

MONEY DEMAND, PPP AND MACROECONOMIC DYNAMICS IN THE DOMINICAN REPUBLIC

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I. 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 that flaw (e.g. Rudebusch 1998). The cointegrating VAR (CVAR) is a plausible alternative in attempting to surpass that critical obstacle¹. CVARs allow a cautious 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. Specimens of diverse investigations, mainly focused on advanced economies, in the spirit of such multivariate time series econometric methodology are King *et al* (1991), Mellander *et al* (1992), Fung and Kasumovich (1998), and Crowder *et al* (1999)².

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 & Reinhart 1991; Kamas 1995), they have not explicitly dealt with the consequential task of *identifying* the long run properties of the system at hand. Remarkably, doing so is crucial if sensible conclusions are

to be derived from the subsequent dynamic analyses, e.g. impulse responses, of the model under scrutiny.

This paper intends to tackle that issue head on. It will do so by investigating the properties of a compact macro-monetary model of a small developing economy, namely the Dominican Republic (DR), through the application of the CVAR methodology. The proposed inquiry involves a series of questions. Particularly,

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. Is the upshot of these exercises economically sensible?
5. Which are the implications for monetary policymaking in the DR and, tentatively, similar economies?

These crucial issues are dealt with in the following fashion. Section II elucidates the theoretical aspects of the economic relations involved in the study. In section III 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 IV. Section V provides concluding remarks.

II. 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 equation³. 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 hold⁴.

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

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

where e is the nominal exchange rate measured in units of home currency per units of foreign currency, while 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-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

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

where φ is the interest semi-elasticity and Φ is the income elasticity of real money balances. In (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; Ball, 2001) report an elasticity of 0.5, 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.

III. EMPIRICAL MODELLING

The analysis of the system $X = ((m - p)_t, y_t, R_t^*, e_t, p_t^D, p_t^F)$ involves several stages. Specifically,

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 arguments elucidated 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 phases outlined above is dealt with in what follows.

Data

The paper examines annual data ranging from 1950 to 1999, thus effectively 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 inside 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 money⁵. e is the log of the nominal parallel (black) market exchange (sell) rate (obtained from the Central Bank of the Dominican Republic -CBDR)⁶; and p^D and p^F are the logs of the domestic and foreign price levels, 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 indexes with 1995 = 100. Figures 1 to 3 in the Appendix 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, therefore, 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. To that end $I(d)$ will be used to express that a given variable has to be differenced d times in order to become a stationary process. The standard procedure to achieve the desired objective is to implement the augmented Dickey-Fuller (ADF) (Dickey & Fuller 1979) test. The results of doing this are reported in

Appendix 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 stationary⁷. Figure 4 exhibits the behaviour of Δp^D . Non-stationarity does not appear to be an *inherent* property of that sequence during the time span under consideration. Henceforth, the analyses to be developed below will treat $X = ((m-p)_t, y_t, R_t^*, e_t, p_t^D, p_t^F)$ as a set of $I(1)$ observations.

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):

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

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), $\Gamma_1, \Gamma_2, \dots, \Gamma_{p-1}, \Pi$ are $m \times m$ matrices of unknown coefficients, Ω is an $m \times s$ matrix, and $\varepsilon_t \sim N(0, \sigma)$. The estimation of (3) is subject to the hypothesis that Π has a reduced rank, $r \leq m$, 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.

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 $X = ((m-p)_t, y_t, R_t^*, e_t, p_t^D, p_t^F)$ 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, by construction, the SBC will select a more parsimonious model than the AIC, and in the light of the fact that for the ADF analysis reported in Table 1 one lag proved to suffice, 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 Appendix 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 & Sánchez-Fung 2000), and the arguments elaborated above, point to the likely existence of two equilibrium relationships amongst the variables under scrutiny: a PPP and a money demand. In the light of that, hereafter it is assumed that two cointegrating vectors are contained in the system⁸.

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 as⁹:

$$\beta = \begin{pmatrix} 0 & -1 \\ 0 & 1 \\ 0 & \varphi \\ \alpha & 0 \\ \lambda & 0 \\ 1 & 0 \\ 0 & 0 \end{pmatrix}. \quad (5)$$

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

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

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

Appendix Table 3 exhibits 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 Appendix 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 0.90. In contrast, foreign prices are found to affect the exchange rate negatively, albeit with a lower coefficient of just over 0.70. For the money demand relation a unitary income elasticity and an interest semi-elasticity of -0.04 are unveiled.

The identification of the two long run relations achieved so far is, by itself, an important step. It is straightforward to agree on the validity of this statement after reviewing the literature on money demand and PPP. Remarkably, the empirical analysis of both concepts has proved to be a daunting task for economists¹⁰. Additionally, PPP and money demand endure as cornerstones in theoretical modelling, and in the design and implementation of economic policies. The dynamic properties of these relations are investigated below.

IV. DYNAMICS

Persistence Profiles

The dynamic analysis begins by displaying the fashion in which the money demand and PPP cointegrating vectors (CVs) identified above adjust to their equilibrium levels. The basic tool employed for such a purpose is the persistence profiles of the CVs (Lee & Pesaran, 1993) after being hit by a system-wide shock.¹¹ The outcome of the persistence profile analysis for the case at hand is compelling, and to a great extent analogous to those of similar investigations for advanced economies (e.g. Pesaran & Shin 1996; Cheung & 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 shock¹². Specifically, around 90% of a PPP disequilibrium is made up, on average, within five years. Such behaviour can be discerned clearly from Figure 5 in the Appendix. 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 in the Appendix 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. 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).¹³

Generalised Impulse Responses of Variables to Shocks Affecting Money Demand and PPP

The inquiry now proceeds 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 case at hand is conducted by the Central Bank of the Dominican Republic (CBDR).¹⁴ 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 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 affect aggregate economic activity positively, generating an increase of roughly 2.5% in real output. So (assuming that *Lucas' critique* does not applies) there is a potential case for activist monetary policy in the DR, at least in the short run.

The dynamics generated after shocking the exchange rate equation are likely to be the most enthralling¹⁵. That is the case given the pivotal role played by such a variable in the transmission of macroeconomic impulses in a small, open, economy like the DR. Preliminarily, the argued importance of the exchange rate is perceived by glancing at Figure 3 in the Appendix. Note that the domestic price level is virtually stationary up until the end of the 1960s. However, after the Dominican Peso started to depreciate at around that time, domestic price also took off. Naturally, these developments are reflected in the inflation rate, which is displayed in Figure 4 in the Appendix

Although the DR's foreign exchange market has historically been a multiple one, the parallel (or black) market is the crucial to consider.¹⁶ The authorities could, and would probably intend, under adverse circumstances (e.g. bubbles, speculative attacks, or other non-real elements), to influence its short-run developments 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.

Figure 7 in the Appendix conveys that an innovation (which amounts to a depreciation) of that nature 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

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

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, a possibility that cannot be ruled out.

Several empirical studies have found a similar response of the macroeconomy after shocks to the exchange rate (see Kamin & Rogers, 2000, and the references therein)¹⁷. 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 momentous conundrums for monetary policymakers in the DR and similar economies.

Before closing this section, it is worth noting that the fact that the impulse responses analysed above generate economically sensible patterns is a further, implicit, validation of the identifying restrictions that were imposed on the system in an earlier phase of the project.

V. 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 grapples with that issue by investigating the long run and dynamic properties of a compact macro-monetary model of the Dominican Republic's economy, for which purpose the cointegrating VAR framework has been employed.

In a system composed of real money, real output, a nominal exchange rate, a foreign interest rate, and domestic and foreign prices, the study is able to identify PPP and money demand cointegrating vectors. The investigation proceeds by examining the underlying dynamic characteristics of the economy. The persistence profile of the PPP cointegrating vector is similar (in that it adjusts to equilibrium slowly) to that of previous investigations (e.g. Pesaran & 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 fact-finding process also delves into the impact of equation specific shocks on the developments of the variables considered in the model. Notably, 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 & Rogers 2000). The latter findings are particularly critical for the design and implementation of monetary policy. This is chiefly due to the centre-stage 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, *alas*, 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 on the trade-offs that policymakers face in the design of certain macroeconomic stabilisation packages, e.g. exchange rate based adjustment programmes.

APPENDIX

Table 1 – Augmented Dickey-Fuller (ADF) unit root test

Variables (levels)	ADF test statistic 1952-1999	Variables (first differences, Δ)	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 on Table 1: 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 was 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	
<i>Trend</i>	0.0042		-0.0232		-0.0412	
List of Eigenvalues	0.84226	0.53041	0.47802	0.33871	0.15421	0.06066
II. Cointegration tests						
Maximal eigenvalue test						
Hypotheses		Statistic			Critical values	
Null hypothesis	Alternative hypothesis				95%	90%
$r = 0$	$r = 1$	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
$r = 3$	$r = 4$	20.46			25.42	23.1
$r = 4$	$r = 5$	8.20			19.22	17.18
$r = 5$	$r = 6$	3.06			12.39	10.55
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
$r \leq 3$	$r > 3$	31.53			42.34	39.34
$r \leq 4$	$r > 4$	11.27			25.77	23.08
$r \leq 5$	$r > 5$	3.06			12.39	10.55

Notes on Table 2: 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>I. Cointegrating vectors</i>		
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
<i>Trend</i>	0.00	0.00
<i>II. Normalised vectors</i>		
Vector 1 (PPP):	$e = 0.86p^D - 0.72p^F$.	
Vector 2 (Money demand):	$(m - p) = y - 0.04R^*$.	
<i>III. Test of restrictions</i>		
LR (7): 6.0099 [0.539].		

Notes on Table 3: 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 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.

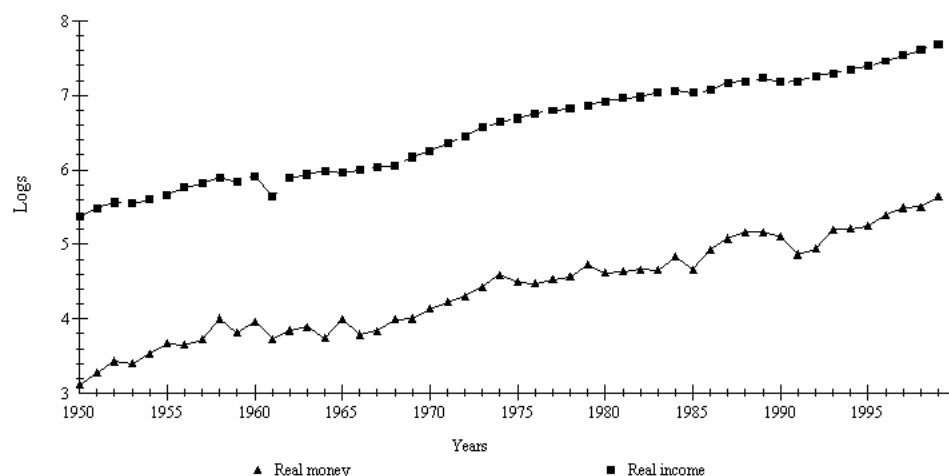
Figure 1 – Real Money and Real Income, 1950-1999

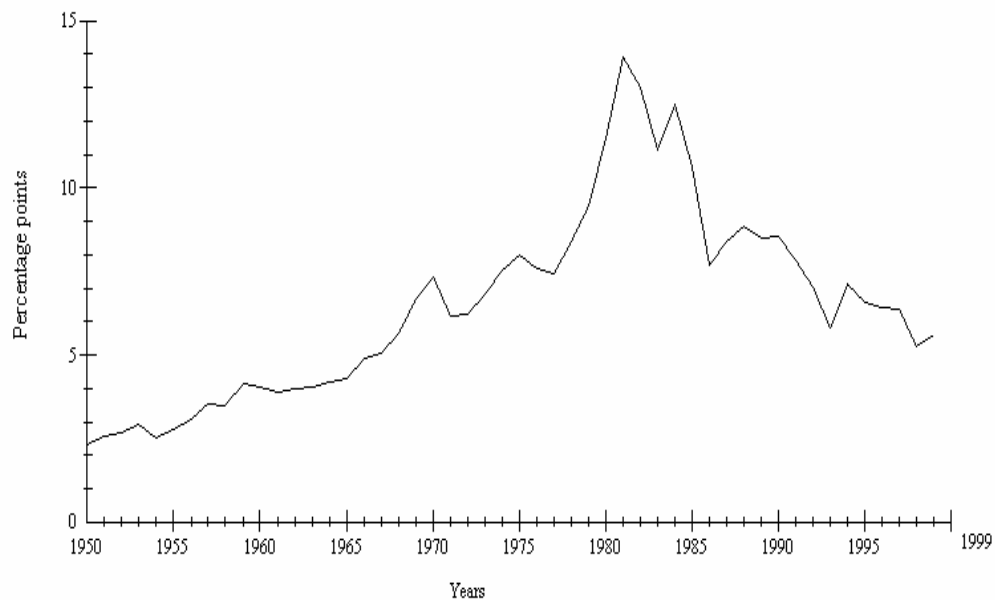
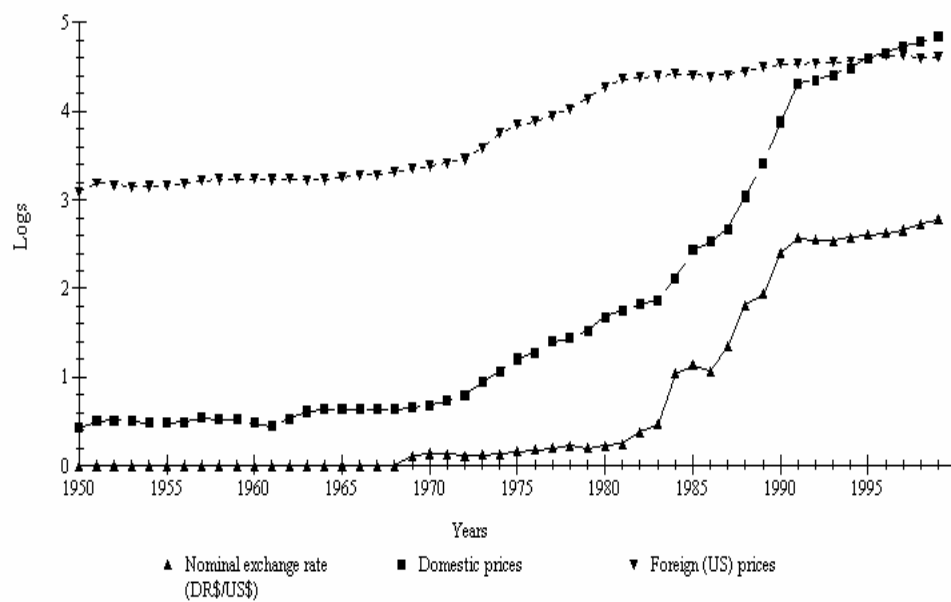
Figure 2 – US Long-term Government Bond Yield, 1950-1999**Figure 3 – Exchange Rate, Domestic and Foreign (US) Prices, 1950-1999**

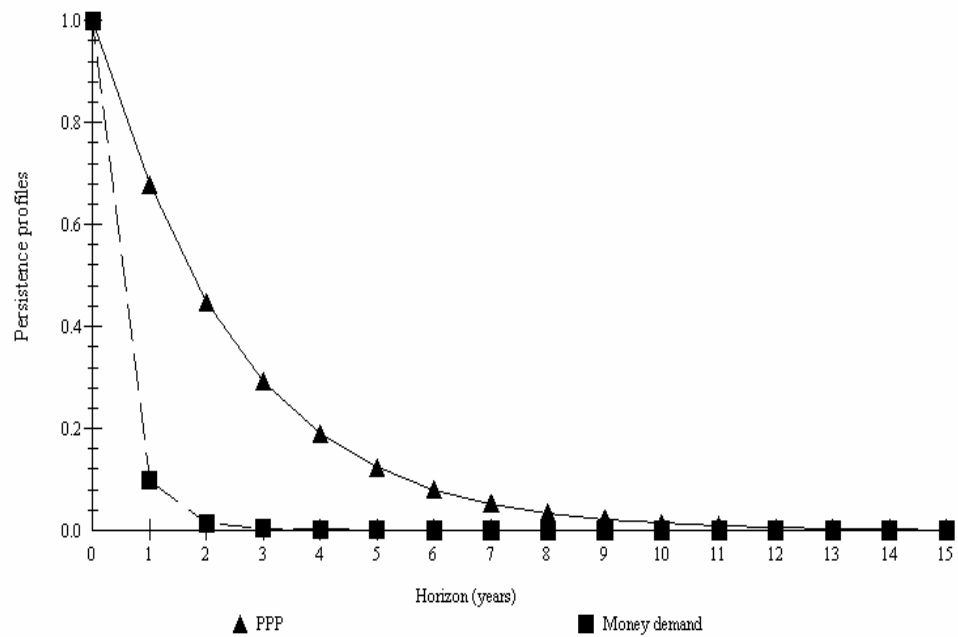
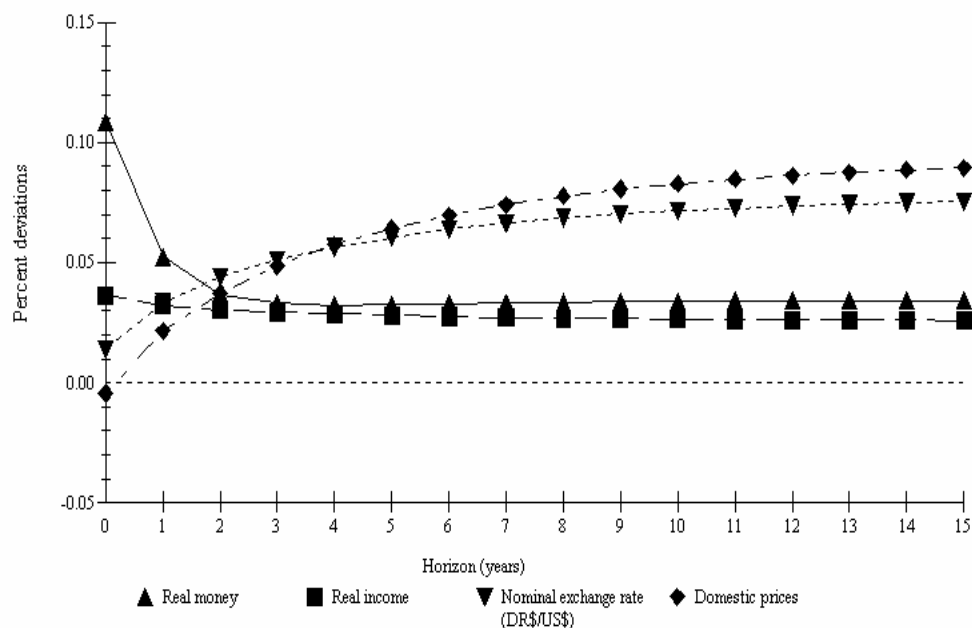
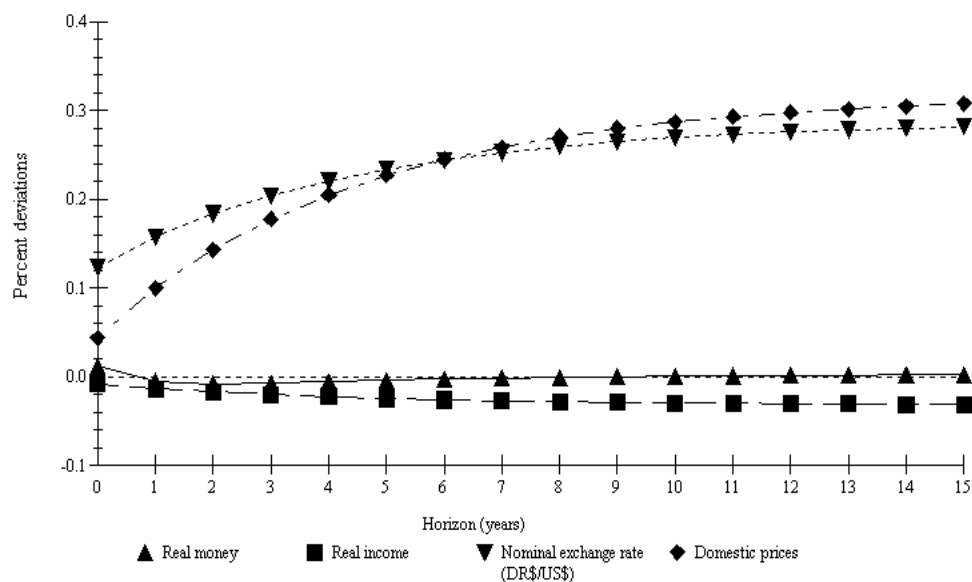
Figure 4 – Inflation, 1951-1999**Figure 5 – Persistence Profiles of the Effect of a System-wide Shock to CVs**

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**

Notes

- 1 A notable effort to deal with the issue at hand is, for example, the work of Leeper et al (1996). The authors' approach (which relies on the implementation of Bayesian methods) has, however, been criticised on various grounds. The most amusing is the one related to the fact that it employs a large number of variables to generate its results, precisely one of Sims' (1980) main critiques to the structural econometric (simultaneous equations) modelling framework.
- 2 Technical surveys of the topic have been written by, for example, Watson (1994) and Pesaran and Smith (1998).
- 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 the paper by Mishkin (1992).
- 4 See, for example, Crowder et al (1999) for a similar intuition.
- 5 The justification for using this series is that the Central Bank of the Dominican Republic 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 crucial to consider. The system is at present composed of the official, banking system, and 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).
- 7 The PP test statistic is the t-ratio of ϕ , in a Dickey-Fuller equation of the form $\Delta y_t = \alpha + \phi y_{t-1} + \delta t + \varepsilon_t$, computed 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.
- 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, in addition to the four just-identifying, restrictions on Johansen's test results. (It goes without saying that the exercise involved experimenting with several alternative restrictions.) The four just-identifying [shown in bold caps in (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.

It is worthy to note that the PPP hypotheses of symmetry and proportionality were tested, but were not statistically valid. In the light of these facts, the reader should note that the analysis provided amounts to a *trivariate stage-three cointegration PPP test* (see Froot and Rogoff, 1995). Nevertheless, an experiment of the system's dynamics 'assuming' that symmetry and proportionality hold generated results identical to those presented below. Such simulations are available from the author upon request.

Alternative specifications also considered the inclusion of constant terms, which are mostly crucial for determining which type of PPP is being analysed. In those specifications, however, such terms were not statistically significant.

- 10 Notably, see Edwards and Savastano (1999) on PPP studies for developing economies.
- 11 Specifically, the shocks consist of innovations to the distribution of the system's disturbances.
- 12 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.
- 13 Finally, note that 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.
- 14 The CBDR and the Dominican Peso (DR\$) were created in 1947.
- 15 The reader should pay attention to the fact that a shock to the disturbance of the equation for e is equivalent to a shock to the 'real exchange rate'.
- 16 As noted above, the system is at present composed of the official, banking system, and extra-banking system (parallel-black) exchange rate markets. At the moment around 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).
- 17 See also Buffie and Won (2001) for a theoretical insight on the matter.

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