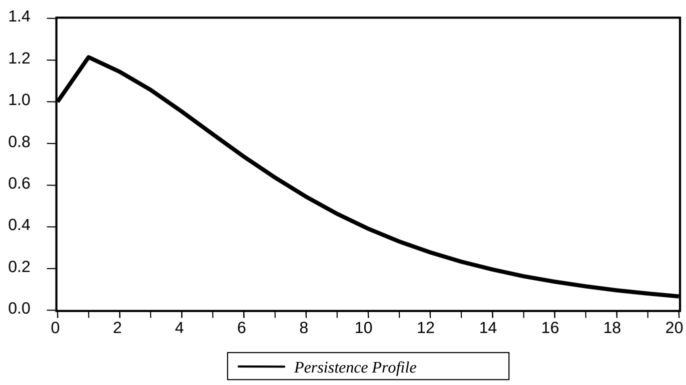


Figure 6. Generalized Impulse Response to one S.E shock in the equation

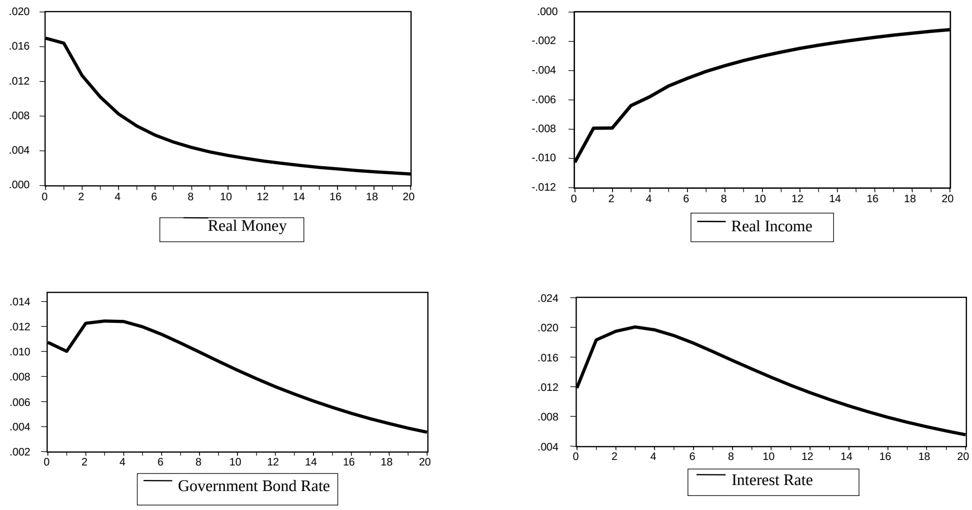


Figure 7. Residuals for the Estimation ECM

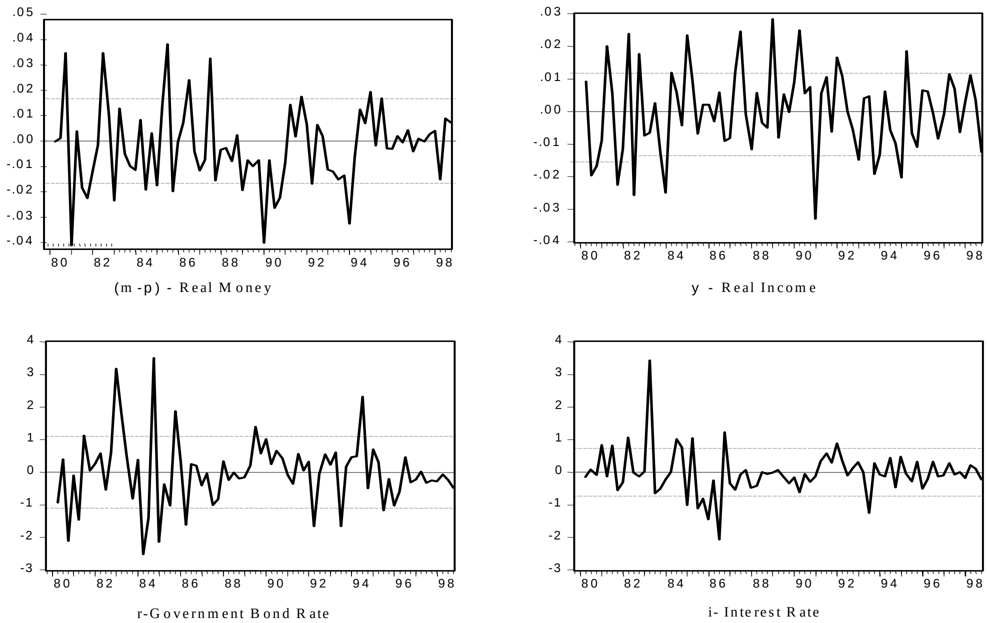


Figure 8. Actual and Fitted values of the variable $\Delta(m\text{-}p)_t$ and Recursive Residuals

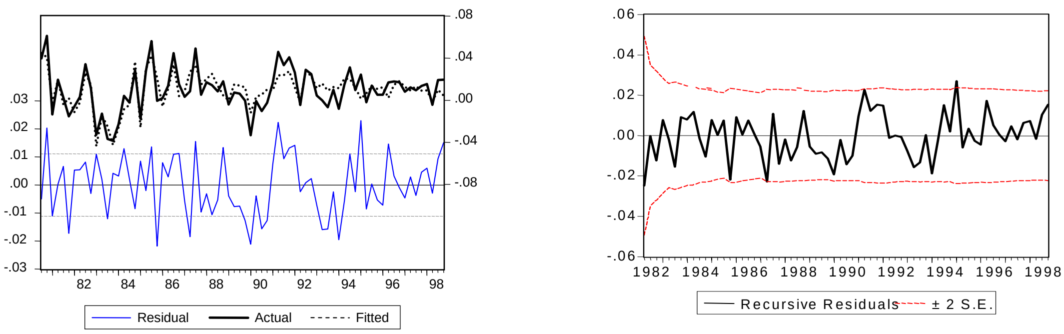


Figure 9. Cumulative sum (CUSUM) of recursive residuals and CUSUMQ of Squares test

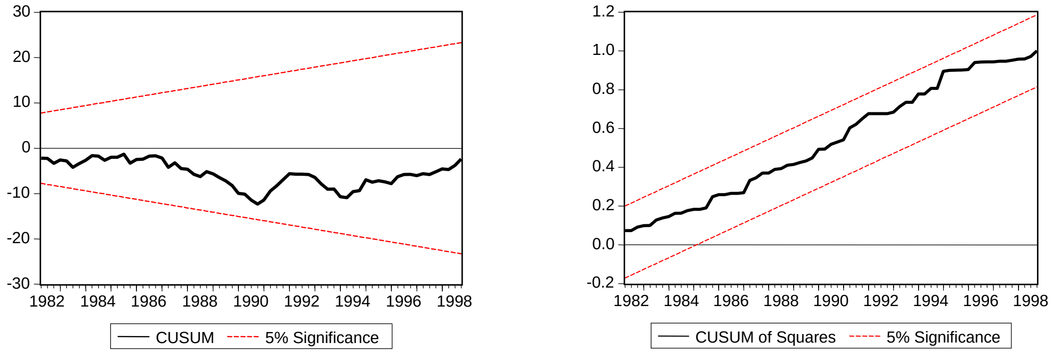


Figure 10. Recursive Coefficient Estimates

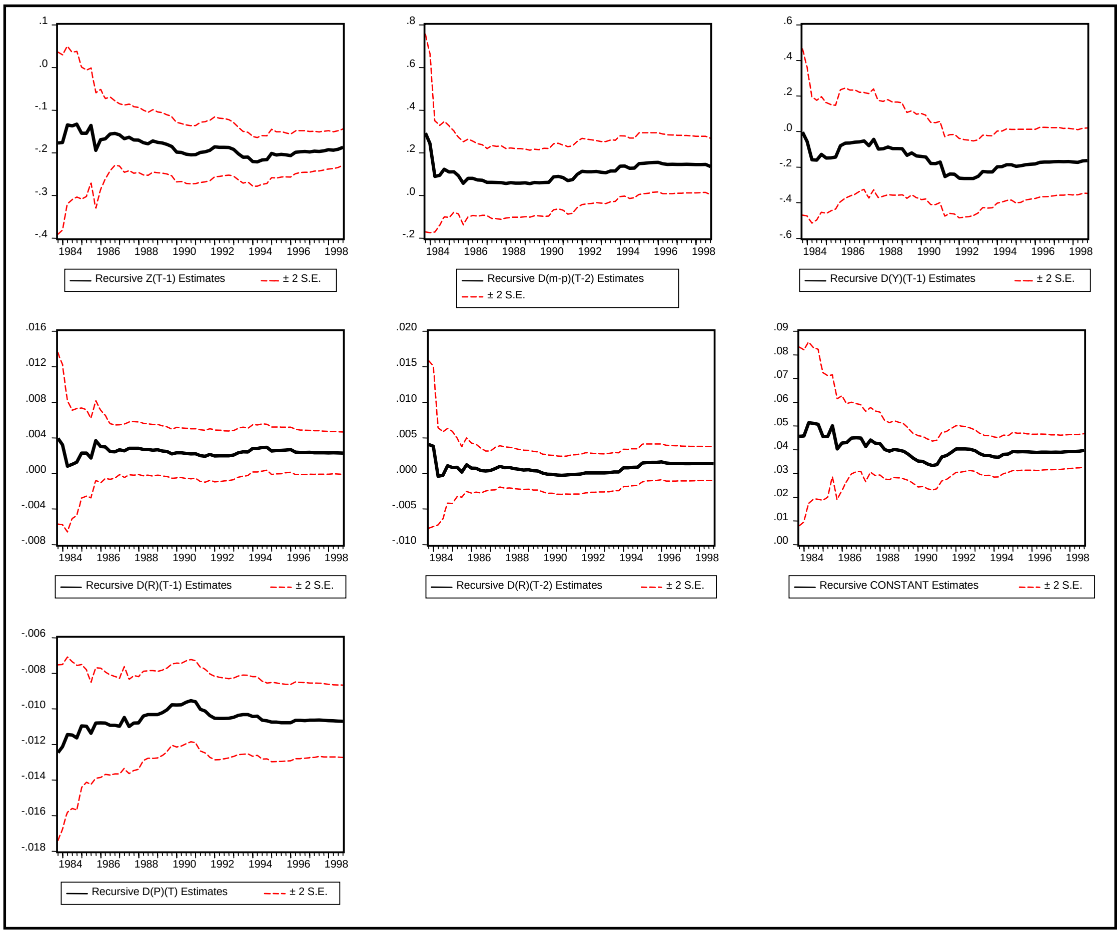


Figure 11. Generalized Impulse Response to one S.E innovations in the ECM

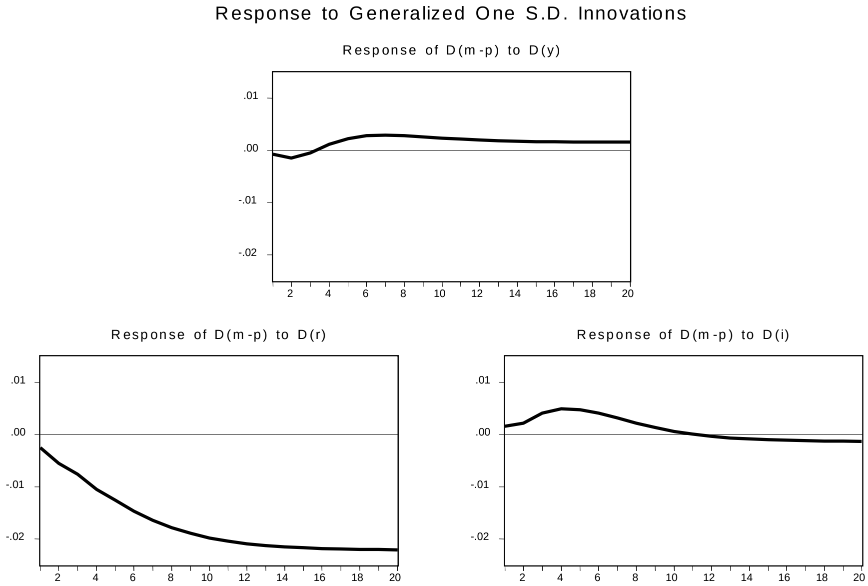
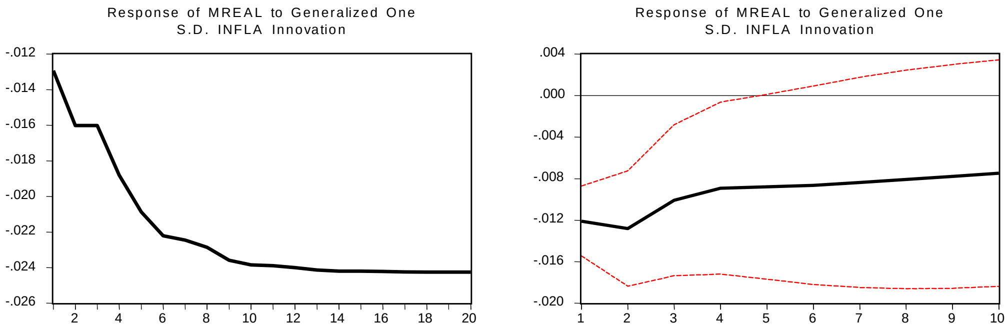


Figure 12. Generalized Impulse Response to one S.E innovations of real money to inflation rate



Restrict VAR (ECM) **Unrestricted VAR**

Figure 13. Variance Decomposition of Real Money