

# Forecasting a monetary aggregate in a changing environment: Argentina after 2002

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## Abstract

*This paper develops a comparative analysis of different forecasting approaches for the aggregate which is a main target of the monetary policy in Argentina. First we present the results of estimating a conditional EqC model of money demand, which characterizes the whole sample and shows “ex-post” constancy. Then we compare forecasts from this “causal” model with those obtained by other methods: VAR in differences, “naive” (univariate) models and robustified devices, as well as forecasting aggregates by disaggregates and by model and window pooling forecasts. They are evaluated for a period in which there was often uncertainty about the economic regime.*

JEL: C53, E41, E47

\*The views expressed herein are solely our own and should not be interpreted as those of the Central Bank of Argentina.

## 1. Introduction

During the last decade main developments in forecasting theory have been focused on DGPs (Data Generating Process-es) subject to major and unanticipated shifts (Clements and Hendry, 1998, 1999). In this more realistic setting conventional results have been reviewed. Specifically, forecasts from a model which approximates the conditional expectations of the data (“an econometric model”) does not need to produce the “best” forecasts. In turn, a simpler and “non causal” model (“a naive model”) “can” do better as many of them resulted to be also more adaptive to the unanticipated changes.

Taking into account the assumption of intermittent and unanticipated DGP shifts to understand economic forecasting is good news for unstable economies like Argentina, where empirical researchers are accustomed to face parameter instability and forecast failures. Structural breaks and policy regime changes have not been exceptional but largely intermittent and unanticipated. Thus, this environment provides a fruitful and defying field to study the relative performance of different forecasting methods. No previous work has been focussed on forecasting performance for Argentina except Aguirre et. al. (2006). They considered the issue of forecasting for a set of different monetary aggregates during 1993-2005 period.

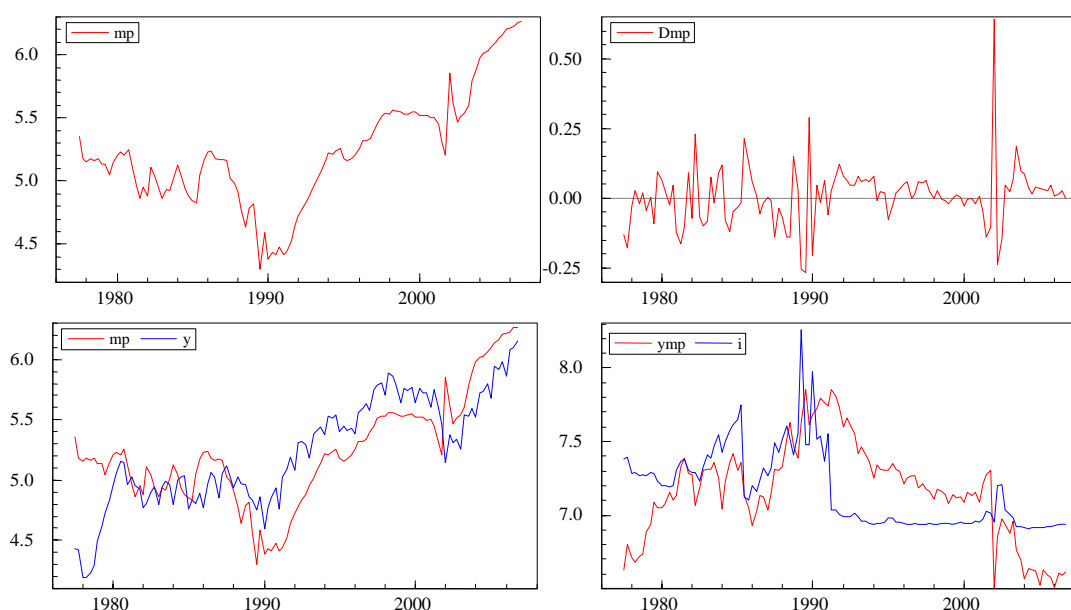
Forecasting monetary aggregates has been a difficult task usually associated to the intrinsic instability of the money demand. Therefore, the aim of this paper is twofold. On the one hand, we estimate a money demand for M2, which has become recently a main target of the monetary policy. This model shows ex post parameter stability “within sample” and (conditionally) non predictive failure. On the other hand, its forecasting performance is compared with a wide range of forecasting alternative approaches. The period evaluated seems very interesting to study because it includes the aftermath of the abandonment of the Convertibility regime and the default of the sovereign debt. In this period there was also a lot of uncertainty about stabilization results until they finally took place.

The next section presents a brief description of the data from a historical perspective. Section 3 shows the results of estimating an econometric model of money demand; it is a causal model which includes an equilibrium correction term. Section 4 analyses its forecast performance in comparison with the other approaches. Section 5 concludes.

## 2. Data Description.

The analysis is focussed on an Argentine monetary aggregate denoted as M2 (defined as narrow money, current account and saving deposits in pesos). Quarterly data over 1977-2006 are empirically studied, although different windows of data are also used according to the purpose of the model. Figure 1 records the time plot of real M2 (deflated by the consumer price index), expressed in logs and in log differences, along with transactions and also defined as velocity, jointly with the nominal interest rate for the whole sample. Visual inspection of Figure 1 shows two periods according to the underlying trend of real money: downwards until 1991 and upwards after this year.

**Figure 1: Real M2, in log levels, in log differences and its long run determinants**



The downward trend of the first period (1977-1991) was also characterised as a whole by an upward trend in inflation that accelerates in the mid-seventies when consumer prices passed the 50% annual rate and becomes a hyperinflation process in 1989 and 1990. Interest rate reflects this behaviour. However, the downward trend of real money was accompanied by several attempts to stabilize inflation. In 1985 a stabilization program known as Plan Austral led to a temporary decrease in inflation and to an increase of money holdings, but inflation soon accelerated and the reduction in real money holdings was dramatically during the hyperinflation process of the end of 1989 and the beginning of 1990.

The upward trend in real money holdings started after the 1991 Convertibility regime that backed the money base on external reserves to guarantee the one-peso to one-dollar rate of exchange. This monetary regime was undertaken at the same time that deep reforms move the economy towards free market and the largest growing in activity within the sample was experienced. This trend -both in real activity and real money- broken up in the second half of the nineties. The relative tranquillity of the first half of the nineties was temporarily interrupted in 1995 due to the regional consequences of the Mexican devaluation (known as "Tequila effect"). Although the Convertibility withstood these external shocks, it was a first evidence of the vulnerability of this monetary regime. The government external debt was increasing over time and began to be perceived as unsustainable once the economy entered a deep recession after the Russian (1998) and Brazilian (1999) crisis.

Regarding the last part of the sample it should be notice that in 2001 a financial and external crisis led to a reduction of real money holding previous to the abandonment of the Convertibility regime which lasted for more than ten years. The regime collapsed in January 2002 after the government announced the default on its sovereign debt and the abandonment of currency board scheme. Before the crisis, the

access to capital markets by Argentina was severely restricted ending the financial liberalization experienced during the 1990's. Although financial flows to emerging countries had been decreasing since the Russian crisis (the "sudden stop" of Calvo, Izquierdo and Talvi, 2002), after the sovereign debt default, the Argentine economy faced further credit restrictions arising from both external and domestic sources. Not only did capital outflows accelerated but also, at the same time, there was a domestic credit disruption because of financial restrictions and the asymmetric pesification of bank deposits and loans which took place after devaluation (Miller, et.al., 2004). Although the devaluation provoked a jump in inflation rate, that reached a peak in the second quarter of 2002, it then returned to the low levels of the Convertibility. Argentine financial system tended to recover and the real money holdings started to increase continuously, also motivated since 2004 by the strong growth that the economy experienced after the prolonged recession that had suffered for several years.

Understanding the behaviour of money demand in such a long period could be useful to learn about the future beyond the forecasting purpose itself.

### 3. A causal Equilibrium Correction Model

The demand for M2 can be related to the transaction motive and also to the precautionary motive for holding money (see Baumol, 1952, Tobin, 1956, and Friedman, 1956)<sup>1</sup>. In both cases, real money would depend on a measure of the volume of real transactions and the opportunity cost of cash holdings. The scale elasticity of transaction variable is anticipated positive, taking values of 1 or 0.5, according to the Cambridge interpretation of the Quantity Theory as a demand function or the Baumol-Tobin hypothesis, respectively. We approximate transactions by aggregate supply (GDP plus imports)<sup>2</sup>. Regarding the opportunity cost three alternatives could be taken into account: inflation, exchange rate and the domestic interest rate. The issue is whether or not they are substitutes or complement measures of the opportunity cost of holding money. In the case of the interest rate it is worth noting that it embodies an expected rate of inflation, which could be – in some periods – quite different from actual ones<sup>3</sup>.

The estimation of the Equilibrium Correction starts with the analysis of cointegration<sup>4</sup>, using the system-based procedure of Johansen (1988) and Johansen and Juselius (1990). It also allows for the exogeneity issue, which should be evaluated to validate a conditional model of money demand. A first system for an extended sample (1975-2006) included the money aggregate ( $m$ ), the level of prices ( $p$ ), the aggregate supply ( $y$ ), inflation ( $\pi$ ), the nominal interest rate of time deposits ( $i$ ) and the nominal exchange rate peso-dollar ( $E$ ). The results showed a long run elasticity of prices and transaction equal to 1 and the lack of significance of inflation and nominal exchange rate variable as long run determinants<sup>5</sup>. Nominal interest rate is the proxy of opportunity cost that resulted as significant. Then the bivariate system showed that real holdings, expressed as inverse velocity ( $mpy$ ), and nominal interest rate ( $i$ ) have one long run (cointegration) relationship with vector coefficient of (1, 0.79). Also LR tests indicated the validity of the conditional model of  $mpy$  on  $i$  for the whole sample. Therefore, the relationship between these two variables was modelled as a conditional univariate equilibrium correction model.<sup>6</sup>

<sup>1</sup> See also Ericsson (1998) for the main issues related to money demand modeling.

<sup>2</sup> Aguirre et. al. (2006) and Gay (2004) considered GDP as transaction variable. Ahumada (1994) and Ahumada and Garegnani (2002) used Aggregate Supply as a proxy for transactions.

<sup>3</sup> Although saving accounts pays interest, this rate has not been considered because it has been very low in comparison with the rate of time deposits and its low participation in the aggregate at least until the nineties.

<sup>4</sup> Unit-root tests indicate that the variables considered are I(1), they are available on request.

<sup>5</sup> Results are available upon request.

<sup>6</sup> All variables are expressed in logs,  $\pi$  as log differences and  $i$  as the log of one plus the rate.

Thus the econometric analysis continued with a model that included the equilibrium correction term of the  $mpy+0.79i$  and 4 lags of the log differences of each variable; also the proxies of opportunity cost that did not enter the long run relationship were again considered but as part of the dynamics. Dummy variables were also introduced for instability periods. The restricted model which has homoscedastic white-noise and normal residuals is,

#### Equation 1

Dmp =	-0.3566	+0.2722 Dy_2	-0.3116 Di
[HCSE]	[0.0944]	[0.0724]	[0.0286]
	-0.1786 Di_1	-0.05242 EqC_1	-0.0324 $D\pi_{nethypp-2}$
	[0.0306]	[0.0135]	[0.0096]
	+0.227 d822	+0.1436 d892	-0.3884 d893
	[0.0059]	[0.0362]	[0.0393]
	-0.1902 d912	-0.1294 d014	+0.6135 d021
	[0.0222]	[0.00674]	[0.0100]
	+0.1611 d033		
	[0.0070]		
$R^2 = 0.795$ $F(12,105)=33.99$ $[0.0000]$ $\sigma=0.051$ $DW = 1.51$			

#### Residual and specification tests

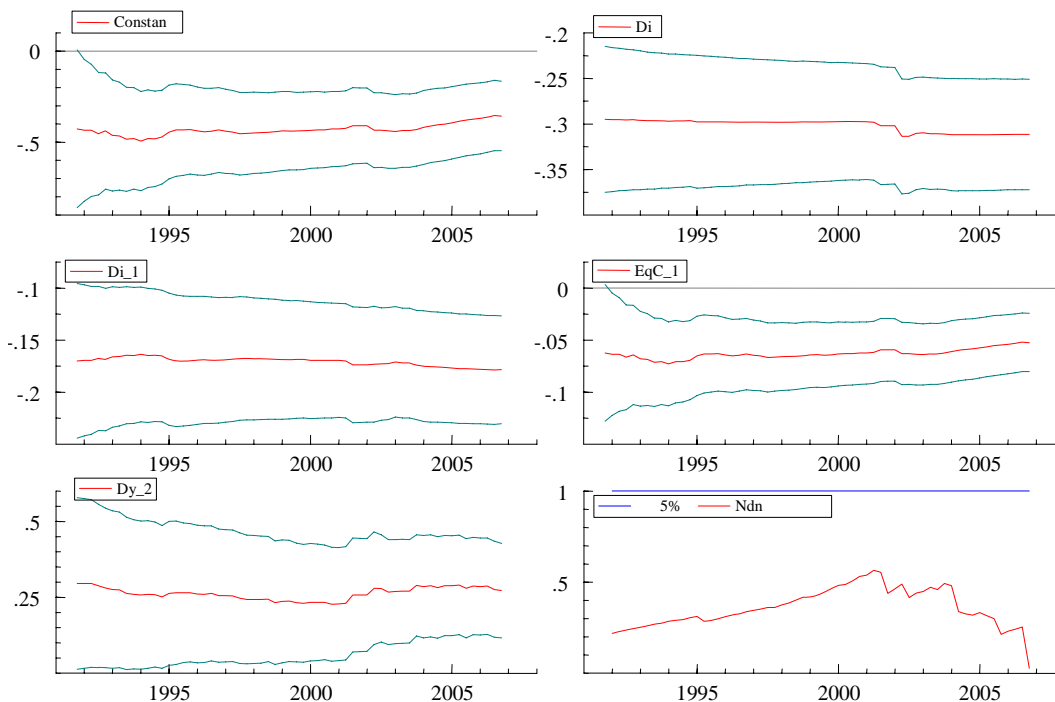
AR 1- 1	F( 1,104) =	1.6653	[0.1996]
AR 1- 4	F( 4,101) =	2.044	[0.0938]
ARCH 1	F( 1,103) =	3.0351	[0.0845]
ARCH 4	F( 4, 97) =	1.0267	[0.3975]
Normality	$\chi^2(2)$ =	0.81974	[0.6637]
$\xi^2$	F(17, 87) =	0.68454	[0.8098]
$\xi \cdot \xi_j$	F(27, 77) =	0.79197	[0.7481]
RESET	F( 1,104) =	0.068769	[0.7937]

In the model presented in Equation 1 the equilibrium correction term (EqC\_1) is significant and about 0.05 of the disequilibria is corrected in the first quarter in order to adjust the long run relationship between  $mpy$  and  $i$ . There is also a short run effect of aggregate supply: an increase of 1% in the growth rate of  $y$  between the second and third lag (Dy\_2), increases the growth rate of real money in 0.27%. In addition, the rate of growth of nominal interest rate of time deposits has a contemporaneous and one lag effect on the rate of growth of real money holdings; the total short run impact is negative and approximately 0.5%. The inflation entered Equation 1, expressed as differences (only positive changes), lagged two periods and net from hyperinflation outbreaks. The delay in this effect could be due to the period of time money holders need to adapt their decisions to changes in the opportunity costs apart from interest rate.

The dummy variables included in Equation 1, coincide with periods of crises or monetary regime changes: the second quarter of 1982 (d822) coincides with the Malvinas' conflict, the second and third quarter of 1989 (d892 and d893) coincide with the hyperinflation period, the second quarter of 1991 (d912) with the beginning of the Convertibility regime, the fourth quarter of 2001 (d014) and the first quarter of 2002 (d021) coincide with the external and financial crises of 2001 and the abandonment of the Convertibility regime. Instead, the dummy variable for the third quarter of 2003 (d033) could be due to a sharp increment in the monetary aggregate after the economy stabilization.

Although the sample includes a period of great macroeconomic variability, parameters constancy of the model of Equation 1 was not rejected by their recursive estimation, as can be observed in the next graphics (the recursive estimates of the main coefficients are within the previous 2 times standard errors intervals and the N-descendant Chow test shows values below the 5% significance critical value).

**Figure 2: Recursive Graphics**



#### 4. A comparative analysis of alternative forecasting methods

The model presented in Section 3 can be considered as a congruent representation of the Argentine money demand DGP over near three decades, accordingly to its within-sample properties. In particular the analysis of recursive estimates and the one-step conditional predictions do not reject “ex-post” constancy (see Clements and Hendry, 1999, Ch. 2) of the model (conditionally also to the model uncertainty). However, the actual forecasting performance may be different “because of the things we don’t know we don’t know”<sup>7</sup> and in this context forecasting failure may be not considered as a fatal flaw. Therefore, in this section we investigate the forecasting performance of this model in relation to other approaches, which are explained in 4.1. In 4.2 we apply them for Argentine real money.

<sup>7</sup>Singer, 1997 p. 39, quoted in Clements and Hendry, 1999.

#### 4.1 A review of the literature

The traditional theory of forecasting has been based on two key assumptions: i) the empirical model is a good representation of the economy and ii) the structure of the economy will remain relatively unchanged. Given these assumptions it has been proved that the best in-sample model produces the best forecasts, that adding causally relevant variables should improve forecast and it should not pay to pool forecast across models (once encompassing has been evaluated), among other properties.

However, empirical evidence has shown how inadequate these assumptions can be. In particular “since the future is rarely like the past in economics, forecast failure has been all too common” (Hendry and Nielsen, 2007, p.325).

Clements and Hendry (1999) reconsider the theory of forecasting relaxing the above mentioned assumptions and their results refute the properties based on them. The main point they addressed is which of the components of the econometric model is the responsible for forecast failure. The surprising “culprit” is the behaviour of determinist components (intercepts, linear trends, etc.). When they allowed determinist components to change, they found that the best model in-sample need not produce the best forecasts, models with no causally relevant variables can outperform and also can do so forecasts pooling, and other equally amazing results. These new properties are examined for the argentine monetary aggregate, by studying the performance of different forecasting approaches that take these properties into account, as explained below.

As the major source of changes in the determinist components are derived from location shifts, particularly, long run means (see Clement and Hendry, 1999, 2005 for the detailed reasons and Hendry and Nielsen, 2007 for a simple example), the vector equilibrium correction model, VEqCM, is the more affected one. The VEqCM is an appropriate re-parameterization of a VAR model in levels (assumed of first order for simplicity) for cointegrated I(1) variables (see Johansen, 1988). In “mean-deviations” the system becomes,

$$(\Delta x_t - \gamma) = \alpha(\beta' x_{t-1} - \mu) + \varepsilon_t \quad \varepsilon_t \sim IN[0, \Omega] \quad (1)$$

where  $x_t$  is a vector of  $n$  variables and  $\beta$  and  $\alpha$  are  $n \times r$  matrices when there are  $r$  cointegration vectors.

Suppose that at  $T+1$  the DGP suffered a break in the long run mean and become

$$\Delta x_t = \gamma + \alpha(\beta' x_{t-1} - \mu^*) + \varepsilon_t \quad t > T+1 \quad (2)$$

If forecasts (denoted by  $\hat{\Delta}$ ) are performed based on (1) the model prior the mean shift, then for the 1-step ahead forecast, the expected forecast error is

$$E[\Delta x_{T+1} - \hat{\Delta} x_{T+1|T}] = -\alpha \nabla \mu^* \quad (3)$$

And the same expected forecast error would result for  $h$ -step forecasts as they are based on model (1). If the model were estimated and not assumed to be the DGP, it could take time until the new long run mean were approximated by re-estimation.

In this case a possible solution to avoid systematic errors is differencing the VEqC (DVEqC). To see this, first it can be noticed that when  $\mu$  does not change,

$$\begin{aligned} \Delta^2 x_t &= \alpha \beta' \Delta x_{t-1} + \Delta \varepsilon_t && \text{or} \\ \Delta x_t &= \Delta x_{t-1} + \alpha \beta' \Delta x_{t-1} + \Delta \varepsilon_t = (I + \alpha \beta') \Delta x_{t-1} + u_t \end{aligned} \quad (4)$$

which is a restricted version of a VAR in differences: DVAR (a preferred model by many users)

After the break in T+1

$$\Delta x_{T+2} = \Delta x_{T+1} + \alpha (\beta' \Delta x_{T+1} - \Delta \mu^*) + \Delta \varepsilon_{T+1} \quad (5)$$

But as  $\nabla \mu^* = 0$  after that period, it can be noticed that the 1-step forecast errors are

$$\begin{aligned} \Delta x_{T+1} - \widehat{\Delta x}_{T+1|T} &= -\alpha \nabla \mu^* + \Delta \varepsilon_{T+1} && \text{and} \\ \Delta x_{T+j} - \widehat{\Delta x}_{T+j|T+j-1} &= \Delta \varepsilon_{T+j} \quad j > 1 \end{aligned} \quad (6)$$

For  $j > 1$ , forecast are unbiased. However, there is a cost in terms of variance (It doubles the forecast variance of the EqC).

For the same reasons the DVAR model is another alternative to explore for forecasting since by construction it does not include the EqC terms.

Alternatively, the EqC model can be adjusted after the break occurs by residual adjustments or intercept corrections(IC)<sup>8</sup>. This can be done putting the forecast “back on track” when forecast errors are correlated, as follows

$$\widehat{\Delta x}_t^{IC} = \widehat{\Delta x}_{t-1} + (\Delta x_{t-1} - \widehat{\Delta x}_{t-1}) \quad (7)$$

Moreover, a quite simple model that removes deterministic components is the second differences models, DDV. Since many economic variables do not continuously accelerate, then,

$$E[\Delta x_t^2] = 0 \quad (8)$$

And therefore, a “minimal information”, “constant change” forecasting rule (see Clements and Hendry, 2006) is,

$$\widehat{\Delta x}_{T+j|T+j-1} = \Delta x_{T+j-1} \quad (9)$$

It reduces the impact of the breaks offsetting breaks in intercepts and trends as well<sup>9</sup>.

The case of a monetary aggregate also allows an interesting approach to be evaluated: forecasting an aggregate (in this case: M2) by disaggregates (DISAGG), in

<sup>8</sup> Clements and Hendry (1999) shows that IC works in a similar way to differencing.

<sup>9</sup> Hendry (2005) analyses how this device works in different DGP.

this case as the sum of currency, current and saving accounts. Hendry and Hubrich (2006) found that including disaggregate information can improve forecasts as opposed forecasting first disaggregates variables and then aggregating those forecasts or using only lagged aggregate information in the aggregate model. They found such a property for the population but empirically results may be different for selection uncertainty and changing collinearity, among other factors.

Finally, forecasting can be improved by pooling forecasts (Clemen, 1989, see also Timmerman, 2006). When no model coincides with a non-constant DGP, Clements and Hendry (2004) show that better forecasts can be obtained by pooling models that are different mis-specified, particularly because of location shifts. They also found that just averaging may dominate over estimated weights in the combination as weights are obtained on the basis of past performance for processes subject to unanticipated breaks<sup>10</sup>

Recently, it has been also suggested that pooling of forecasts obtained for different estimation windows of the same model can help (Pesaran and Timmerman, 2008).

#### 4.2 Forecasting real M2 in the Argentine case

All the described models are employed to forecast the log differences of real M2. The conditional EqC model of Section 3 is first analysed and then it is used for DEqC.

In the case of the DVAR model two kinds of estimation are explored<sup>11</sup>. On the one hand a VAR(4) (reduced form) equation for the log differences of real M2 on the same set of variables entering the long run solution (transactions and interest rates) plus seasonals has been restricted automatically using PcGets (Hendry and Krolzig, 2001). It is denoted as DVARr. On the other hand, the same unrestricted closed system is directly employed for forecasting the log differences of real M2. In this case it is denoted as DVARu.

For DDVAR, two cases are also presented, one is just the last (LOG) difference observed, or  $D^2$  and the other is the last (LOG) difference of the same quarter in the last year, taking into account the forecast horizon as later explained. It is reported as  $D_1D_4$ . In both cases the corresponding double differences are supposed to have an expected value equal to zero (see equation (8)).

DISAGG is the model selected by PcGets from the regression on the 1 to 4-quarter lags of the log differences of each component (real currency, current and saving accounts) plus seasonals<sup>12</sup>. It is compared by a univariate AR(4) for the log differences aggregate also restricted by PcGets estimation using the same data window, DARS. Also this kind of univariate model is estimated in the same way for the whole sample, DARI.

As many of the monetary authorities projections are one year ahead, forecasts four quarters ahead are studied for three different cases. The first period is started just at end of the Convertibility regime and the announcement of sovereign debt default, it is the more difficult situation (see Figure 1 and b) since it includes 2002:1, a huge “ex-

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<sup>10</sup> It can run against forecast encompassing as it cannot be proved that only non-encompassed devices should be retained in the pooling.

<sup>11</sup> For a previous analysis of monetary shocks using a VEqCM see Utrera (2002).

<sup>12</sup> As the aggregate is the sum of the components using log differences as proxies for % variations implies that the coefficient estimates not only includes those of the parameters of the VAR representations of the components but also the shares each component over the aggregate in the corresponding lags.

post” outlier the forecaster must have faced just after the extremely large outlier of the converse sign. The second one coincides with the period that policy makers usually understand the economy seems to be stabilised after such regime changes. The third one corresponds to the last year of the sample. In order to evaluate the relative performance for a different horizon, for the second period, forecasts are also evaluated until the end of the sample.

In all cases we compute dynamic forecasts. For the multivariate variable models (except the unrestricted VAR) we assume that policy makers “know” the true values of the variables on which real M2 are conditioned and the parameters of the EqC do not change, therefore results would be positively biased to obtain better forecasts by this kind of models. It should be noticed that the variables involved are the level of activity and the nominal interest rates, the first one is often conjectured by policy makers and the second is basically an instrument under their control. However, the uncertainty of estimating instead of “knowing” the variables taken as given should be also investigated.<sup>13</sup>

In the case of the “causal” models estimation periods starting in 1977:3 after a main monetary reform that this year took place. However, the models using disaggregates begins in 1994 after the reforms associated with the new regime, which, in particular, gave a “transactional nature” to the saving accounts when wages and salaries started to be paid through deposits in such accounts; the same period was employed for the aggregate AR model in differences to compare with the case of disaggregates. It is worth noting that the model using disaggregates would be also positively biased to better forecasting performance as it is supposed that the components are “known” being actually static forecasts.

The next table reports the corresponding root mean square error (RMSE) and the mean absolute percentage error (MAPE) for each case.

**Table 1: Forecasting performance of alternative models**

**One year ahead**

RMSE										
Forecast Period	EqC	DEqC	DVARr	DVARu	D <sup>2</sup> mp	D <sub>1</sub> D <sub>4</sub>	DARI	DARs	DISAGG	POOL
2002:1-2002:4	0.31	0.50	0.34	0.35	0.59	0.37	0.36	0.34	0.49	0.16
2003:3-2004:2	0.10	0.10	0.11	0.11	0.08	0.17	0.13	0.13	0.13	0.05
2006:1-2006:4	0.04	0.05	0.04	0.03	0.02	0.03	0.03	0.01	0.06	0.01
MAPE										
Forecast Period	EqC	DEqC	DVARr	DVARu	D <sup>2</sup> mp	D <sub>1</sub> D <sub>4</sub>	DARI	DARs	DISAGG	POOL
2002:1-2002:4	0.51	3.36	0.82	0.81	2.42	1.26	0.95	1.18	1.50	0.68
2003:3-2004:2	0.97	1.56	0.74	0.89	0.75	0.97	1.03	0.99	0.99	0.31
2006:1-2006:4	5.40	4.99	10.20	6.08	7.13	10.29	7.75	1.43	5.70	1.04

<sup>13</sup> Greene, 2000, considers this mis-measurement source in terms of the deviations from mean of these variables (see also Clements and Hendry, 2006)

## A long horizon

RMSE										
Forecast Period	EqC	DEqC	DVARr	DVARu	D <sup>2</sup> mp	D <sub>1</sub> D <sub>4</sub>	DARI	DARs	DISAGG	POOL
2003:3-2006:4	0.06	0.19	0.07	0.07	0.04	0.11	0.08	0.07	0.10	0.03
MAPE										
Forecast Period	EqC	DEqC	DVARr	DVARu	D <sup>2</sup> mp	D <sub>1</sub> D <sub>4</sub>	DARI	DARs	DISAGG	POOL
2003:3-2006:4	2.10	19.99	3.73	2.85	2.46	4.30	3.09	1.46	6.28	0.57

The results show that for individual forecasting methods there is no “winner” for all situations and overall they illustrate the difficulties to forecast the rate of change of Argentine M2 (most of the MAPE are higher than 0.5) probably because of the same behaviour of this aggregate (See Figure 1). The EqC forecasts errors are not too far from the “best” competitor in terms of RMSE.

For the long horizon EqC forecasts are the best ones in terms of RMSE (but DARs do better in MAPE). Information about conditioning variables seems to matter for longer horizons. These results are similar to those obtained by Eirtheim, Husebo and Nymoen (1999) who found that at short horizon (up to 4 quarters) simple devices do better than econometric models estimated by the Norges Bank but the latter win for horizon longer than 12 quarters ahead. It would be due to increasing forecast error variances that offset smaller biases. No improvement has been achieved by differencing the EqC. Neither a significant improvement has been achieved when the forecast was put back on track; this IC correction was calculated only for the EqC model in the long horizon showing nearly the same RMSE (not reported) as EqC without correction.

Disaggregates models are worse than aggregates models in all cases despite the former are static and the second dynamic requiring therefore less information. In spite of the population advantages of using disaggregates, it is not the case here analyzed, neither the empirical cases studied by Hendry and Hubrich (2006).

Data windows seem to matter (see Clements and Hendry, 2006) at least for the AR models; when they are estimated for the sample stated in 1994 instead of 1977 forecasts generally improve. DARs forecasts resulted the best for the last year.

The DVARu is slightly better than the restricted case for forecasting (and not too far from the EqC). It is important because being dynamic no conjectures about the interest rate and transactions are needed.

Simple devices can work. In the case of DARs re-estimation seems important. In fact Pcgets selects the first lagged difference in the shortest sample and the third one for the rest (and a different outlier correction, too). Instead the former assume a coefficient equal to one for the fourth lag.

Finally, we compare the relative performance of different pooling (POOL) procedures. The linear combination of the three models with the better forecasting results are calculated considering different techniques to obtain the weightings.

The first pooling is made considering a simple averaging. It is a “trimmed” mean case as discussed by Clements and Hendry (2006). The weights are 1/3 for each: EqC, DVARu and DARs.

The second pooling method consider the estimation of weights by ordinary least squares, regressing realizations of the estimated variable  $y_\tau$  on the N-vector of forecast,  $\hat{y}_\tau$ , using data over the period  $\tau = h, \dots, T$ .

$$\hat{w}_{t+h,t} = \left( \sum_{\tau=1}^{t-h} \hat{y}_{t+h,\tau} \hat{y}'_{t+h,\tau} \right)^{-1} \sum_{\tau=1}^{t-h} \hat{y}_{t+h,\tau} \hat{y}_{t+h,\tau}$$

Following Granger and Ramanathan (1984) the version of the basic least squares projection used is:

$$y_{t+h} = w'_h \hat{y}_{t+h,t} + \varepsilon_{t+h} \quad \text{s.t. } w'_h \mathbf{1} = 1$$

The weights are computed for two cases. Estimation sample ends in 1999 and in 2005.

Marcellino (2002), proposed a linear combination of forecasts according to weighted forecasts, with weighting factors calculated as follows:

$$\hat{y}_{t+h} = \sum_{m=1}^M k_{m,h,t} \hat{y}_{t+h,m}, \quad k_{m,h,t} = (1 / RMSE_{m,h,t})^w / \sum_{j=1}^M (1 / RMSE_{j,h,t})^w$$

where  $m$  indexes the models,  $k_{m,h,t}$  indicates the weighting factors. The weightings for each model are inversely proportional to their predictive capacity statistic in the case of  $w=1$  in the previous equation. In this case the MAPE is also use to obtain the weightings.

**Table 2: Pooling of forecasts**

POOL						
RMSE						
	Models				Windows	
Forecast Period	Simple averaging	w - 1999*	w - inv. capacity - RMSE**	w - 2005***	BP	IS
2002:1-2002:4	0.16	0.14	0.24			
2003:3-2004:2	0.05	0.08	0.10			
2006:1-2006:4	0.010	0.007	0.008	0.003	0.010	0.014
MAPE						
	Models				Windows	
Forecast Period	Simple averaging	w - 1999*	w - inv.capacity- MAPE**	w - 2005***		
2002:1-2002:4	0.68	0.69	0.89			
2003:3-2004:2	0.31	0.63	0.62			
2006:1-2006:4	1.04	1.24	2.54	1.23	2.83	1.68

\*weightings based on estimations until 1999

\*\*weightings inverse proportional to forecast capacity using RMSE/MAPE

\*\*\*weightings based on estimations until 2005

When a pooling of EqC, DVARu and DARs is calculated the forecasting performance is the best compared with all the individual alternatives and for all forecasting periods (the only exceptions are MAPE for 2002:1-2002:4 and weightings inversely proportional to forecast capacity considering MAPE for 2006:1-2006:4).

Therefore, model pooling of forecast appear to be a recommendable alternative for forecasting real M2 in the Argentine case. Moreover the simple averaging case would be the preferred one because it is easy to implement and the net gain with respect to the others seems to be not significant.

Finally, an exploratory analysis of forecast pooling from different windows was performed for a simple AR(1) model of the differences to evaluate forecasts of the last year of the sample. Windows were selected by using Bai-Perron (BP) statistics (Bai Perron, 1998) and an Impulse Saturation (IS) approach (Hendry, et.al. 2007) to determine the timing of the breaks. IS is an algorithm that allows each observations of the sample to be 'dummied-out' and can be used as a break test for unknown dates (Santos, 2008) as well as a model strategy to obtain robust estimators (Johansen and Nielsen, 2008). Because of these properties IS can contribute to the window selection of a model (see Ahumada, 2008).

BP indicated a break in the last quarter of 1989 (and a less significant in 2002-1) and therefore, a full sample and a window starting in 1990-1 were used for estimation. IS suggested three breaks although the last one (2002-1) was not considered due to an excessively short sample. Then, the windows started in 1977-4 and 1990-3 for IS. In this case the model was also saturated using indicators (at 0.01 level)<sup>14</sup> to dummy out temporary breaks like Malvinas conflict, hyperinflation outbreaks and the default and abandonment of the Convertibility regime. Simple averages were used to pool windows determined by BP and IS, respectively. RMSE and MAPE are very close to those obtained with the other approaches. These examples show again how simple devices can help with forecasting an aggregate of such variability such as the rate of growth of the Argentine M2.

## 5. Conclusions

Different approaches to forecast real M2 (expressed as log differences) have been evaluated in line with the theoretical developments in forecasting theory that allow for processes subject to breaks. In particular when they are unanticipated, the forecasting ability of causal models can be jeopardised. This has been shown for Equilibrium Correction models which are more prone to suffer long run mean shifts. In this context more adaptive devices can do better.

In the Argentine case an Equilibrium Correction model has been analysed both within-sample and out-sample for forecasting. Comparatively its forecasting performance has been satisfactory regarding the turbulent period analysed. It would be a winner for long run horizons. However, the VAR system and in particular, a simple autoregressive model can also be taken into account for forecasting, particularly, given that they require less information. Instead the Equilibrium Correction seems to be the more appropriate to understand the economic relationships the policy makers are interested in. Both kinds of models have a role and their integration merits future research. Pooling of forecast has been only one route but there may be many others worth exploring.

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<sup>14</sup> Autometrics was used for this IS approach, see Doornik (2007).

## References

Aguirre, H., Burdisso, T. and Grillo, F. "Hacia una Estimación de la Demanda de Dinero con Fines de Pronóstico: Argentina 1993-2005", *Ensayos Económicos* N° 45, Octubre de 2006, p 7-44, 2006.

Ahumada H. Impulse saturation and the choice of an estimation window for forecasting, *mimeo*, Di Tella University, 2008.

Ahumada H., "Pronóstico con Modelos Econométricos", en *Progresos en Econometría*, Colección Progresos en Economía, Asociación Argentina de Economía política, Ed. M. Marchioni, Editorial Temas: Buenos Aires, 2005.

Ahumada, H. and Garegnani, M.L. "Understanding Money Demand of Argentina: 1935-2000" las Séptimas Jornadas de Economía Monetaria e Internacional Universidad Nacional de La Plata, Mayo, 2002.

Ahumada, H. "A Dynamic Model of the Demand for Currency: Argentina 1977-1988", *Journal of Policy Modelling*, 14, 3, 335-361, reprinted in Ericsson N. and Irons (1994) eds. *Testing Exogeneity*, Oxford University Press, 1992.

Baba, Y., Hendry, D.F. and Starr, R. "The Demand for M1 in the U.S.A., 1960-1988", *Review of Economic Studies*, 59, 25-61, 1992.

Bai J. and Perron P., "Estimating and testing linear models with multiple structural changes", *Econometrica* 66, 47-78, 1998

Baumol, W. J. "The Transactions Demand for Cash: An Inventory Theoretic Approach", *Quarterly Journal of Economics*, 66, 545-556, 1952.

Cagan, R. "The Monetary Dynamics of Hyperinflation", in M. Friedman ed, *Studies in the Quantity Theory of Money*, Chicago: University of Chicago Press, 1956.

Calvo, G., Izquierdo, A. y Talvi, E. "Sudden Stops, the Real Exchange Rate and Fiscal Sustainability: Argentina's Lessons", *Mimeo*, BID, 2002.

Clemen R. (1989), "Combining Forecasts: a review of annotated bibliography", *International Journal of Forecasting* 5, 1-31.

Clements M.P. and Hendry D.F., "Forecasting Annual UK Inflation using an Econometric Model over 1875-1991", Working Paper University of Warwick, 2006.

Clements M.P. and Hendry D.F., "Guest Editors Introduction: Information in Economic Forecasting", *Oxford Bulletin of Economics and Statistics*, 2005, 67, supplement, 713-753, 2005.

Clements M.P. and Hendry D.F., "Pooling of Forecasts", *Econometrics Journal*, 7, 1-31, 2004.

Clements M.P. and Hendry D.F., *Forecasting Non-stationary Economic Time Series*, MIT Press: Cambridge, Mass., 1999.

Clements M.P. and Hendry D.F., *Forecasting Economic Time Series*, Cambridge University Press: Cambridge, 1998.

Cottely, E “Banco Central Etapas de su vida”, BCRA, Cincuentenario del Banco Central de la República Argentina, 1985, 137, 1958.

Doornik J. (2007), “Autometrics”, [www.oxmetrics.net](http://www.oxmetrics.net).

Doornik J. and Hendry D., *Modelling Dynamic Systems using PcGive*, Vol.II, Timberlake Consultants Ltd, 2001.

Eirtheim, O., Husebo, T. and Nymoén, R. “Equilibrium Correction versus Differencing in Macroeconometric Forecasting”, *Economic Modelling*, 16, 515-544, 1999.

Engle R., Hendry, D. and Richard, J.F., ‘Exogeneity’, *Econometrica*, 1983, 51, 277-304.

Ericsson, N. “Empirical modeling of money demand”, *Empirical Economics*, 23, 3, 295-315, 1998.

Ericsson N., “Testing Exogeneity: An Introduction”, in Ericsson N. and Irons J. Eds., 1994.

Ericsson N. and Irons J. Eds., *Testing Exogeneity*, Oxford University Press: Oxford, 1994.

Favero C., *Applied Macroeconometrics*, Oxford University Press, Oxford, 2001.

Friedman, M. “The Quantity Theory of Money- A Restatement”, in *Studies in the Quantity Theory of Money*, Chicago: University of Chicago Press, 3-21, 1956.

Gay, A. “Money Demand and Monetary Disequilibrium in Argentina (1963-2003)”, *Anales de la XXXIX Reunión Annual de la AAEP*, 2004.

Granger, C. and Ramanathan, R. “Improved methods of forecasting”, *Journal of Forecasting*, 1984, 3, 197-204.

Hendry D.F., *Dynamic Econometrics*, Advanced Texts in Econometrics, Oxford University Press: Oxford, 1995.

Hendry D.F and Doornik J., *Empirical Econometric Modelling using PcGive 10*, Vol. I, Timberlake Consultants Ltd, 2001.

Hendry, D.F. and Hubrich, K. “Forecasting Economic Aggregates by Disaggregates”, European Central Bank, Working Paper N° 589, February, 2006.

Hendry, D.F., Johansen S. and Santos C. (2007), “Selecting a regression saturated by indicators”, Discussion Paper 26, Department of Economics, University of Copenhagen

Hendry D.F. and Krolzig H., *Automatic Econometric Model Selection using PcGets*, Timberlake Consultants Ltd, 2001.

Hendry D.F. and Krolzig H., “We ran one regression”, *Oxford Bulletin of Economics and Statistics*, 2004, 66, 5, 799-810.

Hendry, D.F and Massmann M., “Co-breaking: recent advances and a synopsis of the literature”, *Journal of Business and Economic Statistics*, 2007, 25, 33–51.

Hendry D.F and Mizon G., "Evaluating dynamic econometric models by encompassing the VAR", in Phillips P. Ed., *Models, Methods and Applications of Econometrics*, Blackwell: Oxford, 1993.

Hendry D.F. and Nielsen, B. "Econometric Modeling: a Likelihood Approach", Princeton University Press, 2007.

Johansen S., "Statistical Analysis of Cointegration Vectors", *Journal of Economic Dynamics and Control*, 1988, 12, 2-3, 231-254.

Johansen S., "Cointegration in Partial Systems and the Efficiency of Single-equation Analysis", *Journal of Econometrics*, 1992, 52, 389-402.

Johansen S. and Juselius K., "Maximum Likelihood Estimation and Inference on Cointegration-With Application to the Demand for Money", *Oxford Bulletin of Economics and Statistics*, 1990, 52, 2, 169-210.

Johansen S. and Nielsen B. (2008), "An analysis of the indicator saturation estimator as a robust regression estimator", Working Paper W03, Nuffield College, University of Oxford

Juselius K., "Domestic and Foreign Effects on Price in an Open Economy: The case of Denmark" in Ericsson N. and Irons J. Eds., 1994.

Marcellino, M., "Forecasting pooling for short time series of macro-economic variables", *Oxford Bulletin of Economics and Statistics*, 2002, 66, 91-112,

Miller, M., Fronti, J. y Zhang, L. "Default, Devaluation and Depression: Argentina después de 2001", mimeo, 2004.

Pesaran M. and Timmermann A. (2007), "Selection of estimation window in the presence of breaks", *Journal of Econometrics* 137, 134-161

Santos C. (2008), "Impulse saturation break tests", *Economics Letters* 98, 136-143

Timmermann A. (2006), "Forecasting Combination", in Elliot G., Granger C. and Timmermann A. (eds), *Handbook of Economic Forecasting*, Amsterdam: North Holland, 135-196.

Tobin, J. "Liquidity Preference as Behaviour Towards Risk" *Review of Economic Studies*, 25, 65-86, 1956.

Urbain J.P., "On Weak Exogeneity in Error Correction Models", *Oxford Bulletin of Economics and Statistics*, 1992, 54, 187-207.

Utrera, G. "Un Análisis Económico del Efecto de la Política Monetaria en Argentina", Séptimas Jornadas de Economía Monetaria e Internacional, UNLP, 2002.

### **Appendix 1: Data Definitions and Sources**

- *M2*: Narrow money, current account and saving deposits in pesos of private sector at the end of period. Banco Central de la República Argentina. B.C.R. A.
- *Aggregate Supply*: Gross Domestic Product plus Imports. ECLAC Bs.As. and Dirección Nacional de Cuentas Nacionales (INDEC).
- *Nominal Exchange Rate*: Peso/Dollar. B.C.R.A.
- *Interest Rate*: 30-59 day time deposits interest rates. B.C.R.A.
- *Inflation*:  $(p_t - p_{t-1})$  being  $p_t$  the log of general level of consumer prices. INDEC.