MODELLING MONEY DEMAND IN THE DOMINICAN REPUBLIC

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Abstract

The paper models money demand in the Dominican Republic using a novel, automatic general-to-specific, econometric technology -PcGets. The study finds economically sensible long run relations for real M1 and M2. Likewise, meaningful short run money demand functions are estimated. Remarkably, the corresponding rolling equilibrium correction adjustment coefficients imply a highly fine-tuned monetary policy stance in the late 1990s. This feature, however, fades after that period, probably due to time consistency problems (e.g. fiscal dominance).

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Keywords: money demand; monetary policy; financial dollarization; automatic model selection; general-to-specific (GETS); Dominican Republic.

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1. Introduction

During the 1990s the Dominican Republic (DR) experienced a *de facto* dollarization of its banking system. Some basic figures can help to substantiate this statement. For instance, in 1996 the share in M2 of US$ denominated deposits amounted to just over 1.1%. In contrast, for 2002 this figure totaled 25%. Mirroring this development, in 1996 the share of US$ loans in total M2 was 1.2%, whereas it stood at 28% at the end of 2002. As a yardstick, these numbers are fairly close to Ecuador's before it dollarized.

In addition to the above facts, it is worthy to note that although the 1990s were also a period of macroeconomic stability and economic growth (See Young, 2002) the new millennium has brought several adverse shocks, including a major banking crisis costing nearly 20% of GDP and adverse international conditions[1]. The latter, exacerbated by the considerable degree of informal dollarization of the Dominican economy highlighted above, generated exchange rate instability and weakened the effectiveness of monetary and fiscal (stabilization) policies during 2002 and 2003. As a result of these developments the DR signed a stand-by agreement with the IMF that was formally approved in August 2003. It is natural to think that these momentous events potentially imply changes in the structure of the economy, in general, and key economic relations, in particular.

A relation that is of cardinal interest is the money demand function, basically due to its importance in theoretical and empirical macroeconomic models. Moreover, in the DR monetary policy is based on a monetary programme within which money

[1] See *The New York Times* editorial article "Dominican Republic in crisis", December 29th, 2003.

demand plays a critical role, in contrast to what occurs in more advanced economies, such as the US and the UK, were the interest rate is the main policy instrument (Bernanke and Blinder, 1992; Woodford, 2003). So a natural question to ask is if during the 1990s and early 2000s economically sensible money demand functions can be identified for the DR`s economy, and henceforth used in the design and monitoring of monetary policy.

The paper attempts to answer this question through the empirical analysis of money demand in the DR using a novel econometric technology, namely PcGets, the automatic model selection approach put forward by Hendry and Krolzig (2001, 2003). To the best of the author's knowledge, this is an original exercise in the Empirical Development Macroeconomics literature. The technique in question makes operational the ideas developed by Hoover and Perez (1999) -which advanced an algorithm to reproduce the general-to-specific (GETS) methodology- alongside Hendry's approach to empirical econometric modeling (e.g. Hendry, 1995). The automated GETS approach starts the specification search process from a general unrestricted model (GUM) that is assumed to represent the data generating process (DGP). On the reliability of the approach, Monte Carlo experiments by Hendry and Krolzig (2001) show that estimates obtained with the computer programme PcGets are close to those recovered from the actual DGP.

The rest of the paper proceeds as follows. Section 2 explains the specification adopted for the empirical analyses. Estimations of long and short run money demand functions are contained in sections 3 and 4, respectively. Section 5 provides concluding remarks.

2. Empirical specification

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

$$(m-p)_t = \beta_1 y_t + \beta_2 R_t + \xi_t \ , \tag{1}$$

where β_2 is the interest semi-elasticity and β_1 is the income elasticity of real money balances. In (1) β_2 is expected to be negative, while β_1 should lie in the vicinity of unity, although some studies (e.g. Baba et al, 1992; Ball, 2001) report an elasticity around 0.5, as predicted by the Baumol-Tobin transactions demand approach. ξ is expected to be a well behaved disturbance term.

In a small open economy setting equation (1) can be re-formulated to allow for the influence of foreign elements on the behavior of domestic money demand, yielding

$$(m-p)_t = \beta_1 y_t + \beta_2 \left(R - R^*\right)_t + \xi_t \,, \tag{2}$$

where R^* is a foreign interest rate. The coefficient affecting $\left(R - R^*\right)$ is important to capture financial features (e.g. capital mobility, currency substitution) of open economies, and also works as a proxy for expected exchange rate depreciation, inflationary expectations and risk. IMF studies authored by Nadal De-Simone (2002), and Williams and Adedeji (2003) employ a specification like (2) for the analysis of money demand in the DR. Likewise, and in the light of the structural changes and reforms experienced by the DR economy during the 1990s, which should make it more sensitive to foreign financial conditions (See Young, 2002), the present study adopts this equation as the baseline for the empirical analysis.

3. Long run analysis

The data to be employed in the empirical analysis is monthly, ranging from 1991.8 to 2003.8[2]. In the econometric exercises that follow $(m-p)$ are real money balances, where m is the log of nominal M1 (currency plus deposits in checking accounts) or M2 (M1 plus savings and time deposits; from 1996 M2 includes Dollar deposits converted to Pesos at the current exchange rate), and p is the log of the consumer price index (CPI); y is the log of a leading indicator of real economic activity, namely a construction sector index elaborated by the Dominican Construction Chamber[3]. R and R^* are nominal interest rates of deposits in Dominican (average banking system loan rates) and US (prime loan rate) banks, respectively, and are expressed in percentage points. The source for all the data is the Central Bank of the Dominican Republic. The exception is the US interest rate, for which the source is the Federal Reserve Bank of St Louis` FRED database.

[2] To the best of the author's knowledge, this is the first study to formally estimate money demand in the DR using data at the monthly frequency, and for M1 and M2.
[3] Further details on this index can be obtained from the author upon request.

Before moving on to the formal modeling, the time series properties of the data are inquired into. The results of applying the augmented Dickey-Fuller unit root test (Dickey and Fuller, 1979) show that all the data are integrated of order one in their levels, but become stationary after being differenced once, as evidenced by the ADF test statistics in Table 1. Therefore the analysis proceeds to assert the long run, cointegrating, properties of the data under investigation.

The general unrestricted models (GUMs) for M1 and M2 are investigated using an autoregressive distributed lag specification of order twelve, $ADL(12,12,12)$, that can be written as (See Hendry, Pagan, Sargan, 1984)

$$(m-p)_t = \beta_0 + \sum_{i=1}^{12} \alpha_i (m-p)_{t-i} + \sum_{j=0}^{12} \beta_{1j} y_{t-j} + \sum_{k=0}^{12} \beta_{2k} \left(R - R^*\right)_{t-k} + \xi_t. \qquad (3)$$

The money demand equations are computed with monthly data for the period 1993.9-2003.8 using an automated, general-to-specific (GETS), model selection technique, namely *testimation* (See Hendry and Krolzig, 2003). After automatically reducing the GUMs, exhibited in Table 2, the following long run solutions emerge

$$(m1-p) = y - 0.0145\left(R - R^*\right), \qquad (4)$$

$$(m2-p) = 1.10y + 0.21\left(R - R^*\right). \qquad (5)$$

Figure 1 shows the underlying equilibrium correction mechanisms (EqCMs), which correspond to cointegrating relations, as confirmed by the ADF test statistics reported at the bottom of Table 2. Henceforth, the estimators in equations (4) and (5) are *super-consistent* (Stock, 1987).

Equation (4) has economically and statistically sensible coefficients. Notably, they are in line with theoretical predictions and the findings of previous studies. For instance, Carruth and Sánchez-Fung (2000), Nadal De-Simone (2002), and Williams and Adedeji (2003) all estimate unitary income elasticities of the demand for M1 in the DR[4]. The interest rate coefficient is negative, as expected.

For real M2 the econometric exercise yields a long run solution of similar properties for the income elasticity. However, the coefficient of $\left(R-R^{*}\right)$ is positive. Nadal De-Simone (2002) also estimates a positive long run coefficient of $\left(R-R^{*}\right)$ for real M2 demand in the DR using quarterly data for the period 1992-1999. He argues that such results are expected from the predictions of the Mundell-Fleming model.

This model suggests that in small open economies like the DR what matters is the authorities` ability to influence the interest rate differential, and not the domestic rate. More explicitly, the transmission mechanism for this development is

$$\uparrow\left(R-R^{*}\right)\rightarrow\uparrow CapInf \rightarrow\downarrow E \rightarrow\uparrow M2 .$$

The sequence shows that a higher interest rate differential $\uparrow\left(R-R^{*}\right)$ will stimulate capital inflows ($\uparrow CapInf$) and appreciate the domestic currency $(E\downarrow)$ (defined as Dominican Pesos per United States Dollar), enhancing the attractiveness of financial instruments registered as part of M2 and, under certain conditions, finally increasing the

[4] Note that these studies use annual (the first) and quarterly (the last two) data, therefore highlighting the robustness of the money demand function's parameters in the DR.

stock of this aggregate $(\uparrow M2)$. This is a sensible, open economy macroeconomics textbook, explanation of the phenomena at hand. A closer look at the DR`s institutional developments, however, suggests that an alternative evaluation could be illuminating.

As highlighted in the introduction, a *de facto* financial dollarization took place in the DR from 1996, from which point dollar denominated bank operations started to progressively increase. So, particularly during the sample period under study, the positive coefficient on $\left(R-R^{*}\right)$ could actually be reflecting a somewhat structural, *Peso problem*, risk premium that triggered a flight from Peso denominated deposits into Dollar denominated ones. Arguably, the situation was not helped by the newly allowed Dollar bank operations.

The mechanism described above would be more realistic if international parity conditions hold. In fact, Sánchez-Fung and Prazmowski (2004) show that a nested UIP-PPP specification is an adequate framework to model exchange rate developments in the DR. Specifically, the paper reveals that the most significant driver of exchange rate expectations is the interest rate differential between the DR and the US; i.e. an increase in $\left(R-R^{*}\right)$ depreciates the domestic currency $\left(\uparrow E\right)$.

In the light of these facts, the following sequence is put forward as an alternative explanation of the positive coefficient on $\left(R-R^{*}\right)$ unveiled for M2 money demand

$$\uparrow\left(R-R^{*}\right)\rightarrow\uparrow E\rightarrow\uparrow US\$operations\rightarrow\uparrow M2.$$ [5]

So at least part of the story could be seen as a by-product of the fact that economic agents tried to arbitrage the differential between Dollar and Peso denominated bank operations after 1996, in an attempt to hedge against the currency risk that is typical of small developing economies. Banking regulation allowed most of this arbitrage to be internalized by the domestic banking system. In spite of this, at the end of the sample period under scrutiny, 2003, a substantial amount of capital outflows took place (around 7% of GDP), apparently unveiling the non-sustainable nature of the informal financial dollarization process started around 1996.

Summing up this section's results, the empirics show that for real M1 and M2 even during a period of rapid growth, financial dollarization, and consequential external and internal exogenous shocks, economically sensible, cointegrating money demand functions can be identified for the DR´s economy.

4. Short run modelling

Now that long run money demand equations have been identified for M1 and M2 the study proceeds to investigate the underlying short run, dynamic, properties of the relationships at hand. For both monetary aggregates the strategy is to start with a GUM as follows

$$\Delta(m-p)_t = \sum_{i=1}^{6}\alpha_i \Delta(m-p)_{t-i} + \sum_{j=0}^{6}\beta_{1j}\Delta y_{t-j} + \sum_{k=0}^{6}\beta_{2k}\Delta\left(R-R^*\right)_{t-k} + \sum_{l=1}^{6}\lambda_l EqCM_{t-l} + \xi_t . \quad (6)$$

In equation (6) Δ is the first difference operator, and λ is the EqCM`s adjustment coefficient. As with the long run analysis, the initial short run models are estimated

[5] Recall that Dollar operations are recorded in M2 converted to Pesos.

employing an automated (GETS) modeling methodology, but starting with six lags of each variable. The final selected models for M1 and M2 are[6]

M1 equation

$$\Delta(m1-p)_t = \underset{(0.06)}{0.22}\Delta(m1-p)_{t-4} + \underset{(0.12)}{0.44}\Delta y_t + \underset{(0.19)}{0.38}\Delta y_{t-3} - \underset{(0.003)}{0.012}\Delta\left(R-R^*\right)_t - \underset{(0.003)}{0.005}\Delta\left(R-R^*\right)_{t-5}$$

$$-\underset{(0.09)}{0.44}\,EqCM_{t-1} + seasonals, \qquad (7)$$

1993.8-2003.8		$T = 121$
$F_{AR} = 0.17$	$F_{ARCH} = 0.43$	$F_{HET} = 0.64$

where $\sum y = 0.83$ and $\sum\left(R-R^*\right) = -0.018$.

M2 equation

$$\Delta(m2-p)_t = \underset{(0.17)}{0.49}\Delta(m2-p)_{t-1} + \underset{(0.13)}{0.44}\Delta y_{t-4} - \underset{(0.002)}{0.007}\Delta\left(R-R^*\right)_t + \underset{(0.002)}{0.005}\Delta\left(R-R^*\right)_{t-1}$$

$$-\underset{(0.19)}{0.48}\,EqCM_{t-1}, \qquad (8)$$

1993.8-2003.8		$T = 121$
$F_{AR} = 0.11$	$F_{ARCH} = 0.84$	$F_{HET} = 0.09$

where $\sum\left(R-R^*\right) = -0.0021$.

Coefficients` standard errors are inside parentheses, while probability values are displayed for the diagnostic test statistics. The battery of diagnostic tests to detect autocorrelation (F_{AR}), autoregressive conditional heteroscedasticity (F_{ARCH}), and

[6] The M1 model was estimated using a *liberal strategy*, whereas the M2 model was computed via an *expert users´ strategy*. See Hendry and Krolzig (2003) for details on

heteroscedasticity (F_{HET}) are passed by both equations. Equations (7) and (8) also have economically sensible coefficients. A potential explanation for the different coefficients on $\left(R - R^{*}\right)$ for long and short run M2 demand is the lag from the implementation of monetary policy to its final impact. For instance, an increase in the interest rate may initially decrease M2 demand, but have the opposite effect once economic agents optimize their financial positions according to the new policy stance. Finally, the EqCMs in (7) and (8) reflect fairly quick adjustments after departures from the long run relations. About half of any disequilibrium from the long run behavior of either M1 or M2 money demand is, on average, corrected within a month.

In order to learn more about the behavior of these regressions` components, Figures 2 and 3 graph the rolling t-ratios of the coefficients retained after the automatic GETS exercise. Overall, the rolling graphs reflect a period of change in the dynamic structure under scrutiny. Of key importance are the rolling t-ratios affecting $\left(R - R^{*}\right)$, which display strong significance in the late 1990s and again at the end of the sample in 2003.

Recall that the coefficients affecting this variable are expected to embody information on financial developments, inflationary expectations, and risk. Hence the periods after the introduction of dollar denominated banking transactions in 1996, and the one comprising the unset of macroeconomic instability in 2002 and 2003, seem to be reflected in the greater significance of the $\left(R - R^{*}\right)$ rolling t-ratios in Figures 2 and 3 for real M1 and M2, respectively. A somewhat similar pattern is reflected by the rolling t-ratios corresponding to the adjustment coefficients affecting the EqCM`s and output, also exhibited in Figures 2 and 3.

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these strategies.

Focusing on the monetary sector of the economy, it is important to point to the fact that from the beginning of the 1990s the Central Bank increasingly implemented ‘less direct’ instruments in the shape of open market operations, mainly by issuing short-term papers called *Central Bank’s Certificates of Participation*. It is reasonable to think that these operational changes positively affected the credibility and effectiveness of monetary policy. Indicators of this improved performance are the EqCMs` recursive coefficients for real M1 and M2, displayed in Figure 4, which show an increased magnitude and significance (see the corresponding rolling t-ratios in Figures 2 and 3), particularly during the late 1990s.

However, in 1999 the Central Bank started to increasingly service the country’s external debt *without* the corresponding funds being transferred from the Ministry of Finance. Although by itself this factor did not dent the monetary authorities` strategy, at the time it did have an adverse impact on the credibility of the monetary policy stance and the government’s economic policy in general. This process is reflected in a dramatic change in the coefficients of adjustment affecting the EqCMs for real M1 and M2 displayed in Figure 4. Remarkably, the speed of correction from real M1 and M2 disequilibriums roughly halved after this point in time.

It is worth noting that the high credibility of the monetary policy stance observed at the end of the 1990s was to a great extent a by-product of the favorable internal and external economic environment. Particularly, the reader should bear in mind that this lapse saw a colossal performance by the US economy (the DR´s main trading partner), and an impressive growth rate of the Dominican economy. Hence the *finely tuned* monetary outcomes reflected by the econometric exercises were probably not time consistent (Kydland and Prescott, 1977), somehow rationalizing the marked dives observed in the EqCMs` rolling t-ratios at the end of the 1990s. However, further studies need to be undertaken to throw more light on these consequential developments in the DR´s monetary sector.

5. Conclusion

This paper investigates money demand in the Dominican Republic employing monthly data for the 1990s and early 2000s, and an automatic model selection technology – PcGets. The inquiry identifies cointegrating real M1 and M2 demand functions that have economically sensible interpretations. Additionally, the paper models the dynamic properties of such relations incorporating the equilibrium correction mechanisms (EqCM) obtained in the cointegration exercises.

Notably, the rolling EqCMs` adjustment coefficients affecting the short run real M1 and M2 equations imply a highly *fine tuned* monetary policy stance at the end of the 1990s, which, however, fades after that point in time. This development could probably emerge from a *time consistency* problem underlying the short-lived monetary policy credibility success achieved at the end of the last decade. Overall, the rolling coefficients of the dynamic money demand functions display considerable variability, probably compromising their usefulness in short run policy design and monitoring.

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Table 1
ADF unit root test statistics, 1992.9-2003.8

Variable	ADF test statistics
Levels	*Constant and trend included*
$(m1-p)$	-3.382
$(m2-p)$	-2.441
y	1.475
$(R-R^*)$	-0.255
First differences	*Constant included*
$\Delta(m1-p)$	-10.74**
$\Delta(m2-p)$	-8.309**
Δy	-7.413**
$\Delta(R-R^*)$	-6.154**

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). Twelve lags were included in each regression. ** and * denotes rejection of the unit root hypothesis at the 1% and 5% levels, respectively.

Table 2
GETS automatically reduced M1 and M2 long run money demand GUMs
1992.8-2003.8

Variables	**Coefficients**	
Lags	*Dependent variables*	
	$(m1-p)$	$(m2-p)$
Own		
1	0.58**	0.99**
2	-	-
3	-	-
4	0.38**	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-0.17*	-
10	-0.19*	-
11	-	-
12	0.24**	-
$\sum$	0.84	0.99
y_t	0.62**	-
1	-0.49**	-0.09
2	-	-
3	-	0.10
4	-	0.33*
5	-	-
6	-0.45**	-0.34**
7	-	-
8	-	-
9	-	-
10	-	-
11	0.48**	-
12	-	-
$\sum$	0.16	0.0021
$(R-R^*)_t$	-0.01**	-0.006**
1	-	0.006**
2	-	
3	0.01**	
4	-	
5	-	
6	-	
7	-	
8	-	
9	-0.008*	
10	0.006 Ψ	
11	-	
12	-	
$\sum$	-0.0023	0.0004
ADF statistic	-7.653 (-4.40)	-9.136 (-4.40)

Notes on Table 2: GUM: General unrestricted model; GETS: general-to-specific. $\sum$: denotes the sum of coefficients for a given variable. **, * and Ψ indicate coefficient significance at the 1, 5, and 10 percent levels, respectively. The GUMs were reduced using the *liberal strategy* option in PcGets (See Hendry and Krolzig, 2003). The ADF test statistics at the bottom of the Table correspond to the residuals of the M1 and M2 equations. MacKinnon (1991) 1% critical values are displayed inside parentheses.

Figure 1
Real M1 and M2 EqCMs, 1992.8-2003.8

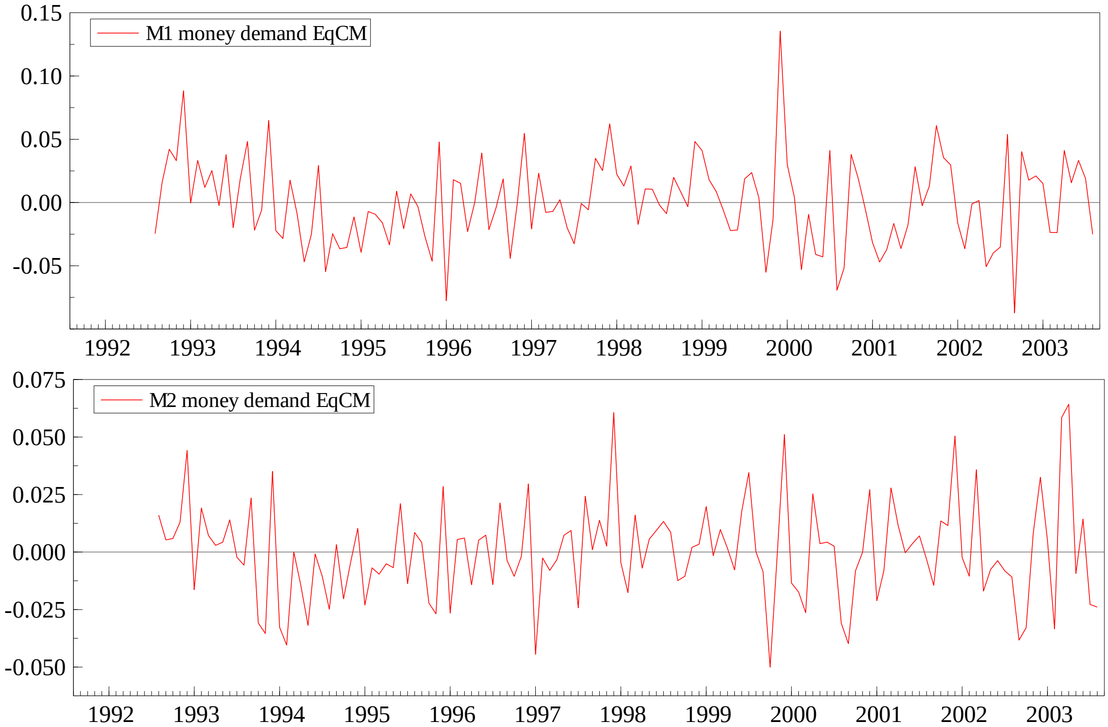

Figure 2
Rolling coefficients` t-ratios (window = 40)
Final short run equation for $\Delta(m1-p)$, 1993.8-2003.8

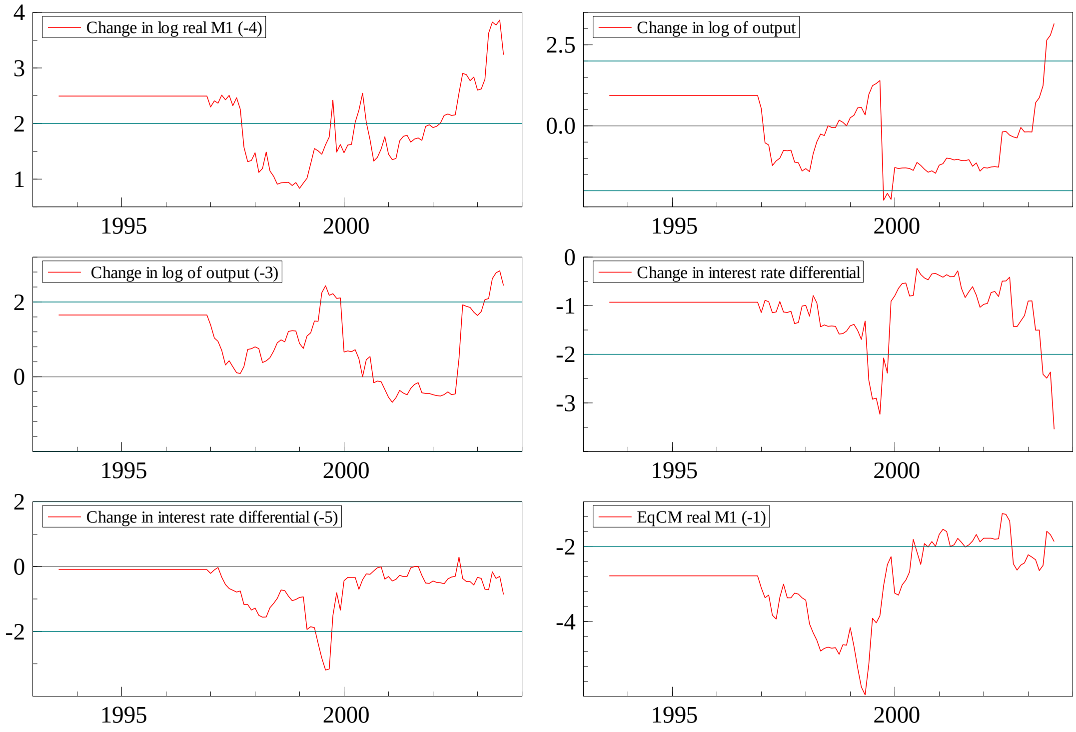

Figure 3
Rolling coefficients` t-ratios (window = 40)
Final short run equation for $\Delta(m2-p)$, 1993.8-2003.8

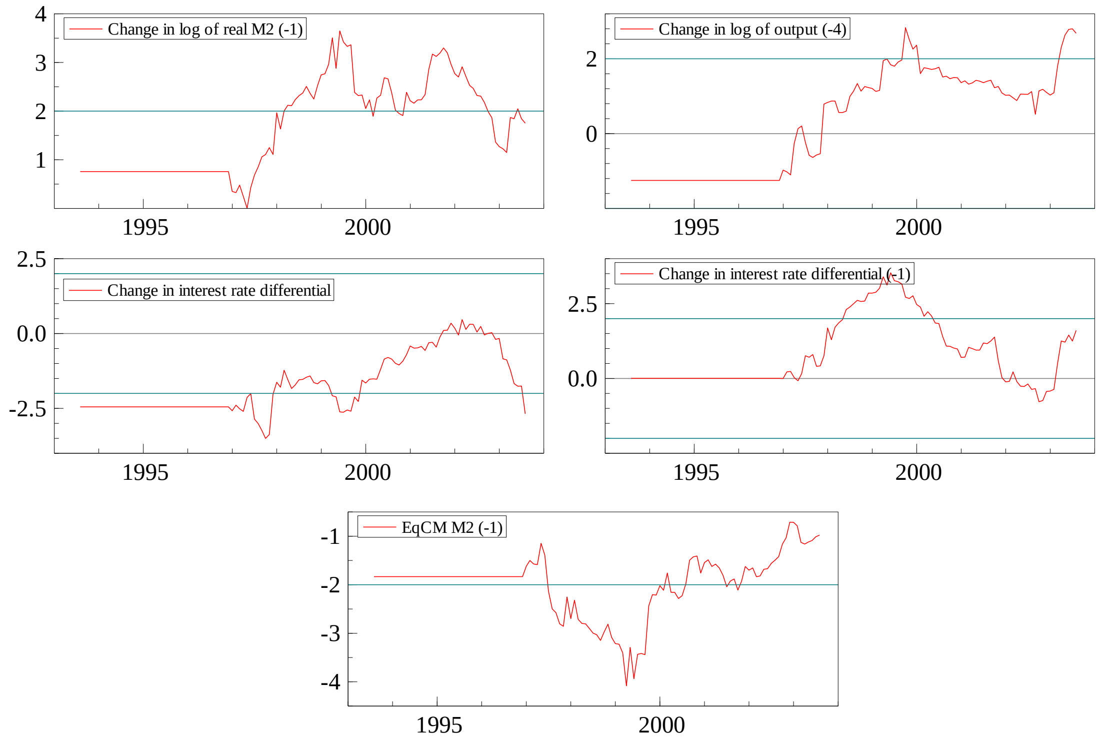

Figure 4
Rolling coefficients of real M1 and M2 EqCMs (window = 40)