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Monetary aggregates and monetary policy: an empirical assessment for Peru

Erick Lahura*

* Banco Central de Reserva del Perú.

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MONETARY AGGREGATES AND MONETARY POLICY: AN EMPIRICAL ASSESSMENT FOR PERU

Erick W. Lahura[1]
(Central Bank of Peru)

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ABSTRACT

In recent years the theoretical and empirical literature has shown a tendency to discard the use of money in monetary policy. This paper provides an empirical evaluation of the relevance of monetary aggregates in the conduct of monetary policy in Peru, a small open and partially dollarized economy. Based on recursive analysis of vector error correction models and allowing for structural breaks, we find that M3 is the only monetary aggregate that helps forecast inflation in Peru and therefore can be useful in monetary policy. There is no clear evidence about the usefulness of any other narrower monetary aggregate either as a potential monetary policy instrument or as an information variable.

JEL Classification: C32, E52, E58

Keywords: cointegration, dollarization, Granger causality, monetary aggregates, monetary policy, structural change, weak and strong exogeneity.

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[1] The views expressed in this paper are those of the author and do not necessarily reflect the official position of the Central Bank of Peru. I am grateful to Kosuke Aoki, Anthony Garratt, Tanja Sturm, Silvana Tenreyro and Hugo Vega for their invaluable comments on earlier drafts. All remaining errors are my own.

1. INTRODUCTION

This paper is motivated by the growing tendency to discard the use of monetary aggregates in monetary policy, both in theory and in practice. Monetary aggregates are among the most important data collected and produced by central banks, and they are usually available in advance of the majority of relevant data for monetary policy (e.g. economic activity, inflation, employment, among others). Thus, whether monetary aggregates should be ignored for monetary policy decisions is a natural and important question.

By the end of the 1960's there was a consensus that money was important in monetary policy, as supported by Friedman and Schwartz (1963), Andersen and Jordan (1968) and later by Sims (1972). Friedman and Schwartz's findings are usually summarized by the phrase "inflation is always and everywhere a monetary phenomenon", while the equation estimated by Andersen and Jordan, known as the St. Louis equation, suggested that monetary policy - measured as the rate of growth of nominal money - explains fluctuations in national income. In his seminal paper, Sims (1972) showed empirically that money can be considered as an exogenous variable for any equation that explains income, since lags of money improve output's forecasts and money's forecasts cannot be improved using lags of income[2].

In general, the literature that has developed around the role of money in monetary policy suggests two ways in which money can be useful in the conduct of monetary policy. First, money can be used as an "information variable" if fluctuations in money provide relevant information about current or future fluctuations in key macroeconomic variables that monetary policy seeks to influence (such as income or prices). Second, money can be used as a monetary policy target or instrument if a given money's rate of growth is equivalent to or consistent with a desired level of inflation or output's rate of growth[3].

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[2] However, using a Vector Autoregressive (VAR) model, Sims (1980) showed that the effect of money on income is reduced when prices and interest rates are included in the empirical model.

[3] As pointed out by Friedman and Kuttner (1992), Kareken et al. (1973) appears to be the first paper which formally introduced the "information-variable" concept into the analysis of monetary policy, whereas Friedman (1975) is an early paper which presents a formal analysis of the use of money as an intermediate target in monetary policy.

The usefulness of money as an "information variable" or "intermediate-target variable" depends on the existence of a relevant relationship over time between fluctuations in money and fluctuations in the key variables that monetary policy tries to influence (Friedman and Kuttner, 1992). Only in this situation, any deviations of money from some *ex ante* path will provide important and systematic information about the future paths of key variables for monetary policy. If money has no implication for future fluctuations in these key variables, then there is no reason why the central bank should react to fluctuations in money, and thus money is not useful as a information variable. Likewise, there is no reason why monetary policy should rely on a monetary target if there is no relation between some monetary aggregate and key macroeconomic variables.

Recent research that supports the idea that monetary aggregates are useful in monetary policy emphasizes the use of money as an information variable. This branch of the literature includes papers by Christiano and Ljungqvist (1988), Stock and Watson (1989), Krol and Ohanian (1990), Thoma (1992), Ramsey and Lampart (1998b), Bernd Hayo (1999), Dotsey, Lantz and Santucci (2000), C. Chew (2001), Gencay, Selcuk and Whitcher (2002), King (2002), Nelson (2003), Nelson (2003b), Dotsey and Hornstein (2003), Coenen et al. (2005), Beck and Wieland (2006), Benatti (2006), Aksoy and Piskorski (2006), Assenmacher-Wesche and Gerlach (2006, 2008), Hafer et al. (2007), among others. The main message from these papers is that money, measured by some monetary aggregate, is useful because it provides relevant information about future imperfectly-observed macroeconomic variables (such as inflation, real and nominal output) that are important for monetary policy decisions.

On the other hand, the branch of the literature that gives no support to the use of money in monetary policy includes papers by King and Plosser (1984), Bernanke (1986), Estrella and Mishkin (1997), Kandill (2005), De Gregorio (2004), Woodford (2003, 2006)[4], Lippi and Neri (2007), among others. The instability of money demand found in

[4] Woodford (2003, 2006) considers that there is no crucial role for monetary aggregates in the conduct of monetary policy. He states that a suitable policy is one that monitors the cumulative increase in prices relative to the annual target, tightening policy if prices have risen too much and loosening it if they have risen too little. Then, measurement of inflation itself is enough: it is not necessary to monitor money growth to know if a long-run inflation trend is developing. The existence of a long-term relation between money growth and inflation does not imply any advantage of money-growth statistics in addressing those questions. Furthermore, Woodford states that the existence of a long-run relation between money growth

many countries is one of the most important reasons use to explain why money is no longer a relevant instrument or target for monetary policy. Furthermore, according to research conducted by Estrella and Miskin (1997), monetary aggregates do not appeared to be a good indicator or "information variable" for monetary policy. All these facts are consistent with recent developments in monetary economics, which show that monetary policy can be studied without making any specific reference to money (Woodford, 2003), and that even making money explicit in the model does not change the results (Woodford, 2006). However, other dimensions of monetary policy related to the central bank's balance sheet, such as the supply of bank reserves and changes in assets acquired by central banks, have acquired growing importance, particularly since the recent financial crisis (Cúrdia and Woodford, 2010).

This paper provides an empirical evaluation of the relevance of monetary aggregates in the conduct of monetary policy in Peru, a small open and partially dollarized economy. Since January 2002, monetary policy in Peru has switched from a monetary targeting regime to an inflation targeting regime, and has explicitly used an official interest rate (the so called "reference interest rate") as its policy instrument since September 2003. Thus, although it is difficult to go back to a monetary-target regime, it is important for policy purposes to determine whether monetary aggregates in Peru are still useful as information variables.

The empirical evaluation is based on vector error correction (VEC) models given the non-stationarity of the series and the existence of at least one cointegrating vector. A recursive analysis of VEC models is also performed in order to provide robustness to the results. Furthermore, we extend previous empirical studies (e.g. Dotsey et al., 2000) in three dimensions. First, we introduce a proxy variable for dollarization in money demand functions for Peru, as proposed by Quispe (2001) and Quispe (2007). Second, following the Gregory and Hansen (1996) approach, we test for cointegration with structural change among the analysed series. Finally, the analysis of relevance of monetary aggregates as information variables is based on the concepts of weak and

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and inflation does not necessarily imply that measures of money growth will be valuable in forecasting inflation. If money were something exogenous with respect to the central bank's actions, like the weather, then it might make sense to try to discern long-run trends from moving averages of recent observations. But the long-run growth rate of the money supply will depend on future monetary policy decisions, and there is no sense in which the existence of a “trend" towards faster money growth in recent years dooms an economy to continue to have fast money growth over some medium- to long-term.

strong exogeneity, as proposed by Engel et al. (1983), Hendry (1995), and Granger and Lin (1995).

The results show no clear evidence that monetary aggregates can be used as policy instruments or information variables except in the case of M3, defined as total liquidity in domestic currency, and which is the broadest monetary aggregate used in this paper. In particular, we find evidence that traditional money demand functions are no longer stable, which invalidates the use of monetary aggregates as policy instruments; however when including a proxy variable for "dollarization" money demand functions become stable in some cases. On the other hand, we find that only M3 can be useful to forecast inflation and thus it has a role in monetary policy as an information variable. In the case of narrower monetary aggregates, we find no clear evidence of whether they can be useful to forecast inflation, real or nominal output.

The paper is organized as follows. In section 2, we find that a suitable econometric model for the data is a VEC model. Furthermore, the possibility of cointegration with structural breaks is also analysed. In section 3 we study the role of money as a policy instrument, based on the analysis of money demand stability. In section 4 we analyse the role of monetary aggregates as informative variables for monetary policy, evaluating whether or not monetary aggregates help forecasting inflation, real and nominal output. Finally, the main conclusions are presented in Section 5.

2. THE ECONOMETRIC MODEL

The main goal of this section is to determine the appropriate econometric model to analyse the relationship among variables that can be included in a standard money demand function, which are usually relevant for monetary policy. The literature provides three general approaches that have been applied to analyse empirically the relationship between money and other important macroeconomic variables (such as output and inflation). The first one is based on Granger causality, Vector Autoregressive (VAR) models and Vector Error Correction (VEC) models, especially after Sims (1972); other papers include Sims (1980), Christiano and Ljungqvist (1988), Stock and Watson (1989), Krol and Ohanian (1990), Friedman and Kuttner (1992), Estrella and Mishkin (1997), B. Hayo (1999), Dotsey, et al. (2000), King (2002), De Gregorio (2004), Kandill (2005). The second approach is based on the analysis of time series in the frequency domain, as in Thoma (1992), Thoma (1994), Benatti (2006), and Assenmacher-Wesche and Gerlach (2006a,b). Finally, a third approach is based on a mix of time domain and frequency domain analysis, which relies on wavelet functions that capture different frequencies at different points in time, as in Ramsey and Lampart (1998b), C. Chew (2001) and Gencay, Selcuk and Whitcher (2002).

In this paper, and relying on the first approach described above, the empirical analysis is based on vector error correction (VEC) models given the non-stationarity of the series and the existence of at least one cointegrating vector. Furthermore, a recursive analysis of VEC models is also performed (e.g. Dotsey et al., 2000) in order to provide robustness to the results.

2.1. Data and unit root tests

The analysis is based on monthly data provided by the Central Bank of Peru (January 1994-December 2006). We use four nominal monetary aggregates as proxies of money: monthly average monetary base (M0), monthly average currency (M1), currency plus demand deposits (M2), and total liquidity in domestic currency (M3). Real activity was approximated by the real Gross Domestic Product (GDP) in terms of 1994 “nuevos soles” and nominal Gross Domestic Output. The CPI (consumer price index) is used as a proxy of the price level. Dollarization is measured by the ratio of liquidity in dollars to total liquidity.

Savings interest rate is used as the opportunity cost of M0, M1 and M2, and the interest paid by central bank bonds minus the former as the opportunity cost of M3. Prior to the estimation of money demand equations, we constructed real monetary aggregates for each definition of money, using CPI as the deflactor. All variables were used in logs, except for interest rates.

The first step was to test for the presence of unit roots in the series. The ADF, Phillip-Perron, KPSS, DF-GLS, ERS optimal point and Ng-Perron tests showed that it is not possible to reject the hypothesis of unit root. Then, in order to evaluate the possibility of breaks we also applied Zivot and Andrews (1992), Perron (1997) and Perron-Rodriguez (2003). The results showed no systematic evidence against the presence of unit roots[5]. Therefore, the log of nominal monetary aggregates, real monetary aggregates, prices, real and nominal output are all integrated of order one, so they should be tested for cointegration.

2.2. Evidence based on Engle-Granger methodology

The Engle-Granger methodology allows us to test for the existence of cointegration between real money, real output and interest rate based on the fact that those variables belong to a money demand equation (so money is on the left hand side of the equation). Table 1 shows the results of the estimation of this cointegrating relationship considering four monetary aggregates (M0, M1, M2 and M3) and two possible specifications: (1) a standard money demand specification; and (2) a money demand equation which incorporates a dollarization indicator as an additional explanatory variable. The last specification is estimated based on the fact that the Peruvian economy is partially dollarized, and therefore it is reasonable to believe that economic decisions take into account dollarization. These results are based on all the monthly data available until 2006. Standard errors and p-values are reported below every estimated coefficient in Table 1.

The estimated coefficients have the expected signs, but their magnitudes are somewhat different to conventional values (especially for real income). Based on Akaike, Schwarz and Hannan-Quinn information criteria, it can be seen that the specification that

[5] The results can be provided upon request.

includes dollarization provides a better fit. However, the hypothesis of no cointegration cannot be rejected except for M3 (with the standard specification) and M2 (taking into account dollarization).

TABLE 1

Money Demand equations for various monetary aggregates
(1994-2006)

	M0		M1		M2		M3	
Real income	**2.24**	**1.50**	**2.39**	**1.39**	**1.64**	**1.90**	**2.52**	**2.22**
	0.08	0.09	0.09	0.08	0.12	0.17	0.07	0.12
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Interest rate	**-0.001**	**0.001**	**-0.002**	**-0.001**	**-0.034**	**-0.034**	**-0.003**	**0.002**
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.72	0.70	0.29	0.66	0.00	0.00	0.35	0.61
Dollarization		**-0.01**		**-0.02**		**0.00**		**-0.01**
		0.00		0.00		0.00		0.00
		0.00		0.00		0.05		0.00
Intercept	**-6.80**	**-2.58**	**-7.74**	**-2.00**	**-3.35**	**-4.86**	**-7.13**	**-5.42**
	0.40	0.50	0.44	0.43	0.58	0.94	0.34	0.64
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R-squared	0.96	0.98	0.96	0.99	0.95	0.95	0.96	0.96
Adj. R-squared	0.96	0.98	0.96	0.99	0.95	0.95	0.96	0.96
AIC	-2.82	-3.36	-2.62	-3.65	-2.08	-2.09	-2.54	-2.59
SC	-2.76	-3.28	-2.56	-3.57	-2.02	-2.01	-2.48	-2.51
Cointegration test 1/								
AIC	-3.054	-3.388	-2.789	-2.961	-2.633	-3.609	**-3.989**	-3.450
SIC	-3.028	-3.388	-2.789	**-5.075**	-2.633	-2.928	-3.740	-3.561
HQ	-3.028	-3.388	-2.789	**-4.248**	-2.633	-2.928	**-3.989**	-3.561

1/ The critical values are for cointegrating relations (with a constant in the cointegrating vector) estimated using the Engle-Granger methodology. For the case of three regressors, the critical values are: -4.368 (1%), -3.785 (5%) and -3.483 (10%). For the case of four regressors, the critical values are: -4.737 (1%), -4.154 (5%) and -3.853 (10%). Source: MacKinnon (1991).

To learn more about the evolution of the cointegrating relationship and to see whether or not the above results depend on the sample used, we estimated recursively the cointegrating relationship using 85 samples in a "rolling windows" fashion, keeping the first date fixed. Specifically, the first estimation period was January 1994-December 1999, the second one January 1994-January 2000, and so on. Based on this rolling estimation or dynamic cointegration approach, we find evidence of cointegration before 2006, as shown in Figures 1 and 2.

Figure 1 shows the results for the standard specification and Figure 2 for the specification that includes dollarization. The critical values for the null hypothesis (of no cointegration) are given by the horizontal dotted lines and each curve shows the evolution of the null hypothesis according to Akaike (red-circled curve), Swcharz (black-thick curve) and Hannan-Quinn (blue-thin curve) information criteria. The null is rejected according to a particular criterion if the corresponding curve crosses the critical values. Notice that the dates that appear in the Figures indicate the last observation of the rolling window.

Figure 1

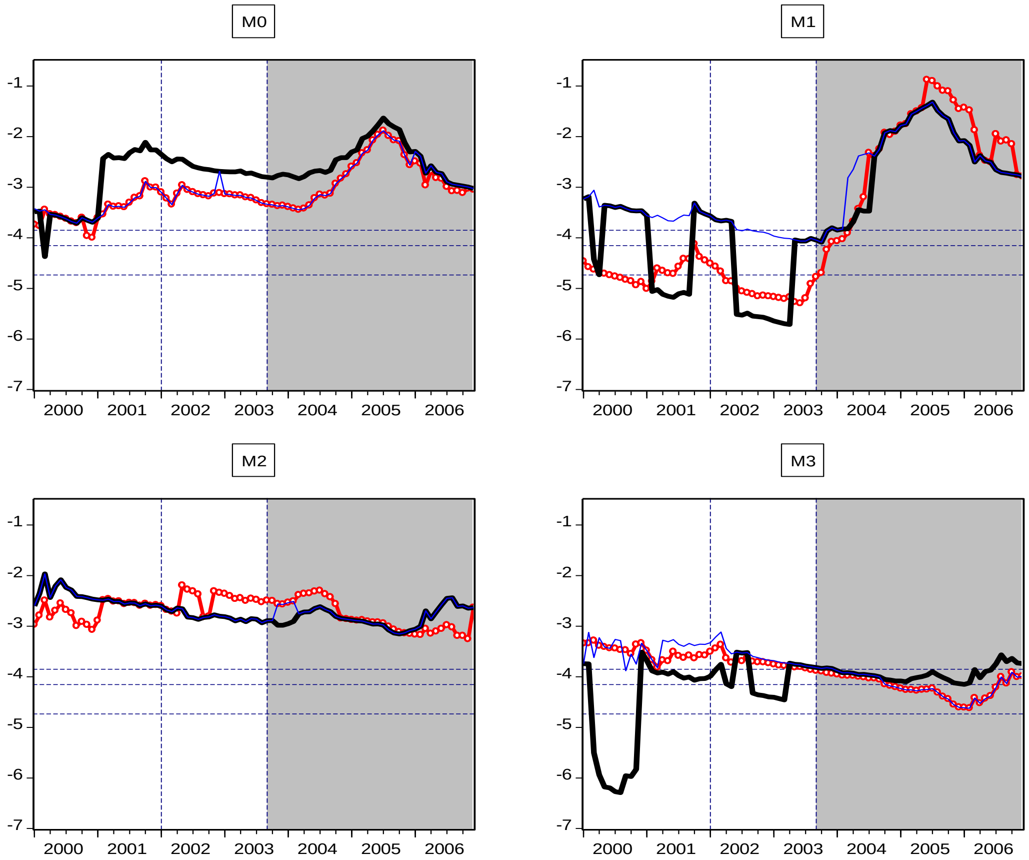
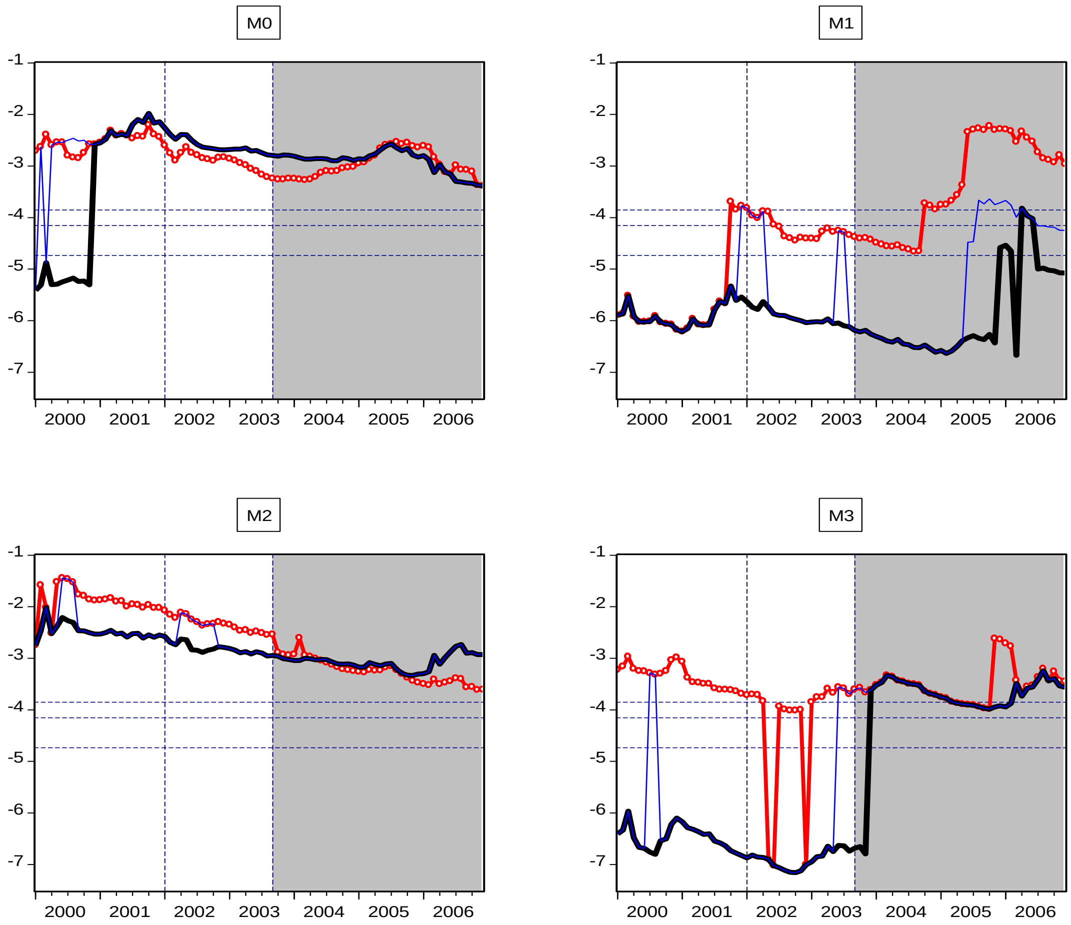


Figure 1 shows that there is no evidence of cointegration for M0 and M2; for M1 the figure suggests no cointegration after September 2003 (which coincides with the time when the interest rate was officially announced as the central bank's policy instrument). For M3 there appears to be a convergence towards a cointegrating relationship, but it is very weak.

Figure 2 shows the results for the money demand specification which includes a dollarization indicator. Again, there is no evidence of cointegration in the case of M0 and M2. However, according to SIC and HQ, there is evidence of cointegration in the case of M1 (for all samples). In the case of M3, cointegration breaks up just after September 2003.

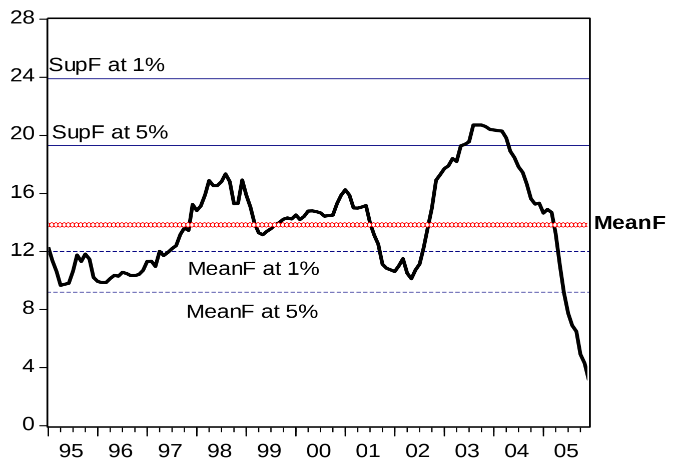
Figure 2



Given that the null of no cointegration was not rejected for M0, M2 and M3, the next step was to investigate the possibility of cointegration with a structural break. Following the test proposed by Gregory and Hansen (1996), we tested the null hypothesis of "no cointegration" versus the alternative of "cointegration with structural break" using the recurvise approach. The results at 5% level of significance (see Appendix A1) show no evidence of cointegration with structural break for M0, M2 or M3 and for any money demand specification (traditional or with dollarization). However, there is some weak evidence of cointegration when using M3 with dollarization.

Given the evidence of cointegration in the money demand specification for M1 with dollarization, we proceeded to test the stability of the cointegrating relationship using the SupF and MeanF statistical tests developed in Hasen (1992). For both statistics the null hypothesis is the existence of cointegration with stable parameters.

Figure 3



In the case of SupF, the alternative hypothesis states that there is an unknown structural break. In the case of MeanF, the alternative is that the coefficients follow a martingale. Following Hasen (1992) if the main interest is to discover whether there was a swift shift in regime, then the SupF is appropriate. On the other hand, if the focus is to test whether or not the specified model is good at representing a stable relationship, then MeanF is more appropriate, since it captures the notion of an unstable model that gradually shifts over time. Figure 3 shows the evolution of the F test (black-tick curve), and the MeanF (the red circled horizontal line). The SupF, the highest value of the F test (mid-2003), indicates that it is not possible to reject the null of parameter stability in the cointegrating equation at 1% level of significance (although we reject at 5%, as there is evidence of a structural change by mid-2003). However, according to the MeanF, we reject the null of parameter stability in the cointegrating equation at 1% level of significance.

2.3. Evidence based on Johansen methodology

One main disadvantage of the Engle-Granger methodology is that the existence of cointegration (and its stability) is based on the analysis of one single cointegrating equation and the assumption that one of these variables is on the left-hand side. However, given that there can be up to “n-1” cointegrating relationships between “n” variables, and the fact that there may exist more than one error correction model (one for each variable that enters into the cointegrating relationship), we use the multivariate procedure proposed by Johansen (1990, 1995) to test for cointegration. Furthermore, we use a recursive approach based on Hansen and Johansen (1999) to test for the stability of the cointegrating relationship.

Figure 4

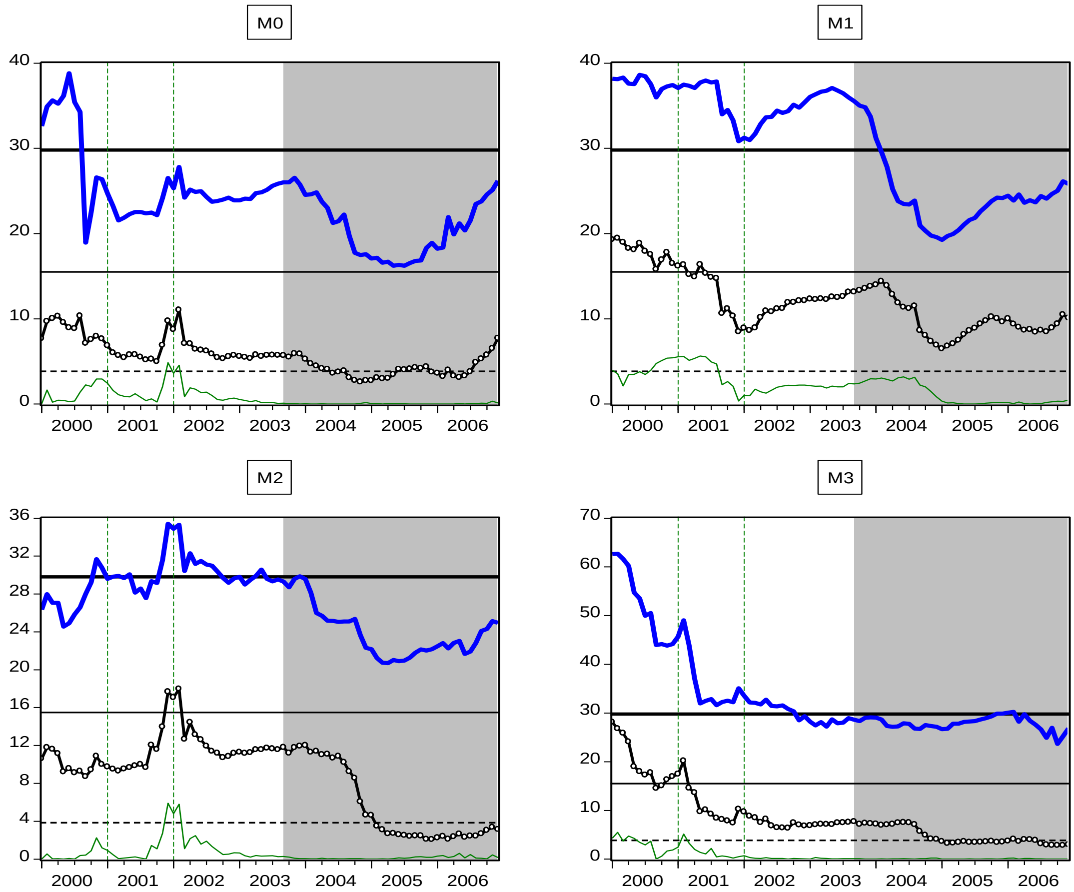
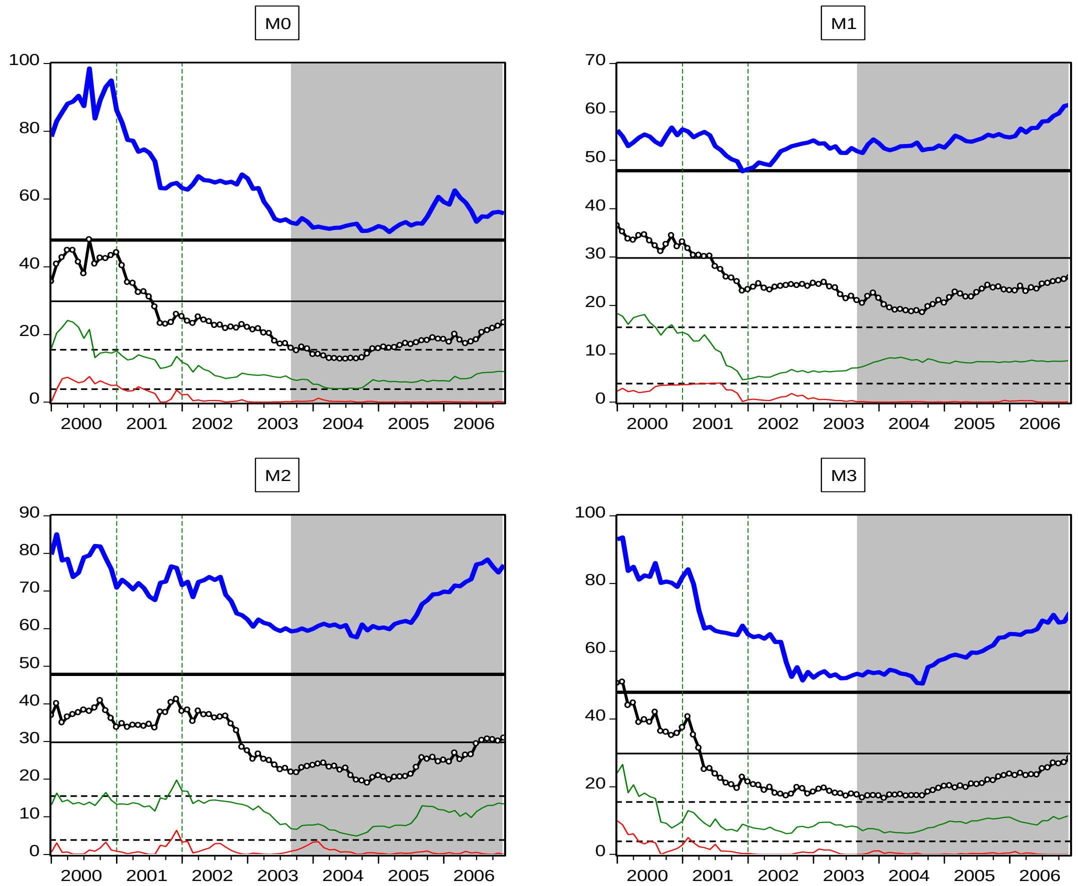


Figure 4 shows the results of the dynamic cointegration analysis for a standard money demand function, based on the evolution of the trace statistic[6] adding observations sequentially, in a rolling windows fashion as before. The upper (blue) curve in each plot corresponds to null hypothesis of no cointegrating vector; the second (circled-black) and the third (green) ones correspond to the null that there are 1 and 2 cointegrating relationships, respectively. In all cases the alternative hypothesis is that there are 3 cointegrating vectors, which means that there is no cointegrating relationship at all (because the model contains three variables). To determine the number of

[6] The evolution of the maximum lambda statistic is similar.

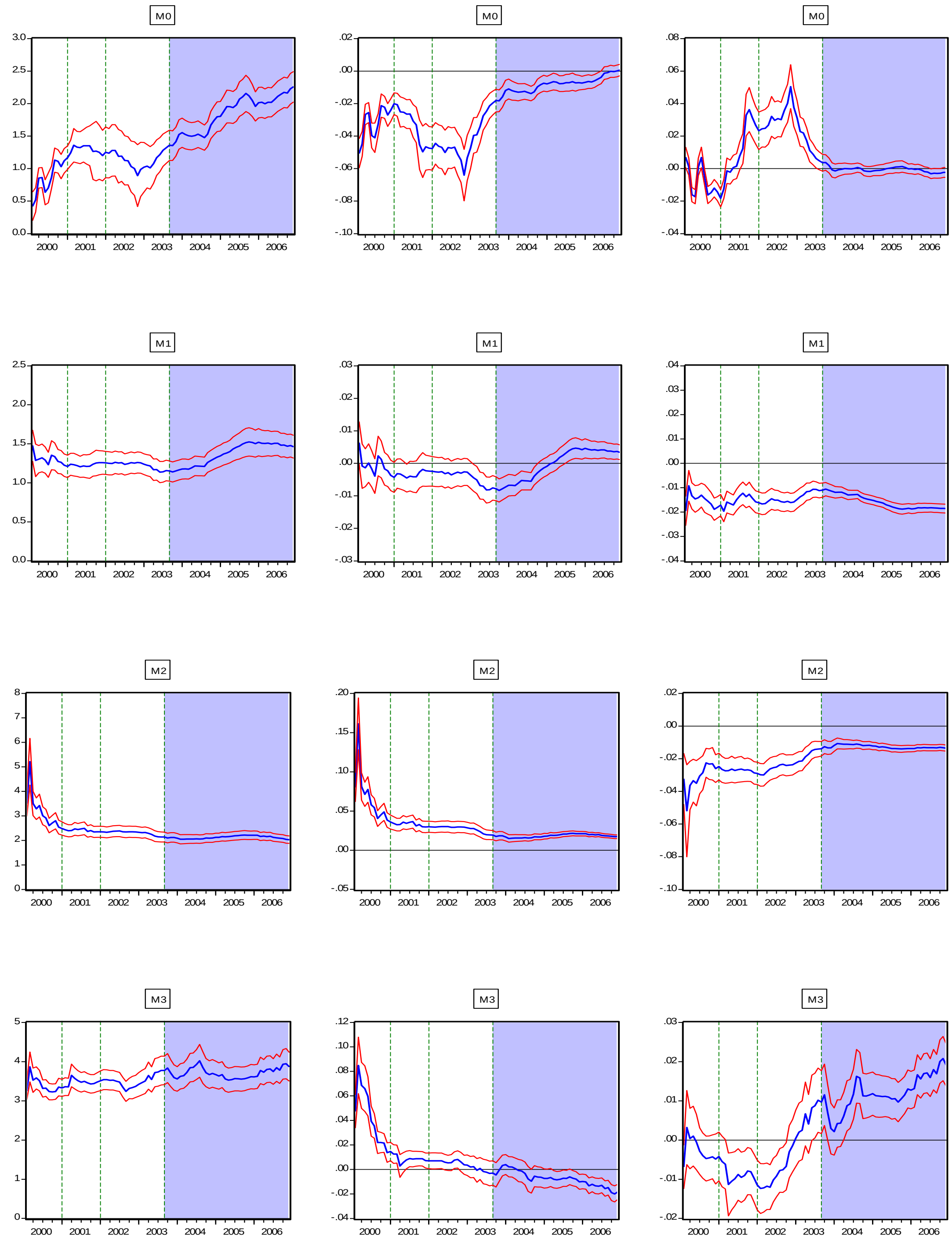
cointegrating vectors, we evaluate sequentially the presence of 0, 1 and 2 cointegrating vectors until we fail to reject the null. The results show that there is no strong evidence of cointegration in the case of M0, M2, and M3. However, there is one cointegrating relationship for the case of M1 when the end-point of the sample is between the end of 2001 and the end of 2003 (we reject the null of "no cointegrating vector" but fail to reject the null of "1 cointegrating vector"). Overall, the results reveal that the relationship between real money, output and interest rate is not suitable for cointegration.

Figure 5



However, the null of no cointegration is rejected for all cases when taking into account the presence of dollarization, as it is shown in Figure 5. Considering mid-2001 as the end-point of the sample (and for subsequent larger samples), there is clearly one cointegrating relationship between real money (based on M0, M1 and M3), real output, interest rate and dollarization. In case of M2, there appear to be 2 cointegrating realtionships before the end of 2002.

Figure 6



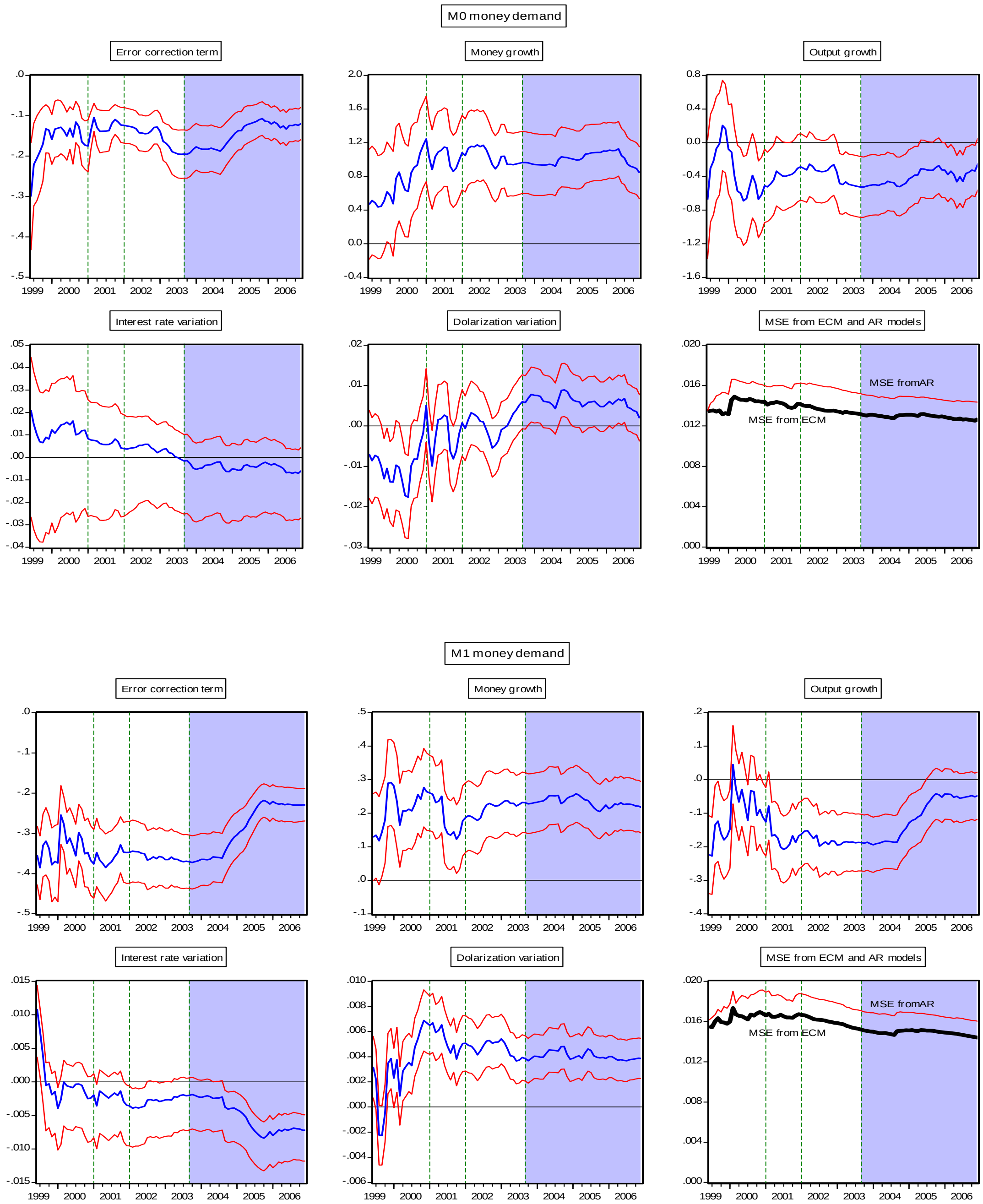
To analyse the stability of the relationship estimated, we again use the SupF and MeanF statistics. In all cases, the null of parameter stability cannot be rejected either at the 1% or 5% level (although in some cases it was rejected at the 10% level). To have a more intuitive understanding of these results, Figure 6 shows the evolution of the recursive coefficients of the cointegrating relationship. The first row shows the recursively-estimated parameters based on M0; the second, third and fourth corresponds to M1, M2 and M3, respectively. The first, second and third columns show the coefficients that correspond to real income, interest rate and dollarization, respectively. The clearest evidence of parameter stability corresponds to the money demand equation based on M1 (second row).

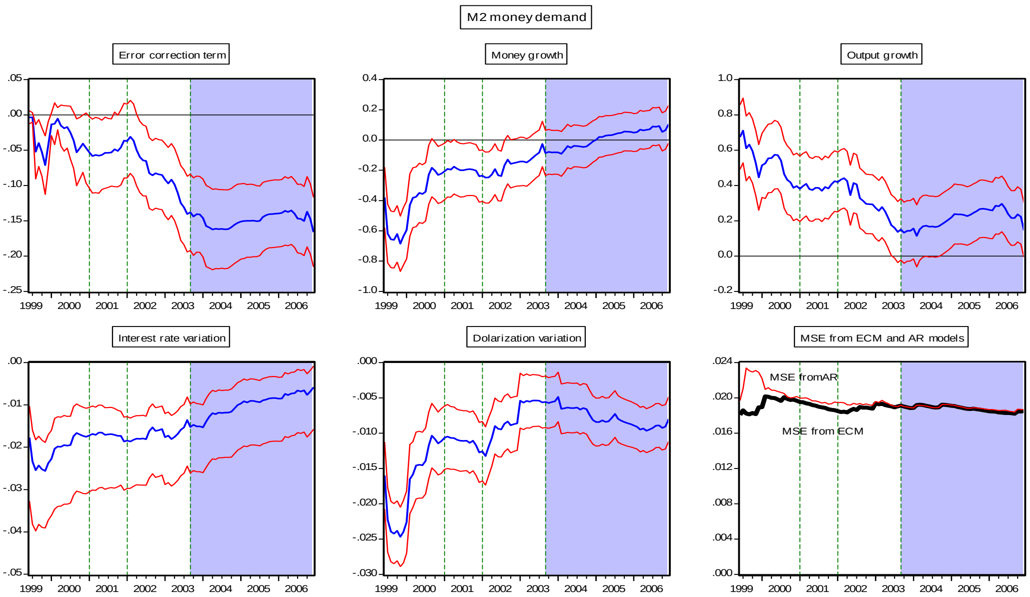
Altogether, these results suggest the use of a VEC model to analyse the relationship between money, output, interest rate, and dollarization.

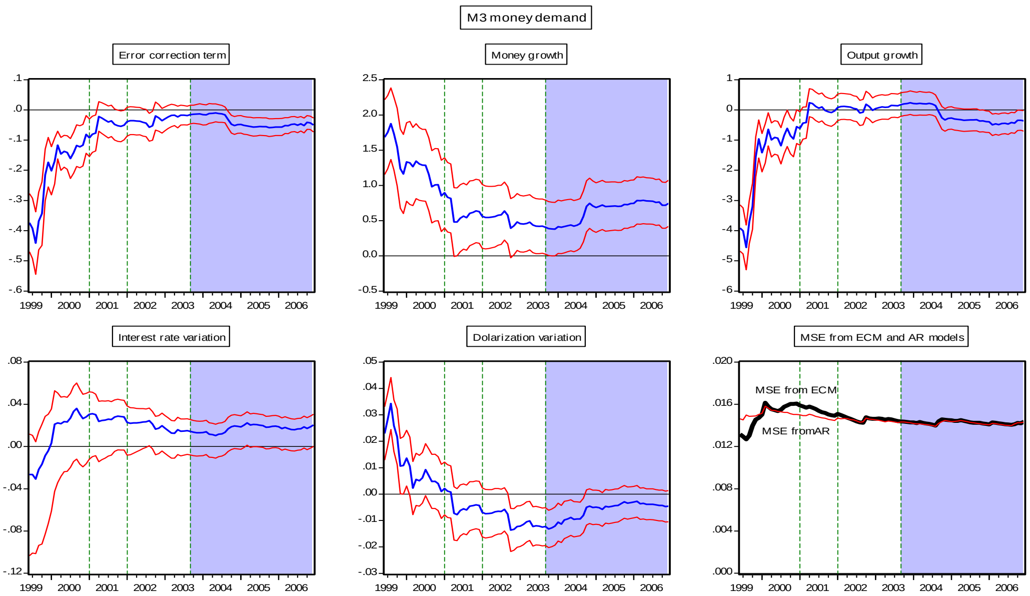
3. MONEY DEMAND INSTABILITY?

In this section we provide evidence that money demand in Peru is stable for the specification that includes dollarization and M1 (the stability analysis of the standard specification is not relevant given the fact that there is no evidence of cointegration for it). The results presented in Figure 7 are based on a VECM estimated using Johansen's methodology.

Figure 7





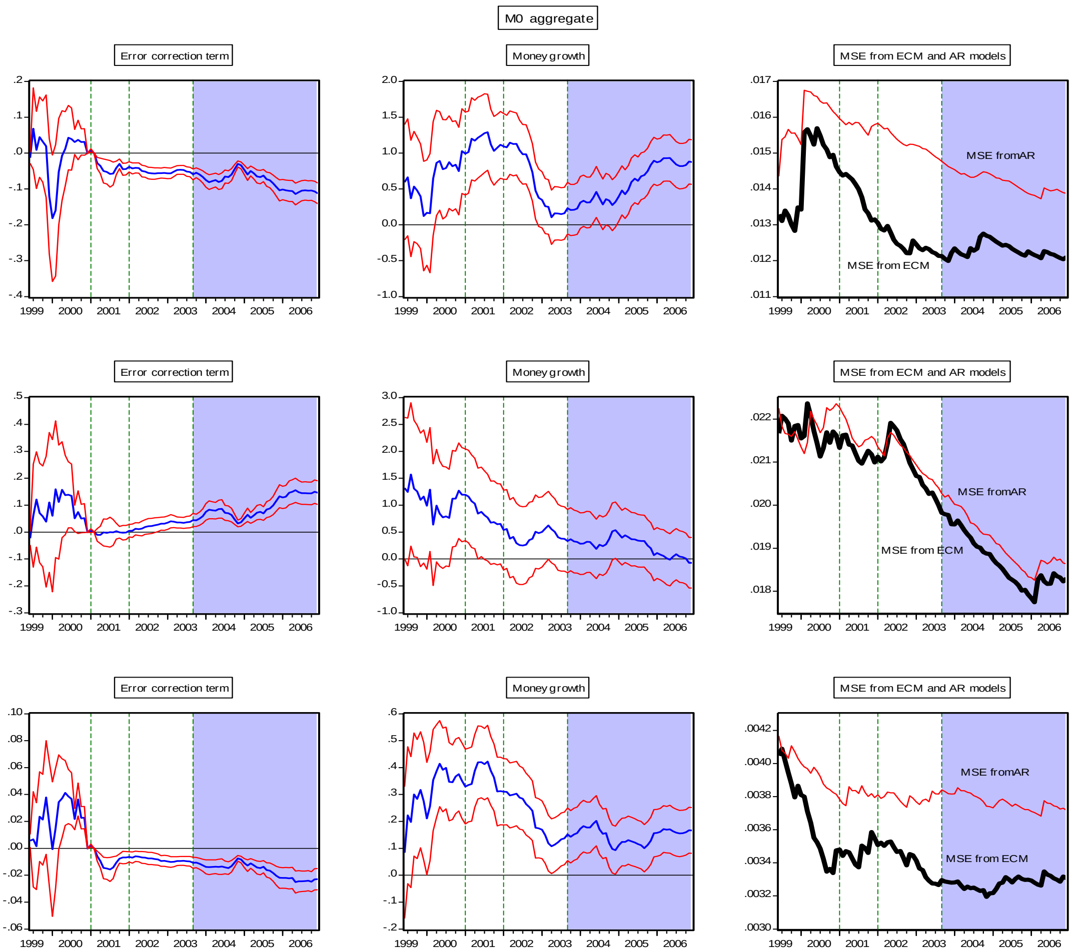


In the case of money demand functions using M0 or M1 as proxies for money, it is evident that the mean square error (MSE) for the error correction model is better (lower) than the corresponding one obtained from a standard autorregresive model. Furthermore, the estimated parameters seem to be more stable for M1 than for M0. In summary, the results suggest that money demand in Peru is stable for M1. This does not mean that the monetary policy regime should change back to a money targeting regime (which would be costly), but that M1 should at least be viewed as a signal variable for output and interest rate (and dollarization as well). Thus, money measured as M1 could be used in a feedback rule because the optimal response is likely to be time invariant.

4. MONEY AS AN INFORMATION VARIABLE

In this section we present results that show clear evidence that money contributes to forecast inflation, real and/or nominal output. The only exception occurs when money is measured by M3 (broadest monetary aggregate); in this case money can be used as an information variable. The results are based on the estimation of a VEC model between nominal money, real (and nominal) output, interest rate, dollarization and prices.

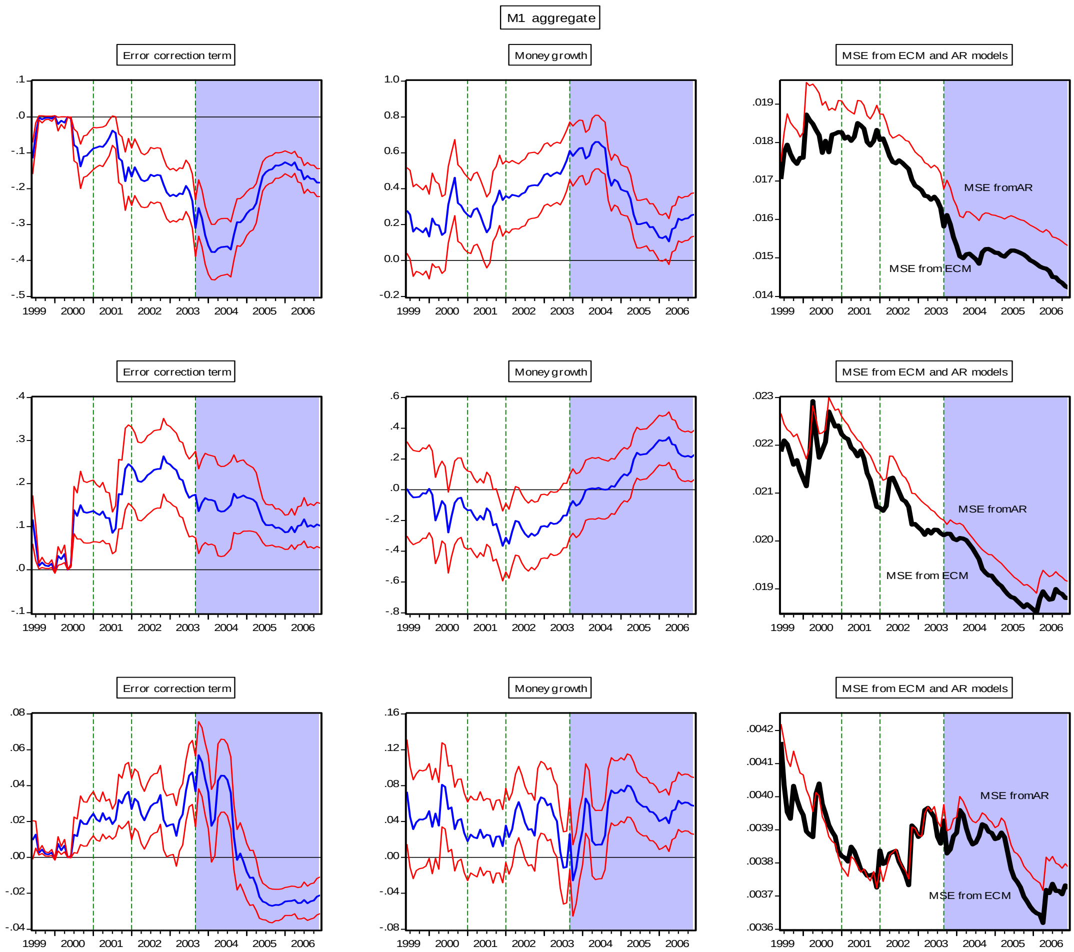
Figure 8



In a cointegrating framework, variable X is said to contribute to the prediction of *Y* if *X* is weakly exogenous (so the cointegrating error term does not affect the error correction model of X), and Y does not Granger cause X. When these two conditions hold, we say that X is strongly exogenous and thus can be used to predict Y (Hendry, 1995). Our results will be interpreted based on these definitions.

Figures 8 to 11 show the evolution of the estimated coefficients of the error correction term (first column), the total effect of money growth (measured as the sum of the coefficients that correspond to the lags of money growth), and the mean squared error (one calculated from the corresponding error correction model and the other from an equivalent autoregressive model) obtained from the estimated VEC model for each monetary aggregate[7]. In each figure, the first, second and third rows show the results for money growth, real output growth and inflation error correction equations, respectively.

Figure 9



From the first row of Figures 8, 9 and 10 we conclude that money (measured as M0, M1 and M2) is not weakly exogenous, because the error correction term is significant for recursive samples of sizes larger than 10 years (from 2003 onwards). Only M3

[7] All the graphs show the estimate coefficients and their corresponding confidence intervals (plus/minus two standard errors).

growth appears to be weakly exogenous (Figure 11), and thus is the only candidate to be strongly exogenous.

Figure 8 suggests that the M0's rate of growth Granger causes inflation but it does not Granger cause real output growth. The comparison of the mean squared errors reveals the importance of the error correction specification for the money growth, real output growth and inflation equations.

Figure 10

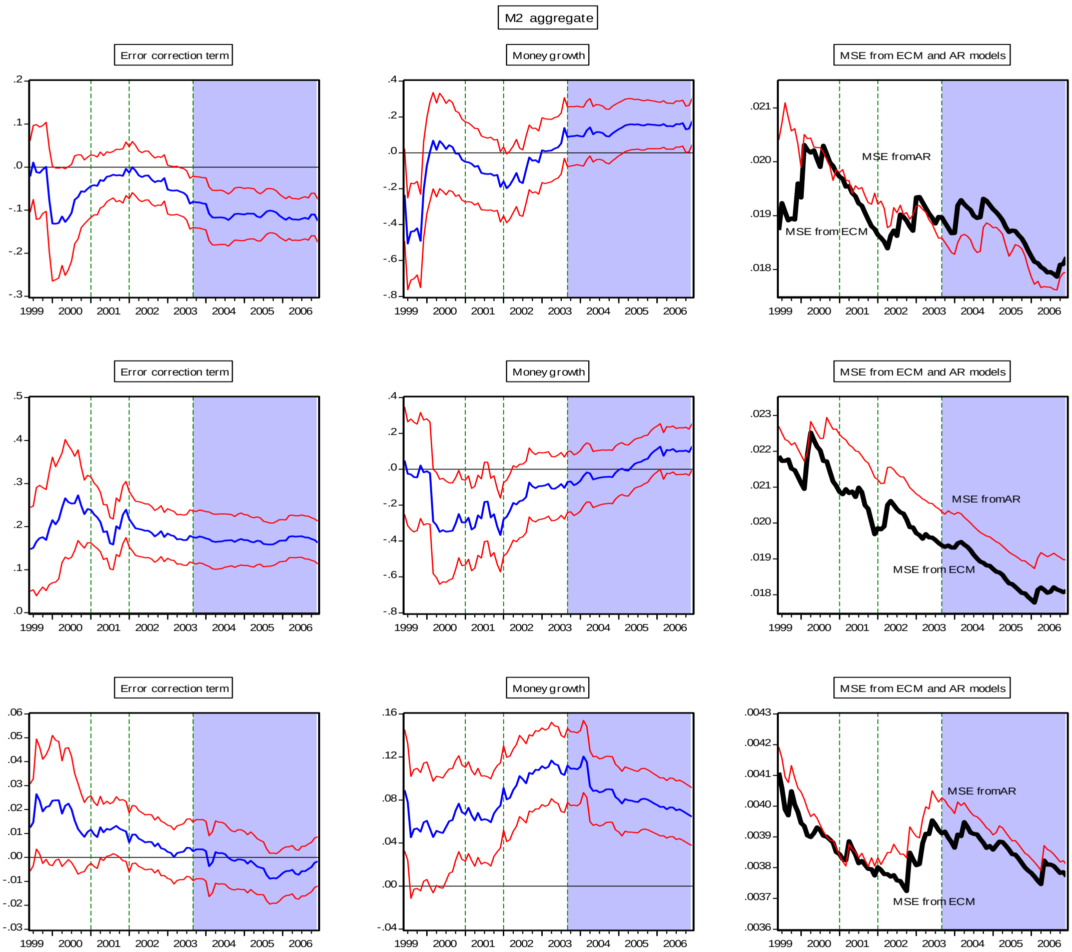
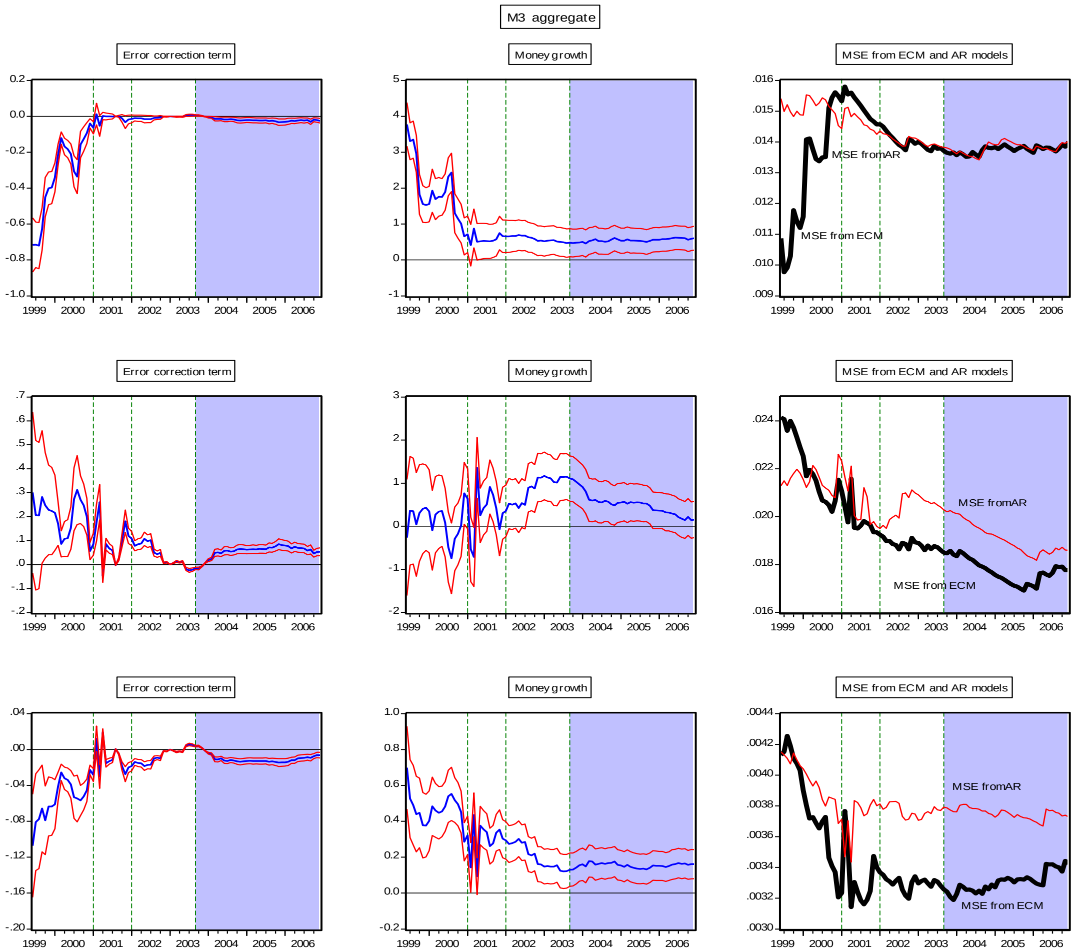


Figure 9 reveals that M1 Granger causes both real output growth (for recursive samples ending in 2004 and onwards), and inflation (for recursive samples ending in 2003 and onwards), and that these causalities seem to be stable once they start to be significant. Again, the comparison of the corresponding MSE's suggests the error correction model specification is reasonable.

From Figures 10 and 11 it is evident that lags of M2 and M3 growth Granger cause inflation, and that the specified dynamic model performs better than the autoregressive alternative. Furthermore, M3 is strongly exogenous given that no other variable Granger causes M3 growth. Finally, there is some evidence that lags of M3 growth contributed to the prediction of real output growth up until 2005.

Figure 11



In summary, from the dynamic relationship between nominal money, real output, interest rate, dollarization and prices we have found no clear evidence that supports the hypothesis that money helps predict for real output and prices. In particular, we find that all monetary aggregates Granger cause inflation and that only M1 seems to Granger cause real output growth. However, only M3 (the broadest monetary aggregate used in this paper) appears to contribute to the prediction of inflation given that M3 is strongly exogenous: M3 growth is not affected by the error correction term and is not Granger caused by inflation. Therefore, only M3 can be useful as an information variable for monetary policy in Peru.

Figure 12

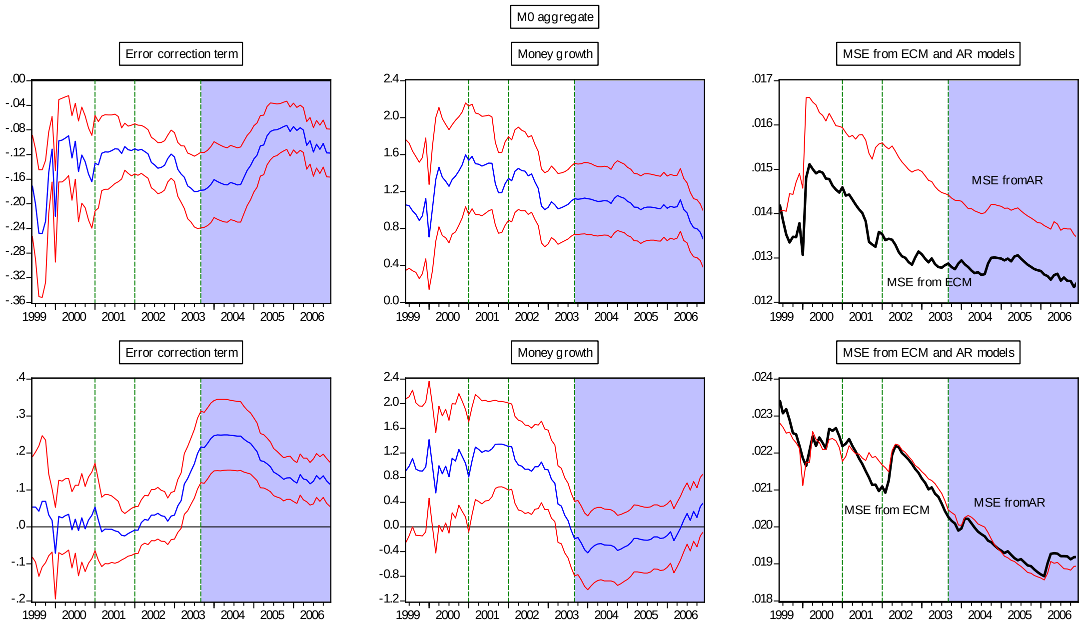
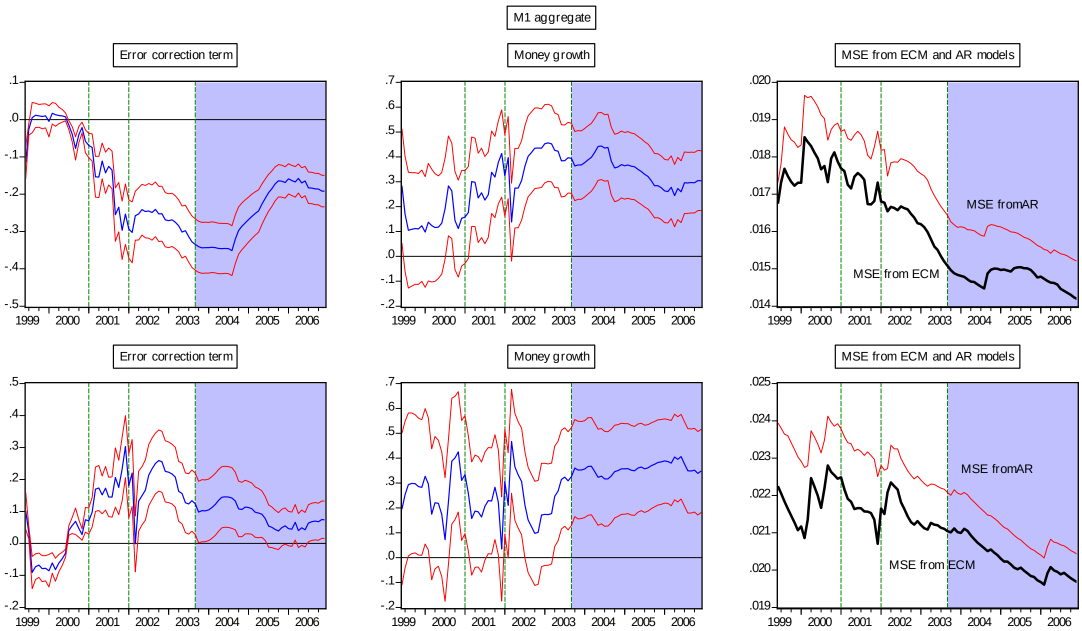


Figure 13



Finally, when considering nominal output in the cointegrating relationship (Figures 12-15), we find that only M1 and M2 Granger cause nominal output (in each figure, the second row corresponds to the error correction model for nominal output). Furthermore, we do not find evidence of strong exogeneity and thus no support for the hypothesis that money can be useful as an informative variable.

Figure 14

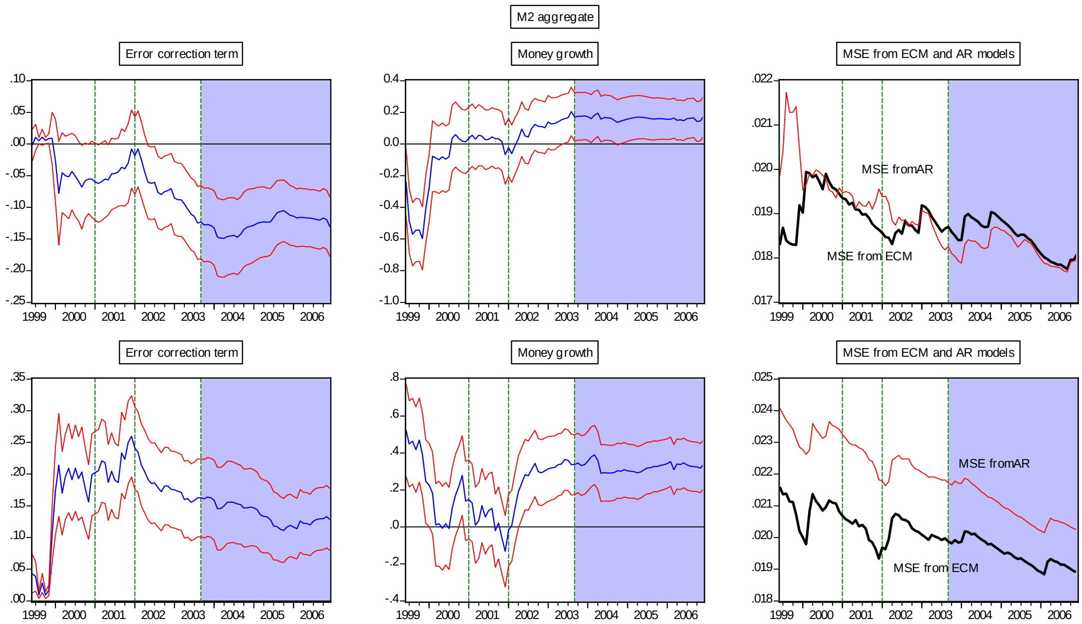
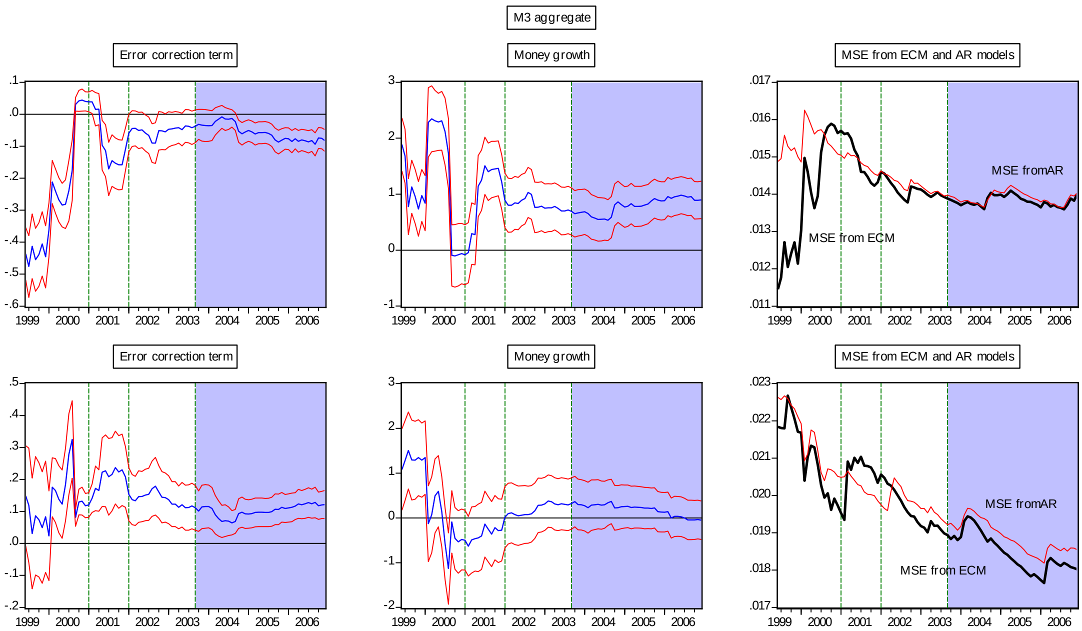


Figure 15



5. CONCLUSIONS

The purpose of this paper was to provide an empirical evaluation of the relevance of monetary aggregates in the conduct of monetary policy in Peru, a small-open and partially dollarised economy. The paper was motivated by the recent tendency to discard the use of monetary aggregates as a central piece for monetary policy, both in theory and in practice. Apparently, monetary policy in Peru has followed this trend since 2002, switching from a monetary targeting regime to an inflation targeting regime, and explicitly using an official interest rate (the so called "reference interest rate") as its policy instrument since September 2003.

The empirical evaluation was based on vector error correction (VEC) models given the non-stationarity of the series and the existence of at least one cointegrating vector. A recursive analysis of VEC models was also performed in order to provide robustness to the results. Furthermore, previous empirical studies where extended as follows: (i) introducing a proxy variable for dollarization in money demand functions for Peru, and (ii) testing for the presence of cointegration with structural change among the analysed series. Finally, the analysis of relevance of monetary aggregates as information variables was based on the concepts of weak and strong exogeneity, as proposed by Engel et al. (1983), Hendry (1995), and Granger and Lin (1995).

The results show no clear evidence that monetary aggregates can be use as policy instruments or information variables, except for the case of the broadest monetary aggregate, M3. In particular, we find evidence that traditional money demand functions are not longer stable, which is against the use of monetary aggregates as policy instruments; however when including a proxy variable for “dollarization” money demand functions become stable in some cases. On the other hand, we find that only M3 can be useful to forecast inflation and thus it has a role in monetary policy as an information variable. In the case of narrower monetary aggregates, we find no clear evidence of whether they can be useful to forecast inflation, real or nominal output.

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Appendix

A1. Structural break and cointegration

The literature on cointegration shows that traditional cointegration tests are biased towards the non-rejection of the null hypothesis of no cointegration when there is any structural break. Thus, it is possible to wrongly reject the existence of cointegration if there exists structural change.

Quintos (1995), Gregory and Hansen (1996), Seo (1998), Hansen (2000) and Lütkepohl et al. (2001) provide tests of cointegration under structural breaks. The main difference among these tests is the **null hypothesis about cointegration**. Quintos (1995), Seo (1998) and Hansen (2000) develop tests based on likelihood functions under the **null hypothesis of cointegration** versus the alternative hypothesis of **cointegration with a structural break** or (like in Quintos, 1995) changing regime over time. Gregory and Hansen (1996) develop test under the null hypothesis of no cointegration versus the alternative hypothesis of cointegration and cointegration with break.

Gregory and Hansen (1996), propose extensions of the ADF tests (with intercept and trend) to evaluate the presence of cointegration with structural break. The proposed methodology provides tests to assess of the presence of a regime change in the intercept or in the coefficients vector. The tests can be considered as multivariate extensions of existing univariate tests with the null hypothesis of unit root in a time series versus the alternative hypothesis of stationarity with break in the deterministic component of the series, e.g. Perron (1989), Banerjee, et. al. (1992), Perron and Vogelsang (1992) and Zivot and Andrews (1992). In particular, some of the results of these papers can be considered as special cases of Gregory and Hansen's (1996) results, when the number of stochastic regressors is zero.

The main advantage of the methodology proposed by Gregory and Hansen (1996) is the specification of the null and the alternative hypotheses in the construction of the statistics, the main limitation being the presence of only one structural break.

Gregory and Hansen test (1996)

Gregory and Hansen base their analysis on four cannonical models. Let $y_t = (y_{1t}, y_{2t})$ be the vector that contains the observed values in *t* of y_{1t}, which takes real values, and of y_{2t}, which is a vector of m elements.

Model 1: ***Standard Cointegration***

(1) $y_{1t} = \mu + \alpha^T y_{2t} + e_t, \qquad t = 1,\ldots,n,$

where y_{2t} is $I(1)$ and e_t is $I(0)$. In this model the parameters μ and α describe an *m*-dimensional hyperplane towards which the process vector y_t tends over time.

In many cases, if model 1 is used to capture long-run relationships, the μ and a α can be considered time-independent parameters. Nevertheless, in other applications it may be desirable that cointegration holds for a period of (long) time and then changes to another long-run relation. The structural change can be reflected in changes in the intercept μ and /or in the slope α. To model a structural change, it is useful to define the following dummy variable:

$$\varphi_{t\tau} = \begin{cases} 0 & si \quad t \le [nt] \\ 1 & si \quad t > [nt] \end{cases}$$

where the unknown parameter $\tau \in (0,1)$ indicates the (relative) timing of the change point, and $[\ ]$ denotes integer part.

Gregory and Hansen (1996) discuss three among many possibilities of structural change. One simple case is when there is a change in the level of the cointegrating relationship, which can be modelled as a change in the intercept μ, holding constant the slope coefficients inside α. This implies that the equilibrium equation has shifted in a parallel fashion. This is a level shift and it is denoted by C.

Model 2: Level shift (C)

(2) $y_{1t} = \mu_1 + \mu_2 \varphi_{\tau t} + \alpha^T y_{2t} + e_t \qquad t = 1, \ldots, n.$

In this equation, μ_1 represents the intercept before the change, and μ_2 represents the change in the intercept in the moment of change and afterwards. Also, a time trend can be introduced into the level shift model:

Model 3: Level shift with trend (C/T)

(3) $y_{1t} = \mu_1 + \mu_2 \varphi_{\tau t} + \beta t + \alpha^T y_{2t} + e_t \qquad t = 1, \ldots, n.$

Another possible structural change can be modelled allowing changes in the slope vector, which allows the equilibrium relation to rotate as well as shift paralell:

Model 4: Regime Shift (C/S)

(4) $y_{1t} = \mu_1 + \mu_2 \varphi_{\tau t} + \beta t + \alpha_1^T y_{2t} + \alpha_2^T y_{2t} \varphi_{t\tau} + e_t \qquad t = 1, \ldots, n.$

In this case μ_1 and μ_2 are the same as in the level shift model, α_1 indicates the slope coefficients of cointegration before the regime shift and α_2 denotes the change in the slope coefficients.

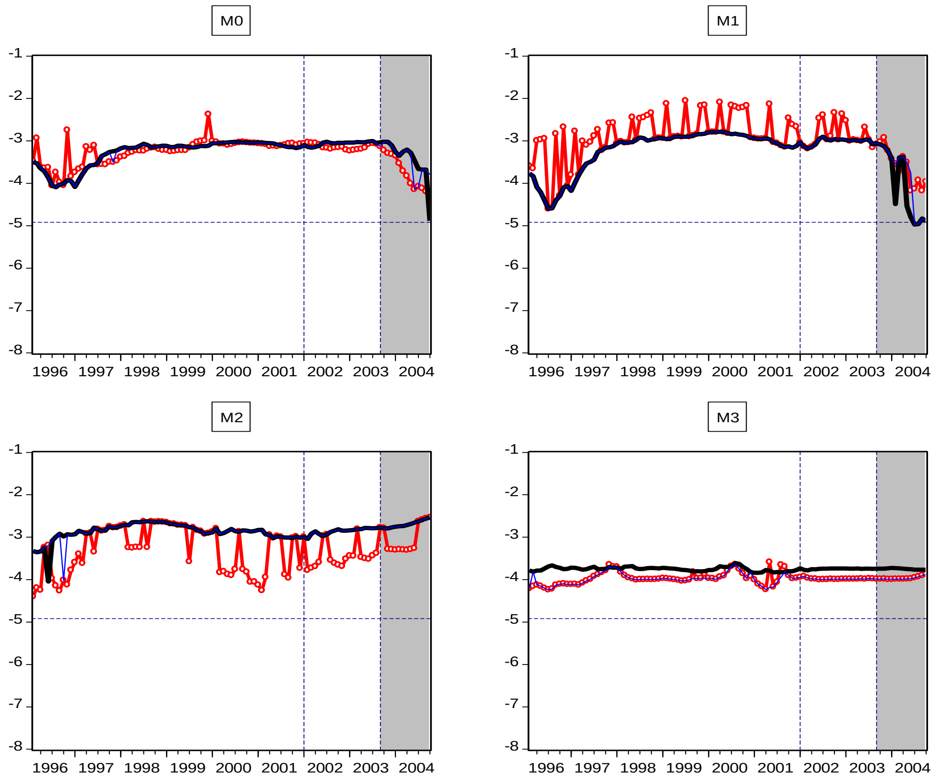
The standard methodologies to evaluate the null hypothesis of no cointegration (derived from the model 1) are residual-based. The candidate relation of cointegration is estimated by Ordinary Least Squares (OLS), and a unit root test is applied to the regression residuals. In principle, the same approximation can be used to evaluate models 2, 3 and 4 if the duration of the regime change τ were known. Nevertheless, the authors assume that the break points have a low probability to be known in practice.

Gregory and Hansen (1996) suggest evaluating the cointegration with structural break in two steps. First the researcher evaluates cointegration using (1), if the null hypothesis of no cointegration is not rejected then the cointegration can be evaluated using (2), (3) and (4). If the null hypothesis of no cointegration is rejected then it can be concluded that there is a high probability that a structural break has occurred. The procedure is as follows:

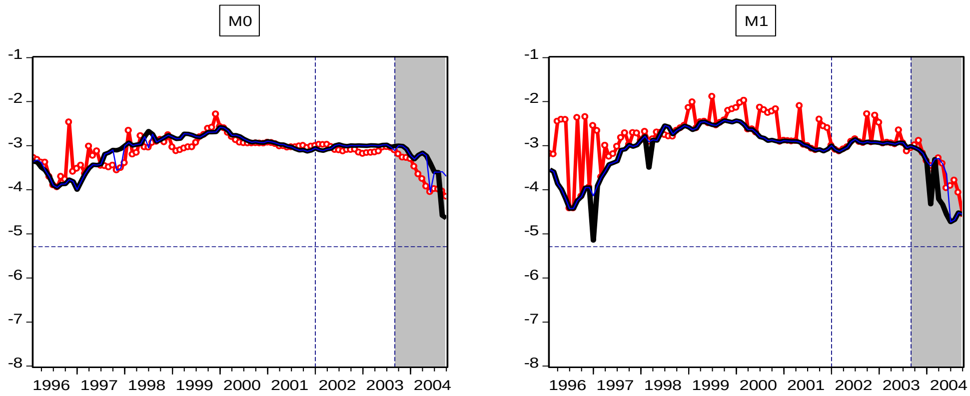
a. Estimate any model (2), (3) or (4) for every point contained in the interval 15% - 85% of the total sample.
b. Apply ADF tests to each set of regression residuals.
c. Choose the smaller ADF statistic (known as ADF^{*}) and then compare it with the critical value tabulated by Gregory and Hansen (1996). If the null hypothesis of no cointegration is rejected using (2), (3) or (4), this can be interpreted as evidence of a structural break.

The following figures show the results for Gregory and Hansen's test applied recursively to the standard money demand specification and the one with dollarization. The tests show no evidence of cointegration with unknown structural break in any case, except for M1 with dollarization, for which the test is not applicable given that for that model the null of no cointegration was rejected with the standard tests.

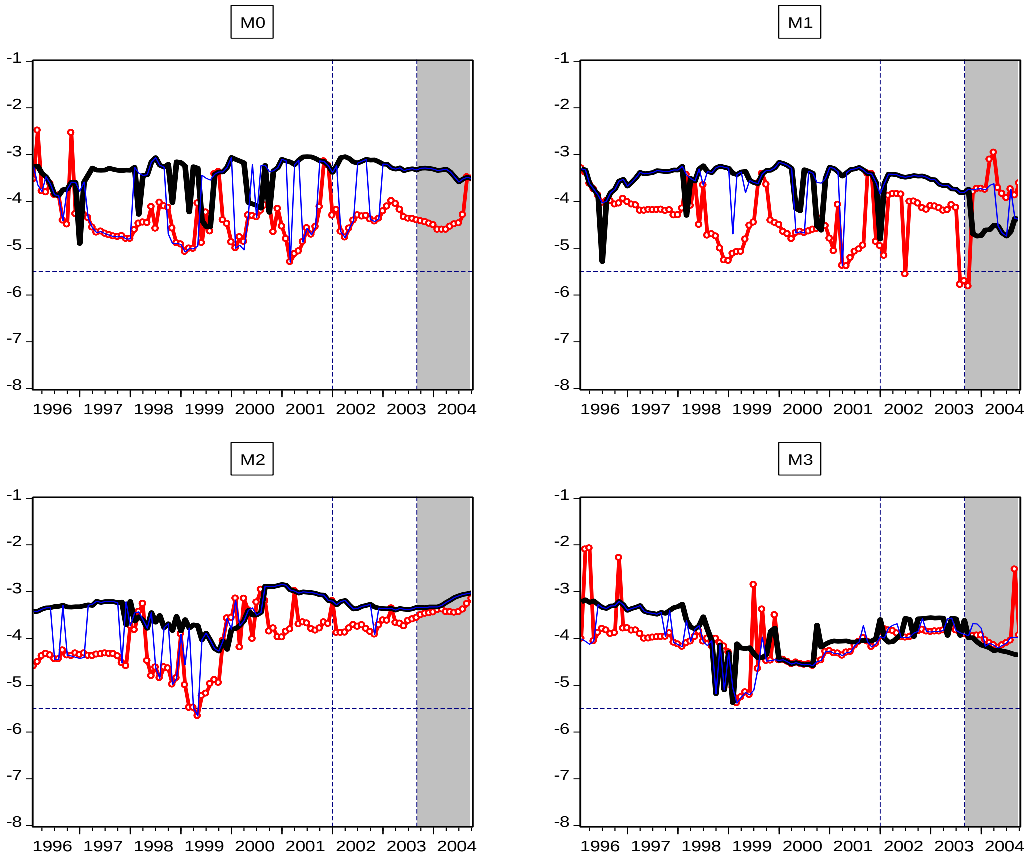
Model C



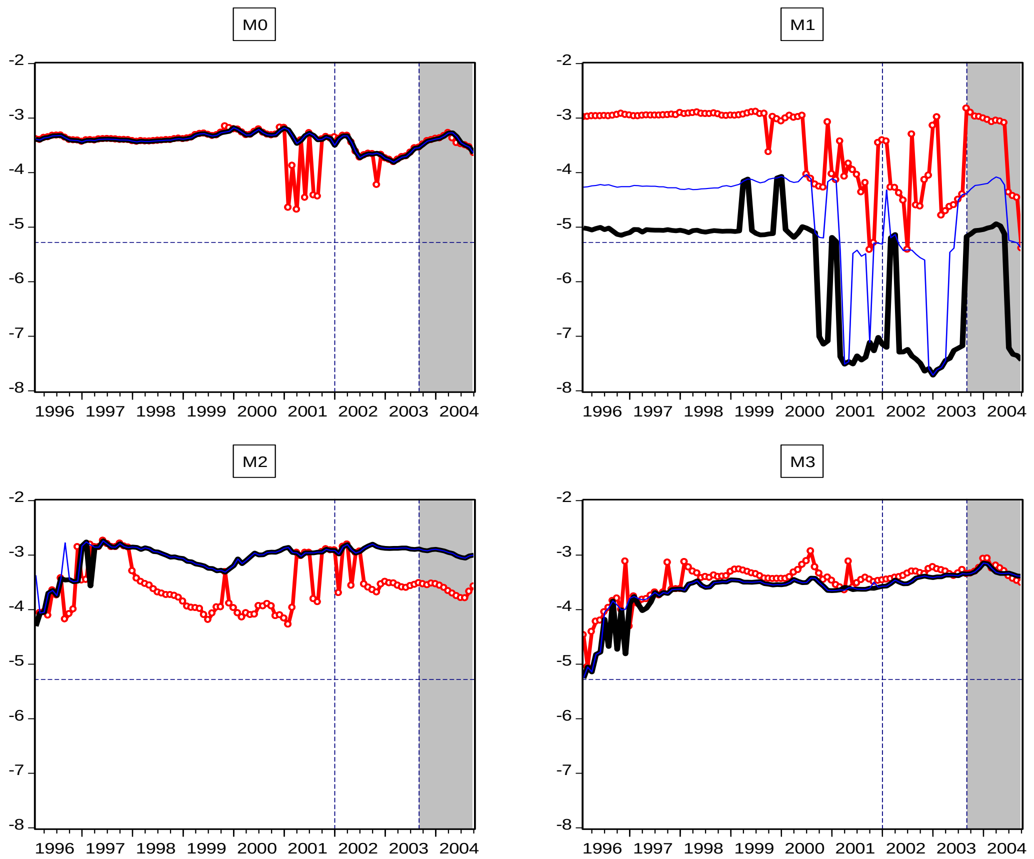
Model CT



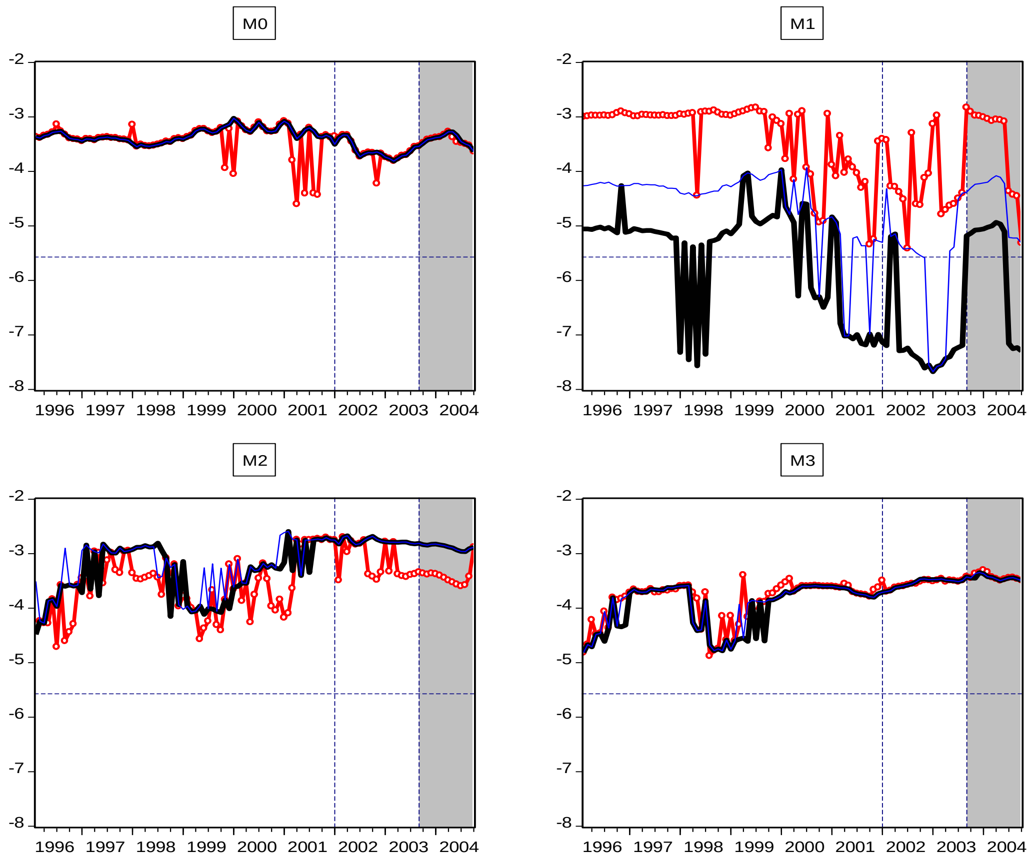
Model CS



Model C with dollarization



Model CT with dollarization



Model CS with dollarization