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MONEY DEMAND, PPP AND MACROECONOMIC DYNAMICS IN A SMALL DEVELOPING ECONOMY

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Abstract

This paper aims at improving our understanding of macro-monetary phenomena in developing countries. Specifically, it analyses a six-variable model of the Dominican Republic by implementing the cointegrating VAR framework, using annual data for the period 1950-1999. The inquiry is able to identify money demand and PPP cointegrating relationships that are economically and statistically sensible, displaying half-life persistence profiles of approximately one and three years, respectively. Additionally, generalised impulse response functions observed after shocking the money demand relation suggest that there is scope for activist monetary policy, while those derived from perturbations to PPP show that real exchange rate depreciations generate both contractionary and inflationary developments.

JEL Classification: E41, E52, F41.

Keywords: Cointegrating VAR; Money demand; PPP; Persistence profiles; Generalised impulse responses; Monetary policy; Dominican Republic.

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1. Introduction

The impact of money on real and nominal economic variables has been approached from various perspectives. The vector autoregression (VAR) method popularised by Sims (1980) is arguably the tool macroeconomists employ the most when dealing with such a task. The extensive (mainly) monetary policy VAR literature spurred by Sims' programme is surveyed in Christiano *et al* (1999).

In spite of its pandemic utilisation, the VAR technique is not free of drawbacks. For instance, non-practitioners have labelled the approach atheoretical. Some of the puzzles generated by the literature (e.g. Sims, 1992) have been (partly) attributed to this weakness (e.g. Rudebusch, 1998). The cointegrating VAR (CVAR) approach is a plausible alternative which attempts to circumvent this criticism[1]. CVARs allow an examination of the long *and* short run properties of the statistical information at hand, while enabling economic theory to be incorporated fully in the modelling process. However, the method also demands the researcher's judgement to be exercised at some points. Examples, mainly focused on advanced economies, include King *et al* (1991), Mellander *et al* (1992), Fung and Kasumovich (1998), and Crowder *et al* (1999)[2].

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[1] Another approach, which relies on the implementation of Bayesian methods, is suggested by Leeper *et al* (1996). However, this has been criticised on various grounds, the most significant of which is that it employs a large number of variables to generate its results and this is one of Sims' (1980) main critiques of the structural econometric (simultaneous equations) modelling framework.

[2] Technical surveys of the topic have been written by Watson (1994) and Pesaran and Smith (1998) *inter alia*.

Although various studies have attempted to add to our understanding of macroeconomic fluctuations in developing countries through the application of the traditional VAR approach (e.g. Leiderman, 1984; Reinhart and Reinhart, 1991; and Kamas, 1995), they have not explicitly dealt with the task of identifying the long run properties of the system at hand. However, this is crucial if sensible conclusions are to be derived from the subsequent dynamic analyses - such as impulse responses - of the model under scrutiny.

This paper addresses this issue by investigating the properties of a compact macro-monetary model of a small developing economy, namely the Dominican Republic (DR), using the CVAR methodology. To the best of the author's knowledge, this paper is the first time that such an approach has been applied in the 'Development Macroeconomics' literature.

The paper tackles a series of questions:

(1) Are standard, textbook, cointegrating economic relations identifiable in a compact set of DR macroeconomic variables?

(2) If so, how quick do these relations achieve their long run equilibrium levels after being hit by a system-wide perturbation?

(3) Furthermore, what are the trajectories followed by the individual variables in the system after a shock to a specific equation's residuals?

(4) Are the estimated outcomes economically sensible?

(5) What are the implications for monetary policymaking in the DR?

These issues are addressed in the remaining sections. Section 2 elucidates the theoretical aspects of the economic relations involved in the study. In section 3 the nature of the data is explained, and its integration and cointegration properties are ascertained. The model's underlying dynamic properties are dissected in section 4. Section 5 provides concluding remarks.

2. Economic Background

Economic theory frequently suggests that certain variables enjoy a long-run relationship, i.e. are cointegrated, often with specific coefficient values. Examples of such relations are money demand, purchasing parity power (PPP), uncovered interest parity (UIP), and the Fisher equation[3]. For instance, in a vector X containing real money, real income, an exchange rate, a foreign interest rate, and domestic and foreign prices at least a money demand and a PPP relation could be expected to hold[4].

The absolute PPP hypothesis (see Froot and Rogoff, 1995) states that the exchange rate between the currencies of two countries should equal the ratio of their price levels. In equation (log) form:

$$e_t = \lambda p_t^{\ D} + \eta p_t^{\ F} + \xi_{1t}, \qquad (1)$$

where e_t is the nominal exchange rate measured in units of home currency per units of foreign currency, and $p_t^{\ D}$ and $p_t^{\ F}$ are the domestic and foreign price levels, respectively. More precisely, economic theory predicts that $\lambda = 1$ and $\eta = -\lambda$, which amounts to the well-

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[3] The empirical evidence on these relationships is substantial. Examples of recent money demand studies are those of Hoffman *et al* (1995), and Muscatelli and Spinelli (2000). For evidence and controversies surrounding the empirical aspects of the PPP relation, see Froot and Rogoff (1995), and the references therein. Edwards and Savastano (1999) survey the PPP literature for emerging market economies. An example of the quantitative assessment of the Fisher relation is Mishkin (1992).

[4] See Crowder *et al* (1999) for a similar intuition.

known hypotheses of the symmetry and proportionality of the impact of domestic and foreign prices on the nominal exchange rate.

A simple, textbook, money demand relationship (e.g. Lucas, 1988) relating real monetary balances to a scale variable and a measure of the opportunity cost of holding money can be expressed as:

$$(m-p)_t = \Phi y_t + \varphi R_t + \xi_{2t}, \qquad (2)$$

where φ is the interest semi-elasticity and Φ is the income elasticity of real money balances. In equation (2), φ is expected to be negative, while Φ should lie in the vicinity of unity, although some studies (e.g. Baba *et al*, 1992) report an elasticity of half, as predicted by the Baumol-Tobin transactions demand approach. If in (1) and (2) the error terms are stationary, the relations are confirmed to be long-run equilibrium relationships.

3. Empirical Modelling

The analysis of the system $X = \left((m-p)_t, y_t, R_t^*, e_t, p_t^D, p_t^F\right)'$ involves several stages:

1. Unit root testing: determining the order of integration of the variables to be analysed, mainly by applying the standard augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979) unit root test.

2. Order of the VAR: selecting the lag length of the VAR model to be estimated.

3. Cointegration analysis: estimating an unrestricted VAR model using Johansen's (1988) approach to determine the cointegration rank (r) of the system.

4. Identification: imposing and testing the just-identifying and over-identifying restrictions on the cointegration space, as dictated by the economic relationships described in section 2.

5. Persistence profiles: analysing the fashion in which the cointegrating vectors (CVs) adjust to their equilibrium levels (Lee and Pesaran, 1993).

6. Generalised impulse response analysis: exploring the impact of shocks to specific equations on each of the variables in the system (Koop *et al*, 1996; Pesaran and Shin, 1998).

Each of the above phases is considered sequentially in the analysis presented below.

3.1. Data

The paper examines annual data for 1950 to 1999, thus encompassing the DR's macroeconomic developments during the second half of the 20th century. The time series were obtained from various volumes of the International Monetary Fund's *International Financial Statistics Yearbooks*. The line numbers corresponding to each of the series are displayed in parentheses.

The mnemonics for the statistical data to be used in the empirical exercises are as follows: $(m-p)$ are real money balances, where m is the log of nominal M_1 (*line 34*), and p is the log of the GDP deflator (*line 99bip*); y is the log of real GDP (*line 99b* divided by *line 99bip*); R^* is a measure of the foreign interest rate given by the yield from long-term US government bonds (*line 61*), which is a proxy for the domestic opportunity cost of holding money[5]; e is the log of the nominal parallel (black) market exchange (sell) rate (obtained from the CBDR)[6]; p^D and p^F are the logs of the domestic and foreign price levels,

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[5] The justification for using this series is that the Central Bank of the Dominican Republic (CBDR) imposed a legal ceiling on the level of interest rates until the beginning of the 1990s (i.e. financial repression policies were in place). Additionally, a consistent time series of a suitable indicator of the domestic opportunity cost of holding money is not readily available for the complete sample period under analysis.

[6] Even though the DR's foreign exchange market has historically been a multiple one, the parallel (or black) market is the most important. At present, the system is composed of the official, banking system, and the extra-banking system (parallel-black) exchange rate markets. Currently, nearly 15% of the total volume of foreign exchange transactions are subject to CBDR surrender requirements, while the rest take place in the private (banking and parallel) markets (see Young *et al*, 1999).

respectively; p^D is approximated by the DR's consumer price index (*line 64*), while p^F is proxied by the US wholesale price index (WPI) (*line 63*), in the light of the fact that the US is the DR's main trading partner. The use of the WPI in this type of exercise is standard in the literature, and is based on the fact that such a variable provides a more accurate measure of the prices of traded goods. For the DR no WPI-type index is available, so the CPI is employed.

Original values of money and income are expressed in millions of Dominican Republic Pesos (DR$); R^* is given in percentage points; and e is the DR$ price of the US dollar (DR$/US$), so that an increase (decrease) in e indicates a depreciation (appreciation) of the domestic price of foreign currency. Finally, p, p^D, and p^F are indices with 1995 = 100. Figures 1 to 3 display the univariate characteristics of the six series to be investigated below. All of them show a clear trending, or integrated, pattern.

The first step in the econometric analysis is to ascertain the order of integration of the variables to be considered, given that the CVAR technique pre-supposes that these are a set of $I(1)$ sequences. The standard procedure is to implement the augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979) test and the results of so doing are reported in Table 1. All the series appear to contain a unit root in their levels, i.e. they are $I(1)$. Their first differences, however, seem to be $I(0)$. The only exception is the variable Δp^D (Δ is the difference operator). However, the results of applying the Phillips–Perron (PP) (Phillips and Perron,

1988) test indicates that inflation is indeed stationary[7]. Figure 4 exhibits the behaviour of Δp^D. Non-stationarity does not appear to be an inherent property of the series during the time span under consideration. Henceforth, the analyses to be developed below will treat $X = \left((m-p)_t, y_t, R_t^*, e_t, p_t^D, p_t^F\right)'$ as a set of $I(1)$ observations.

3.2. Long-run Modelling

The Johansen (1988) technique is used for the cointegration analysis. The estimation method proposed by Johansen is based on the error correction representation of the VAR(p) model (in difference form):

$$\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \ldots + \Gamma_{p-1} \Delta X_{t-p+1} + \Pi X_{t-p} + \Omega Z_t + \varepsilon_t \quad (3)$$

where X_t is an $m \times 1$ vector of $I(1)$ variables, Z_t is an $s \times 1$ vector of $I(0)$ variables (which can include seasonal dummies or innovations in variables that are exogenous to the VAR under analysis), $\Gamma_1, \Gamma_2, \ldots, \Gamma_{p-1}, \Pi$ are $m \times m$ matrices of unknown coefficients, Ω is an $m \times s$ matrix, and $\varepsilon_t \sim N(0, \sigma^2)$. The estimation of (3) is subject to the hypothesis that Π has a reduced rank, $r \prec m$, which can be written as:

$$H(r) : \Pi = \alpha\beta'. \quad (4)$$

The reduced rank condition (4) implies that the process ΔX_t is stationary, X_t is non-stationary, and $\beta' X_t$ is stationary. The stationary relations are referred to as the cointegrating relations.

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[7] The PP test statistic is the t-ratio of ϕ, in a Dickey-Fuller equation of the form $\Delta y_t = \alpha + \phi y_{t-1} + \delta t + \varepsilon_t$, computing using its Newey-West standard error. For Δp^D the PP test is -3.6055 (for 1952-1999), which has a corresponding 95% critical value of -2.9241.

The application of Johansen's cointegration technique generates two likelihood tests, known as the maximal eigenvalue and the trace tests, to determine the number of cointegrating vectors. The rank of a given matrix Π, which 'statistically' determines the number of cointegrating vectors (r), is established using the eigenvalues in the maximum eigenvalue and trace tests. Note that the identification of a particular system can be ascertained by imposing r^2 (non-testable) identifying restrictions, and (if needed) further (testable) over-identifying restrictions, preferably suggested by economic theory (see Pesaran and Shin, 1999).

In order to establish the lag length to be used in the cointegration analysis of the vector $\mathrm{X} = \left((m-p)_t, y_t, R_t^*, e_t, p_t^D, p_t^F\right)'$ the Akaike (AIC) and Schwarz Bayesian (SBC) information criteria were employed. A lag length of up to three was initially considered. The AIC test supported two lags as optimal, whereas the SBC endorsed one. Since it is known that the SBC consistently estimates the true but unknown lag length, and in light of the fact that for the ADF analysis reported in Table 1 one lag proved to be sufficient, it seems reasonable to undertake the analysis using a lag length of one.

The outcome of applying Johansen's (1988) cointegration test is displayed in Table 2. Both the maximum eigenvalue and the trace tests strongly reject the null hypothesis of no cointegrating vectors $(r = 0)$ at the 95% level of significance. Moreover, they point to the fact that there could be up to three cointegrating vectors in the VAR under consideration. However, previous empirical evidence for the DR (see Sánchez-Fung, 1999; Carruth and Sánchez-Fung, 2000), and the arguments elaborated above, point to the likely existence of two equilibrium relationships amongst the variables under scrutiny: a PPP equation and a money demand function. Thus it is assumed that two cointegrating vectors are contained in the system[8].

The next step is to impose two just-identifying restrictions on each cointegrating vector (a total of four), and a further seven over-identifying restrictions on the system. In matrix notation the coefficients of the restricted cointegrating relations can be expressed as[9,10]:

$$\beta = \begin{pmatrix} \mathbf{0} & -1 \\ 0 & \mathbf{1} \\ 0 & \varphi \\ \alpha & 0 \\ \lambda & \mathbf{0} \\ \mathbf{1} & 0 \\ 0 & 0 \end{pmatrix}. \tag{5}$$

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[8] Nevertheless, it was found that a cointegrating space in which three vectors exist generate PPP and money demand equations that are similar to those described below for the case of two equilibrium relationships. Regrettably, an economically sensible explanation of the third vector could not be achieved.

[9] The final system is achieved after gradually imposing a total of seven over-identifying restrictions in addition to the four just-identifying restrictions on Johansen's test results (this exercise involved experimenting with several alternative restrictions). The four just-identifying restrictions (shown in bold in equation (5)) restricted the coefficient of real money balances to zero, and that of foreign prices to unity in the first (PPP) vector. In the second vector (money demand) the coefficient of real output was restricted to unity, and a zero restriction on domestic prices was imposed. The seven over-identifying restrictions imply that real income and the interest rate do not enter the PPP equation. Additionally, the exchange rate and foreign prices were excluded from the second vector, while the coefficient of real money was restricted to minus one in the money demand equation. Note that the system has also been restricted to not having linear trends, which implies that the cointegrating relations are co-trending.

[10] The PPP hypotheses of symmetry and proportionality were tested, but were rejected. The analysis amounts to a *trivariate stage-three cointegration PPP test* (see Froot and Rogoff, 1995). Nevertheless, an investigation of the system's dynamics assuming that symmetry and proportionality hold generated results identical to those presented below. These simulations are available from the author upon request. Alternative specifications also considered the inclusion of constant terms, which are crucial for determining which type of PPP is being analysed. However, these were not statistically significant.

In (5) the first column corresponds to the PPP relation and the second to the money demand equation. Re-writing equations (1) and (2), as implied by (5), yields:

$$\alpha e_t + \lambda p_t^{\ D} + p_t^{\ F} = \xi_{1t}\,, \tag{1a}$$

$$-(m-p)_t + y_t + \varphi R_t = \xi_{2t}\,. \tag{2a}$$

Table 3 presents the results of the restricted cointegration exercise. The seven over-identifying restrictions cannot be rejected by the value of the χ^2 distributed likelihood ratio test reported in the lower part of that Table. Furthermore, all the estimated coefficients are statistically significant.

The normalised cointegrating relations are also displayed in Table 3. Both vectors are consistent with the frameworks expounded in section 2. For the PPP equation, domestic prices are estimated to have a positive impact on the exchange rate, entering with a coefficient close to 0.9. In contrast, foreign prices are found to negatively affect the exchange rate, albeit with a lower coefficient of just over 0.7. In the money demand relation, as well as a unitary income elasticity, we obtain an interest semi-elasticity of -0.04.

The identification of the two long run relations achieved so far is an important step. The literature on money demand and PPP reveals that the empirical analysis of both PPP and money demands has proved to be a difficult task for economists[11]. Both concepts as cornerstones in theoretical modelling, and in the design and implementation of economic policies. The dynamic properties of these relations are investigated below.

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[11] Notably, see Edwards and Savastano (1999) on PPP studies for developing economies.

4. Dynamics

4.1 Persistence Profiles

The dynamic analysis begins by displaying the way in which the money demand and PPP cointegrating vectors (CVs) identified above adjust to their equilibrium levels. The basic tool employed for this purpose is the persistence profiles of the CVs after being hit by a system-wide shock (Lee and Pesaran, 1993)[12]. The outcome of the persistence profile analysis is very similar to that of comparable investigations for advanced economies (e.g. Pesaran and Shin, 1996; Cheung and Lai, 2000). The present study finds that the persistence profile of the PPP cointegrating vector converges rather slowly to its long-run equilibrium level after being perturbed by a system-wide shock[13]. Specifically, around 90% of a PPP disequilibrium is made up, on average, within five years. Such behaviour can be discerned clearly from Figure 5. There are numerous economic reasons to expect that a PPP relation would require a considerable amount of time to return to equilibrium after being ruffled. Factors such as 'news', incomplete information, barriers to foreign trade, and productivity differentials (as in Balassa-Samuelson) can all lead to slow adjustment.

In contrast, the persistence profile of the money demand equation suggests that this relation reaches equilibrium relatively quickly, doing so almost completely (91%) within one year. Figure 5 provides visual evidence on the matter. The pattern revealed is precisely what could, in principle, be expected to happen in a money market: economic agents will try to expeditiously correct any monetary imbalances they might experience. This is more likely to be the case in the DR economy, which has an underdeveloped banking and financial system.

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[12] Specifically, the shocks consist of innovations to the distribution of the system's disturbances.

[13] Pesaran and Shin, for example, report that the PPP relation for the UK takes over five years to adjust to its long-run equilibrium level.

Furthermore, these findings are in harmony with the estimated lagged equilibrium correction term (ECM_{t-1}) coefficient of -0.718 obtained for the DR's short-run money demand equation analysed in Carruth and Sánchez-Fung (2000)[14].

4.2. Generalised Impulse Responses of Variables to Shocks affecting Money Demand and PP

We now proceed to examine the dynamic characteristics of the system under scrutiny, specifically by exploiting the generalised impulse response (GIR) technique. Why are GIRs useful in the analysis of a CVAR model? Impulse responses aid in visually determining the impact through time of a one-off shock to a given variable on a system, other variables, or itself. Koop *et al* (1996) and Pesaran and Shin (1998) show that GIRs are more convenient than the widely used orthogonalised approach to impulse responses championed by Sims (1980) because, in contrast to the orthogonalised impulse responses, the results obtained from the generalised ones are invariant to the ordering of the variables in the VAR.

The GIRs are calculated for a 15-year horizon, and are expressed as percent deviations (given that the logs of the variables are analysed). Figure 6 exhibits the impact of a one standard error perturbation to the equation for real money demand. Such an innovation can, in principle, be interpreted as a monetary policy shock, which, in the DR, is conducted by the CBDR[15]. Although it is difficult for the CBDR to directly control $M1$ (which is the aggregate considered in the money demand equation), it is reasonable to think that the monetary authorities target it through manipulations of the monetary base. This latter variable is the

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[14] The results also implicitly rule out the relevance of critical issues such as financial innovation in modelling the aggregate money demand equation (e.g. Arrau *et al*, 1995) for the case at hand.

[15] The CBDR and the Dominican Peso (DR$) were created in 1947.

most likely (primary) demand management instrument to be used by such authorities in a developing country, which is expected to be linked to $M1$ through the money multiplier. Therefore, $M1$ could be seen as an *intermediate target*, or information variable, of the central bank (see Friedman, 1990).

As can be expected, shocks to the equation for real money balances have a positive impact on prices and the exchange rate of up to 7% and 8%, respectively, within the time horizon considered. In contrast, real money initially overshoots just above 10%, decreasing below, and staying at, around 3.6% after approximately two years. Interestingly, shocks to real money seem to positively affect aggregate economic activity, generating an increase in real output of roughly 2.5%. Thus, assuming that the Lucas critique does not apply, there appears to be an opportunity for activist monetary policy in the DR, at least in the short run.

The dynamics generated after shocking the exchange rate equation are the most interesting given its pivotal role in the transmission of macroeconomic impulses in a small, open, economy like the DR[16]. Under adverse circumstances (e.g. bubbles, speculative attacks, or other non-real elements), the monetary authorities could and would probably attempt to influence the short-run development of the exchange rate with the intention of maintaining a 'healthy' foreign exchange environment. Consequently, the system's evolution after a shock to the equation for the exchange rate is critical for monetary policy makers.

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[16] Note that a shock to the disturbance of the equation for e is equivalent to a shock to the 'real exchange rate'. The importance of the exchange rate can be perceived from Figure 3. The domestic price level is virtually constant up until the end of the 1960s, but after the Dominican Peso started to depreciate at around that time, domestic prices accelerated. These developments are reflected in the inflation rate, which is displayed in Figure 4.

Figure 7 reveals that an innovation (depreciation) of the exchange rate has a negative impact on real money balances and on real output. The former very likely arises due to an underlying currency substitution effect. The permanent negative effect on real output, of just over 3%, could be interpreted as the result of an adverse aggregate supply shock. Such an outcome is sensible, chiefly due to the high dependence of the DR economy on imported inputs. In contrast, the impulse responses of the exchange rate and of domestic prices display increasing paths, reaching almost 28% and 30%, respectively, after 15 years. It transpires that shocks to the exchange rate play a paramount role in the dynamics of the DR's macroeconomy.

Based on the above outcomes, the transmission mechanism of impulses from the exchange rate to the macroeconomy could be symbolically expressed as

$$e \uparrow \rightarrow p^D \uparrow \rightarrow y \downarrow \rightarrow (m - p) \downarrow . \tag{6}$$

The variables in (6) are as described above. The message of (6) is that a positive innovation ($\uparrow$) to e (a depreciation) leads to ($\rightarrow$) an (apparently quick) increase in domestic prices, a *pass-through effect*, which subsequently depresses ($\downarrow$) economic activity, and therefore the demand for real money balances. However, as noted before, there could also be a direct link between $e(\uparrow)$ and $(m - p)(\downarrow)$, i.e. a currency substitution effect.

An additional factor that might be playing a considerable role after a shock to the exchange rate is 'country risk'. In a small open economy, the domestic interest rate (not explicitly modelled here) will probably increase if economic agents have uncertainty about whether or not the domestic currency will continue to depreciate, *à la* Dornbusch (1976). Given the precarious nature of the DR's financial system, such developments could lead to a credit crunch in most sectors of the economy. The effect could also work its way through the system by affecting the balance sheets of firms that have borrowed in foreign currency.

Several empirical studies have found a similar response of the macroeconomy after shocks to the exchange rate (see Kamin and Rogers, 2000, and the references therein). The results obtained in this study do not, however, imply that devaluations are always and everywhere a contractionary and inflationary phenomenon. These findings certainly do, however, raise important issues for monetary policymakers in the DR and similar economies.

Finally, it is worth noting that the impulse responses analysed above generate economically sensible patterns. This provides a further, implicit, validation of the identifying restrictions that were imposed on the system in section 3.

5. Concluding Remarks

Various investigations have attempted to clarify our understanding of macroeconomic fluctuations in developing countries through the application of the vector autoregression (VAR) approach. However, the fashion in which these exercises have dealt with the consequential problem of identification has been rather dubious. This paper tackles this issue by investigating the long run and dynamic properties of a compact macro-monetary model of the Dominican Republic's economy utilising the cointegrating VAR framework.

In a system composed of real money, real output, a nominal exchange rate, a foreign interest rate, and domestic and foreign prices, we are able to identify PPP and money demand cointegrating vectors. The persistence profile of the PPP cointegrating vector is similar (in that it adjusts to equilibrium slowly) to that of previous studies (e.g. Pesaran and Shin's, 1996, analysis of the UK). The money demand equation, in contrast, swiftly converges to its long-run equilibrium, as could be expected.

The paper also analyses the impact of equation-specific shocks on the development of the variables considered in the model. The results of these exercises suggest that (a) there is scope for activist monetary policy, and that (b) perturbations to the real exchange rate have contractionary and inflationary consequences (see Kamin and Rogers, 2000). The latter finding is particularly critical for the design and implementation of monetary policy due to the central role played by the exchange rate in the transmission mechanism of macroeconomic shocks, not only in the DR, but also in similar economies. For instance, policies of targeting the exchange rate implemented by central banks, which have been a widespread practice, should try to prevent it from achieving an excessively devalued level. Conversely, attempting to keep an overvalued currency could also hinder economic activity. The results also have repercussions for the trade-offs that policymakers face in the design of certain macroeconomic stabilisation packages, e.g. exchange rate based adjustment programmes.

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Table 1

Augmented Dickey-Fuller (ADF) unit root test

Variables (levels)	ADF test statistic 1952-1999	Variables (first differences)	ADF test statistic 1953-1999
$(m-p)$	-3.0339	$\Delta(m-p)$	-6.0595
y	-1.8077	Δy	-4.7913
R^*	-1.2245	ΔR^*	-5.3402
e	-1.3265	Δe	-3.5186
p^D	-1.9361	Δp^D	-2.8524
p^F	-2.6843	Δp^F	-3.3666

Notes:

The ADF test is based on a regression of the form $\Delta y_t = \alpha + \phi y_{t-1} + \sum_{i=1}^{T} \Theta \Delta y_{t-i} + \delta t + \varepsilon_t$, where ε_t is a random error term, and α and t are a constant and time trend, respectively. The ADF test corresponds to the value of the t-ratio of the coefficient ϕ. The null hypothesis of the ADF test is that y_t is a non-stationary series, which is rejected when ϕ is significantly negative. If $i = 0$ the test is the Dickey-Fuller (DF). Adding one lag to the ADF equation proved to be adequate for all the series under consideration. A constant and time trend were included when the test was applied to the levels, while for the corresponding first differences only a constant was considered. The critical values at the 95% level are -3.5045 and -2.9241 for the levels and the first differences, respectively.

Table 2

Johansen's maximum likelihood cointegration test, 1951-1999

System: $X = \left((m-p), y, R^*, e, p^D, p^F\right)'$			
I Cointegrating vectors			
Variable	Vector 1	Vector 2	Vector 3
$(m-p)$	-0.0034	-1.4518	0.6310
y	-0.0892	2.4234	0.5085
R^*	0.0006	-0.0369	0.0674
e	-0.9596	0.4218	-0.1965
p^D	0.8236	-0.3398	0.2395
p^F	-0.6793	-0.2978	-0.7413
trend	0.0042	-0.0232	-0.0412
List of Eigenvalues	(0.84226, 0.53041, 0.47802, 0.33871, 0.15421, 0.06066)		

Hypotheses: Null:	Alternative:	Test statistic:	Critical values: 95%	90%
II Cointegration Tests				
Maximal eigenvalue test				
$r = 0$	$r = 1$	90.49	43.61	40.76
$r = 1$	$r = 2$	37.04	37.86	35.04
$r = 2$	$r = 3$	31.86	31.79	29.13
Trace test				
$r = 0$	$r > 0$	190.93	115.85	110.60
$r \leq 1$	$r > 1$	100.43	87.17	82.88
$r \leq 2$	$r > 2$	63.39	63.00	59.16

Notes:

Johansen's (1988) cointegration methodology generates two likelihood tests, known as the maximal eigenvalue and the trace tests, to determine the number of cointegrating vectors (r). One lag and a time trend were included in the VARs. In order to establish the lag length of the vector the Akaike (AIC) and Schwarz Bayesian (SBC) information criteria were employed.

Table 3

Restricted cointegrating relations, 1951-1999

System: $X = ((m-p), y, R^*, e, p^D, p^F)'$		
I Cointegrating vectors		
Variables	Vector 1	Vector 2
$(m-p)$	0.00	-1.00
y	0.00	1.00
R^*	0.00	-0.037 (0.009)
e	1.394 (0.099)	0.00
p^D	-1.199 (0.063)	0.00
p^F	1.00	0.00
trend	0.00	0.00
II Normalised vectors		
Vector 1 (PPP): $e = 0.86 p^D - 0.72 p^F$.		
Vector 2 (Money demand): $(m-p) = y - 0.04R^*$.		
III Test of restrictions		
LR(7): 6.0099 [0.539].		

Notes:
The asymptotic standard errors of the unrestricted coefficients are given inside parentheses. The likelihood ratio (LR) statistic is χ^2 distributed, and tests the null hypothesis that the joint restrictions imposed on the cointegrating vectors are valid; the probability value is inside [ ]. The degree of freedom of such test, shown in parentheses, is equal to $k - r^2$, with k denoting the total number of restrictions (11), and r^2 the number of just-identifying (non-testable) restrictions (4). Note that the system has been restricted to not having a linear trend, which implies that the cointegrating relations are co-trending.

Figure 1 Real Money and Real Income, 1950-1999

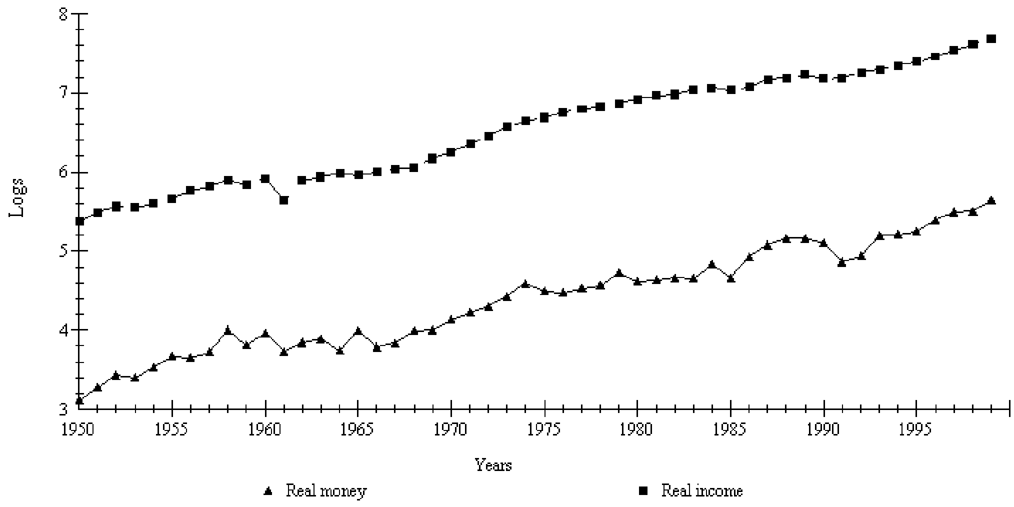

Figure 2 US Long-term Government Bond Yield, 1950-1999

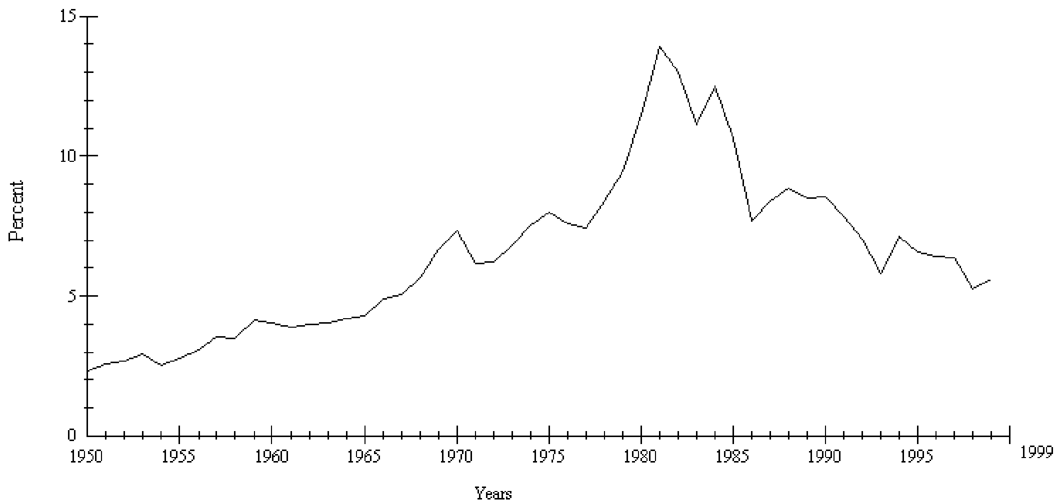

Figure 3 Exchange rate, Domestic and Foreign (US) prices, 1950-1999

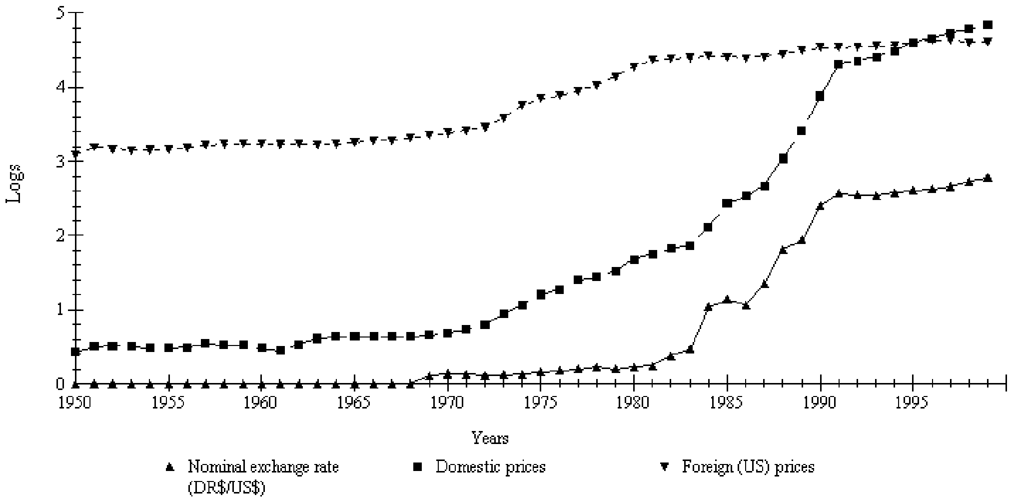

Figure 4 Inflation, 1951-1999

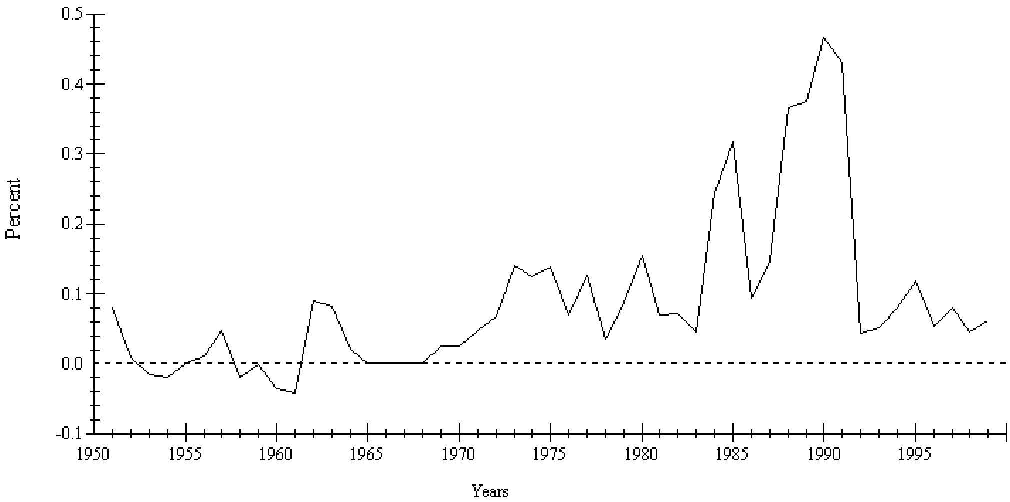

Figure 5 Persistence Profiles of the Effect of a System-wide Shock to CVs

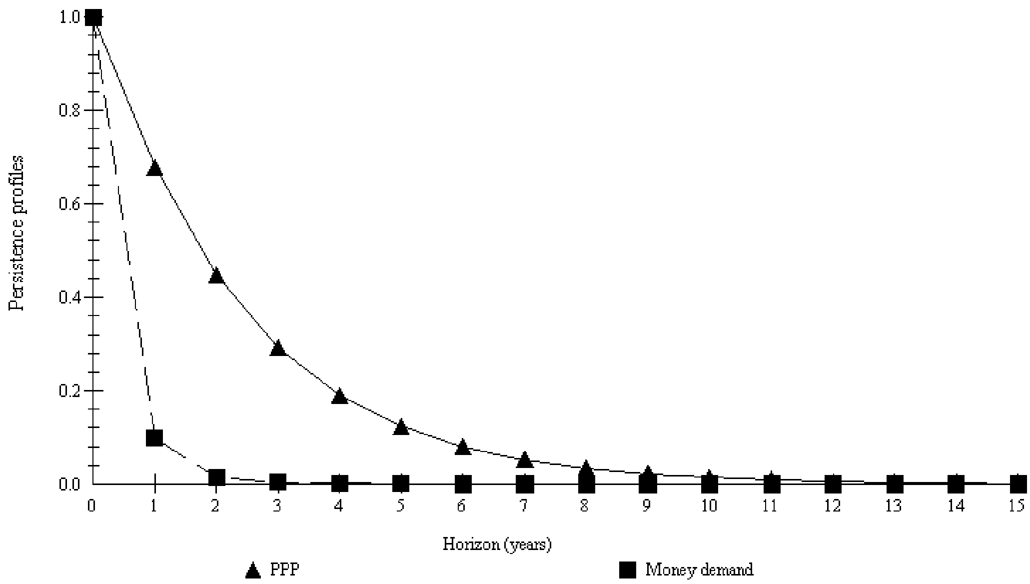

Figure 6 GIRs to One S.E. Shock in the Equation for Real Money

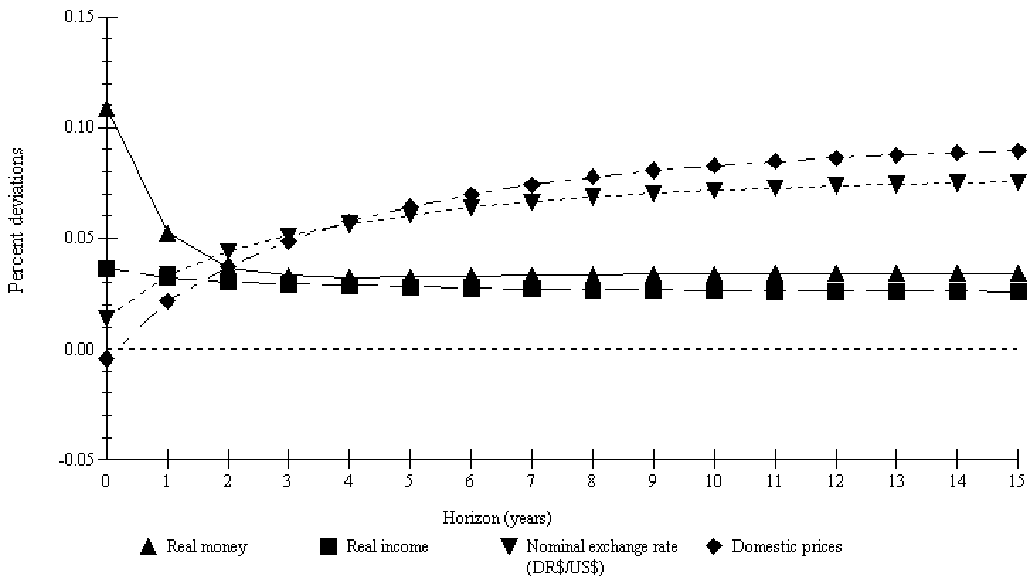

Figure 7 GIRs to One S.E. Shock in the Equation for the Exchange Rate