An Empirical Money Demand Estimation for
Mexico, 1986-2004*

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[WORKING PAPER]

Abstract

An econometric money demand equation is estimated for the Mexican economy using quarterly time series data following a cointegration methodology. In addition to the long run results, an Error Correction Model that shows a fast converge to equilibrium is developed. Results are contrasted with previous empirical studies for Mexico and Chile. Evidence of parametric instability is found, but contrasting with other studies, CUSUM tests shows evidence that, for the Mexican case, such instability was due the Peso devaluation, rather than improved credit technologies.

Keywords: Money Demand, Error Correction Model, Cointegration, Mexican Devaluation.

JEL Classification: E41, E43

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1 Introduction

By 1994, the Central Bank of Mexico (BANXICO) was unable to sustain a grossly overvaluated currency, and finally accepted to abandon a quasi-fixed exchange rate regime to implement a floating exchange rate system. Driven by speculation and virtually overnight, the value of US currency went from 3.3 to 7 pesos for dollar, triggering one of the biggest financial and economic debacles of Mexico history.

In terms of political economy, this change also implied for the BANXICO a more active role in the Mexican economy (Carstens, 1999). Yet to completely determine the implications of the monetary policy, is utterly important to have handy an empirical estimation of money demand (Castellanos, 2000).

In this paper I conduct an empirical money demand estimation for Mexico using quarterly time series data from 1986:1 to 2004:4. This work was done following closely a theoretical formulation on Demand for Money on the Handbook of Monetary Economics by (Goldfeld, 1990). During the process of estimation, I reviewed also many other empirical money demand estimations (Aguilar and Vela, 1996; Matte and Vela, 1989; Larraín and Larraín, 1988). All data used in this work were obtained online from both the Mexican Bureau of Statistics (INEGI) and from BANXICO.

2 Theoretical Background

In essence, money is a financial asset that allows interchange of goods and services. People demand money for several reasons: in order to purchase goods and services now (transaction motive) or in the future (precautionary motive); Economic agents also demand money as a way mean of conserving value over time (reserve of value motive)
Modern theoretical approaches to money demand started around the fifties with explicit inventory models (Boulmol, 1952; Tobin 1952). In these models, economic agents hold only the optimum amount of money just as a firm optimize the level of inventories, considering the trade off between the opportunity cost of holding money (interest rate) and the benefit of holding it (money needed for transactions and as a reserve of value).

Stephen Goldfeld (Goldfeld, 1990), defines a money demand equation as:

\[
\ln m_t = \alpha_0 + \alpha_1 \ln y_t + \alpha_2 \ln r_t + \alpha_3 \ln m_{t-1} + \alpha_4 \ln \frac{p_t}{p_{t-1}} + u_t
\]

Where, \( u_t \) is a spherical stochastic term, and \( \frac{\partial \ln m_t}{\partial \ln y_t} > 0, \frac{\partial \ln m_t}{\partial \ln r_t} < 0, \frac{\partial \ln m_t}{\partial \ln m_{t-1}} > 0, \frac{\partial \ln m_t}{\partial \ln p_t} < 0 \) according to economic theory.

3 Variables, Data Analysis and Potential Econometric problems

Acronyms in equation 1 stands for:

\( \ln t \) and \( \ln m_{t-1} \) natural logarithm of a representative monetary aggregate, M1 in this case.

\( \ln y_t \) represents the scale variable, natural logarithm of GDP in Mexican real pesos, base year 1994.

\( \ln r_t \) represents the opportunity cost of money, a Mexican Government debt paper called CETES which is widely used in Mexican business environment.

\( \ln \frac{p_t}{p_{t-1}} \) is an inflation indicator, based upon the CPI (\( p_t \)) calculated by INEGI.
$u_t$ stands for the stochastic disturbance term.

A priori, we suspect this disturbance term to be non spherical. This suspect is based upon three reasons: 1) Model (1) may be ill specified if, for instance, Money Demand equation is not endogenously adjustable but dependent on a more “structural” equation in which GDP and interest rate are determined simultaneously. This approach is suggested in other studies (Larraín and Larraín, 1988). The context of a broader macroeconomic model that includes a money rule followed by the central bank, a Taylor Rule or Inflation Targeting as in the case of Mexico, has also being proposed (Attanasio and Jappelli, 1998); 2) As suggested by nowadays classical studies (Goldfeld, 1976; Larraín and Larraín, 1988), this specification may be subject to the Lucas Critique, since is static and doesn’t incorporate technical advances as ATM machines and improved credit technologies; and 3) as seen in class, the inclusion of a lagged dependent variable may cause the disturbance term to have serial correlation.

4 Econometric Estimation

4.1 Long Run Behavior of main variables and Normality Test

As we would expect, GDP shows an upward trend during all the sample space, the only exception being the 1994-1996 peso devaluation crisis. Accordingly, our main monetary aggregate, M1, shows a similar trend but presents a deep decline during the same crisis, as we would expect according to partial derivative signs in equation 1. The main interest rate indicator follows a turbulent trend since the time frame of this

\footnote{An attempt of “endogenize” the relevant interest rate is presented in Appendix 1.}
estimations include a high inflation period (almost hyperinflation during 1986 to 1990, actually), followed by a stabilization period from 1990 to 1994, and the devaluation episode from 1994 to 1996; after that, Mexican economy has shown macroeconomic stability.

We also present the result for a normality test on the dependent variable. The Jarque-Bera (JB) statistic measures the difference of the skewness and kurtosis of the series with those from the normal distribution. Under the null hypothesis of a normal distribution, the Jarque-Bera statistic is distributed as with 2 degrees of freedom. The reported p-value is the probability that a Jarque-Bera statistic exceeds (in absolute value) the observed value under the null—In this case, we fail to reject the null hypothesis of a normal distribution. Under certain conditions this result will allow us to argue that population disturbance \( u_t \) in equation 1 will also distribute normal, therefore that all the results regarding statistical inference that we saw in class hold, without having to invoke large sample properties. Graphic representation of the variables are shown in the Appendix.

4.2 Long Run Estimation

All the estimations in this paper were performed using Eviews version 5. Empirical estimation is shown in the Appendix. With exception of constant term, all parameters are statistically significant at a 6% confidence level.

In accordance with theory, money demand responds positively with the income and the lag of the dependent variable, and negatively with the opportunity cost and the inflation indicator. Next we compare our results with two of the most referred works on money demand in Latin America: the previous and most comprehensive study on Money Demand in Mexico done by BANXICO (Aguilar and Vela, 1996,
pages 20 and 21) and the empirical estimation done by Felipe Larraín at Harvard University for Chile (Larraín and Larraín, 1988, page 254).

### 4.3 Stability Tests: Cusum and Cusum of Square Tests

The CUSUM test (Brown et al, 1975) is based on the cumulative sum of the recursive residuals. This option plots the cumulative sum together with the 5% critical lines. The test finds parameter instability if the cumulative sum goes outside the area between the two critical lines (Greene, 2003). For our model, results suggest some parameter instability specifically starting in 1993; the timing is not surprising: most economic historians now see the couple of years preceding 1995 as the genesis of the Mexican peso crisis, which exploded in December of 1994.

More on Instability of the Money Demand Parameters: As seen in class, we can use a Chow test to find the same result without using the CUSUM and the CUSUM squared tests. If we suspect a structural change, we can conceptually think the problem as composed of three different models:

1) \( Y = X\beta + \mu \) the complete model that we have already estimated.

2) \( Y^I = X\beta^I + \mu^I \) the partial model that includes only the observations corresponding to dates before 1995, in which we suspect the structural change took place.

3) \( Y^{II} = X\beta^{II} + \mu^{II} \) the partial model that includes only the observations corresponding to dates after 1995.

Where \( \beta \) is the vector of parameters including a constant term. So the main hypothesis to test structural change is:

\[ H_0: \beta^I = \beta^{II} \]

\[ H_a: \beta^I \neq \beta^{II} \]
But first we need to test the implicit assumption here that $\sigma_i^2 = \sigma_{II}^2$. We do this with the statistic:

$$\frac{\epsilon_I^2 - \epsilon_{II}^2}{\epsilon_{II}^2} \approx F(n_1 - k, n_2 - k)$$

In this case, the estimate results in:

- F-test value: 7.89 ; $F_{critical} (31,36) = 1.84$
- In this case, $F_{calculated} (7.89) > F_{table} (1.84)$

In this case again we reject $H_0$. We cannot assume variances in the two subsamples are equal. Now, testing the main hypothesis under this finding, we use the Wald Statistic (Greene, 2003):

$$\left(\hat{\beta}^I - \hat{\beta}^{II}\right)'\left(V^I - V^{II}\right)^{-1}\left(\hat{\beta}^I - \hat{\beta}^{II}\right) \approx \chi_k^2$$

After computation this formula yields $\chi_k^2 = 42.19$, and a chi-squared with 5 degrees of freedom at a significance level of 5% has a value around 11, so in this case:

- $\chi_{calculated}^2 (42.2) > \chi_{table}^2 (11.07)$

And once again we reject $H_0$. Sample data supports the evidence of a structural change in the parameters before and after the Mexican devaluation of 1995. It’s worth noting that this result on instability of money demand parameters has been found in several empirical studies (Matte y Rojas, 1989; Corbo, 1982)

### 4.4 Cointegration Analysis (Parul and Choon-Geol, 1994)

In order to verify if there exist a long run relationship among the variables in model (1) we proceeded to analyze the order of integration for each one of the variables. Results are shown in the Appendix.

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$^2$I used Gauss to get this result since the asymptotic result the equation is not incorporated in Eviews.
This implies that out of all the variables in our model, only CPI is stationary. Furthermore, the rest of the variables are integrated of order one. Under non stationary series we face the possibility of having an spurious estimation: In order to guarantee a long run relationship, we need to verify that there exist a lineal combination of the I(1) variables that is per se stationary. If such relationship exists, is called co-integrated equations and we can still state that the model (1) holds as a long run relationship. In order to verify if this linear combination exists, we can either perform a Johansen cointegration test, or to do a traditional Augmented Dickey-Fuller unit root test to the residuals of model one (Enders, 1995). The Former test is presented as in Appendix Number Two, the latter test results suggests an ADF value of -8.4 versus a critical value of -1.95 (Phillips and Ouliaris, 1990). This allows us to reject the null hypothesis of unit root on the residuals; with stationary residuals, we can conclude model (1) is a valid long run relationship, with variables co-integrating in the long run.

4.5 Potential non spherical disturbance term

Breusch-Godfrey Serial Correlation Test concludes that serial correlation problem does not exist in model (1) The complete auxiliary regression is presented in the Appendix, in which we can verify the almost null statistical significance on all the parameters in the auxiliary regression.

Other approach to detect a first order autorregresive process using the Durbin-Watson statistic. The reported value of 1.95 fails to reject the hypothesis of $H_o: \rho=0$ in the process $\varepsilon_t= \rho \varepsilon_{t-1} + \zeta_t$ Therefore, there is no evidence of serial correlation of order one. Full description of the test is given in Appendix.
To detect the presence of heteroskedasticity in the disturbance term, we proceeded to perform a White test with both cross and no cross terms.

4.6 Short Run Model Estimation: Error Correction Model (ECM)

We just showed that model (1) presents at least one cointegrated linear combination; in other words, there’s a long term or equilibrium relationship. In the short run, however, there may be disequilibrium. In these cases (Sargan, 1984), we can treat error term in (1) as the equilibrium error to tie the short run with the long run behavior. A model or mechanism showing this short run dynamics is often referred as the Error Correction Model, includes only stationary variables and the residual of the original model (1) as explanatory variable. The results are as shown in Appendix. Results suggests, first, that parameter associated with the lagged error term in the Error Correction Model has a high statistical significance. This high significance implies that there’s a disequilibrium at the short run, with an eventual Long Run Equilibrium. Second, the speed of adjusted, given by the absolute value of the error coefficient which in this case is around $\frac{3}{4}$, implies that full adjustment towards long term equilibrium is achieved in less than two years. Third, a visual inspection of the error of the ECM doesn’t suggest the existence of econometric problems such serial correlation and Heteroskedasticity.

4.7 Stability Test

Results for the ECM both in the CUSUM and the CUSUM of squared test are consistent with the structural change starting around 1993 detected in the Long Run
Model, are presented in the Appendix.

5 Conclusions

1. The long run equation presented by Goldfeld in the Handbook of Monetary Economics shows a nice fit for our case of study, that is, for Mexico during the period 1986-2004. Theoretical signs are according to the theory and the magnitudes of key elasticities are in line with other empirical studies.

2. Other empirical estimations differs from the present incorporating other money aggregates as M2 or M3 (Aguilar and Vela, 1996; Larraín and Larraín, 1988) as dependent variable. An alternative estimation using M2 as the aggregate money demand is presented in Annex Number Five. Statistical problems are found in this model, which leads us to reject M2 as the dependent variable, favoring M1 instead.

3. Evidence that support the thesis of a structural change is found by at least two different criterions: CUSUM and CUSUM of squared test and the Chow Test. This evidence of instability is common in most of the other empirical studies reviewed, notoriously in Goldfeld’s famous Case of the Missing Money (Goldfeld, 1976). Even though in the literature this instability is linked basically to technical change and credit technologies improvement (such as credit cards and ATM’s), in the case of Mexico and given that the CUSUM of squares test identifies specifically a time in which the suspected structural change may have occurred, we can argue the instability was caused for the Peso Devaluation rather than some technical change. Chow test supports these findings.
4. Unlike old studies, we favored and follow a co-integration approach. The statistically highly significance of the parameter associated with the lagged error term in the Error Correction Model would simply mean there’s a disequilibrium at the short run, with an eventual Long Run Equilibrium, which we tested using the Johansen test for cointegration. Furthermore, the speed of the adjusted, measured by absolute value of the error coefficient, is high, which implies Mexican agents adjust fast to changes in their economic environment.

REFERENCES


Appendix

Basic Graphic Representation of main Variables

Jarque-Bera Test for the residuals of main model

Series: M1  Sample: 1986:1 2004:4  Observations: 76
Mean: 1.06E+08  Median: 1.16E+08  Maximum: 1.98E+08  Minimum: 33826888
Std. Dev.: 47301692  Skewness: -0.052824  Kurtosis: 1.972746
Jarque-Bera: 3.376972  Probability: 0.184799
Output for Main Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.633916</td>
<td>1.379609</td>
<td>0.459489</td>
<td>0.6473</td>
</tr>
<tr>
<td>LOG(GDP)</td>
<td>0.230506</td>
<td>0.118149</td>
<td>1.950974</td>
<td>0.0551</td>
</tr>
<tr>
<td>LOG(CETES)</td>
<td>-0.003801</td>
<td>0.001305</td>
<td>-2.913371</td>
<td>0.0048</td>
</tr>
<tr>
<td>LOG(CPI/(CPI(-1)))</td>
<td>-0.424697</td>
<td>0.228520</td>
<td>-1.858467</td>
<td>0.0673</td>
</tr>
<tr>
<td>LOG(M1(-1))</td>
<td>0.802079</td>
<td>0.039167</td>
<td>20.47836</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

CUSUM of Squares 5% Significance

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Summary of Empirical Elasticity’s Comparison

<table>
<thead>
<tr>
<th>Type of Elasticity on Money Demand</th>
<th>Current Estimation</th>
<th>Aguilar and Vela for Mexico, 1996</th>
<th>Larraín and Larraín for Chile, 1988</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest Elasticity (\eta_M)</td>
<td>-0.3%</td>
<td>-0.1%</td>
<td>-2.1%</td>
</tr>
<tr>
<td>Income Elasticity (\eta_{M1,GDP})</td>
<td>23%</td>
<td>15%</td>
<td>13%</td>
</tr>
<tr>
<td>Lagged M1 Elasticity (\eta_{M1,M1(-1)})</td>
<td>80%</td>
<td>89%</td>
<td>75%</td>
</tr>
</tbody>
</table>

Stability Tests:
Cointegration Analysis

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>Unit Root Test</th>
<th>MODEL Estimated Included*</th>
<th>ADF</th>
<th>Critical Value**</th>
<th>Result</th>
<th>Integration Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log M1</td>
<td>Level No</td>
<td>No</td>
<td>1.796999</td>
<td>-1.9446</td>
<td>Don't Reject H₀</td>
<td>I(1)</td>
</tr>
<tr>
<td></td>
<td>1st Differ. No</td>
<td>No</td>
<td>-7.862032</td>
<td>-1.9447</td>
<td>Reject H₀</td>
<td>I(1)</td>
</tr>
<tr>
<td>Log GDP</td>
<td>Level No</td>
<td>No</td>
<td>1.278212</td>
<td>-1.9447</td>
<td>Don't Reject H₀</td>
<td>I(1)</td>
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<tr>
<td></td>
<td>1st Differ. No</td>
<td>No</td>
<td>-19.96238</td>
<td>-1.9447</td>
<td>Reject H₀</td>
<td>I(1)</td>
</tr>
<tr>
<td>Log CETES</td>
<td>Level No</td>
<td>No</td>
<td>-1.908106</td>
<td>-1.9447</td>
<td>Don't Reject H₀</td>
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<td>1st Differ. No</td>
<td>No</td>
<td>-9.433448</td>
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<td>Reject H₀</td>
<td>I(1)</td>
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<td>Log CPI</td>
<td>Level No</td>
<td>No</td>
<td>9.402313</td>
<td>-1.9447</td>
<td>Reject H₀</td>
<td>I(0)</td>
</tr>
</tbody>
</table>

* Therefore, the model tested is: \( \Delta Y_t = \gamma Y_{t-1} + \varepsilon_t \)

With: \( H_0: \gamma = 0 \)
If \( \gamma \neq 0 \) \( \Rightarrow \) Unit Root: Non stationary series.
Criterion: If ADF < Valor Crítico, Reject \( H_0 \)

** Obtained from (Phillips and Ouliaris, 1990)

Serial Correlation on Error Term

Breusch-Godfrey Serial Correlation Test, 2 lags (p).

<table>
<thead>
<tr>
<th></th>
<th>F-Statistic</th>
<th>Probability</th>
<th>N*R²</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.032965</td>
<td>0.967588</td>
<td>0.072646</td>
<td>0.964329</td>
</tr>
</tbody>
</table>

In auxiliary regression:
\( \varepsilon_t = \rho \beta + B \sum_{p=0}^p + \zeta_t \)
\( H_0: \rho = B = 0 \) \( \Rightarrow \) Serial Correlation does not exist.
Criterion: If \( (n-p)R^2 > \chi^2_p \) Reject \( H_0 \).
Critical value for \( \chi^2 \) at 5% significance level \( \approx 6 \)
Result: **Fail to Reject \( H_0 \).**

White Heteroskedasticity Test

<table>
<thead>
<tr>
<th></th>
<th>F Statistic</th>
<th>Probability</th>
<th>N*R²</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.117182</td>
<td>0.363445</td>
<td>8.944918</td>
<td>0.346964</td>
</tr>
</tbody>
</table>

\( H_0: \sigma^2 = \sigma^2 I \) \( \Rightarrow \) Residuals are Homoskedastic
Criterion: If \( (n)R^2 > \chi^2 \) d.f. auxiliary reg, Reject \( H_0 \).
\( \chi^2 \) d.f aux reg critic at 5% \( \approx 90 \)
Result: **Fail to Reject \( H_0 \).**
Error Correction Model

Dependent Variable: D(LOG(M1))
Method: Least Squares
Date: 04/16/05   Time: 20:17
Sample(adjusted): 1986:3 2004:4
Included observations: 74 after adjusting endpoints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.001770</td>
<td>0.007904</td>
<td>-0.223997</td>
<td>0.8234</td>
</tr>
<tr>
<td>D(LOG(GDP))</td>
<td>1.037408</td>
<td>0.156775</td>
<td>6.617191</td>
<td>0.0000</td>
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<tr>
<td>D(LOG(CETES))</td>
<td>-0.083153</td>
<td>0.038944</td>
<td>-2.135170</td>
<td>0.0364</td>
</tr>
<tr>
<td>D(LOG(CPI/(CPI(-1))))</td>
<td>-0.187385</td>
<td>0.284992</td>
<td>-0.657509</td>
<td>0.5131</td>
</tr>
<tr>
<td>D(LOG(M1(-1)))</td>
<td>0.626591</td>
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<td>0.0000</td>
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<tr>
<td>RESIDUALS1(-1)</td>
<td>-0.755186</td>
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<td>-4.450174</td>
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<tr>
<td>R-squared</td>
<td>0.543348</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.509771</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>0.0629476</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum squared resid</td>
<td>0.269476</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>102.7661</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durbin-Watson stat</td>
<td>1.891783</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-squared: 0.543348
Adjusted R-squared: 0.509771
S.E. of regression: 0.0629476
Sum squared resid: 0.269476
Log likelihood: 102.7661
Durbin-Watson stat: 1.891783

White Heteroskedasticity Test, No Cross Terms.

F Statistic | 1.060204  | Probability | 0.405818
N*R^2       | 10.659364 | Probability | 0.384665

H_0: \sigma^2=\sigma^2 I \Rightarrow Residuals are Homoskedastic
Criterion: If (n)R^2>\chi^2_{d.f. auxiliary reg} Reject H_0; \chi^2_{d.f aux reg} critic at 5% \approx 90
Result: Fail to Reject H_0.
Breusch-Godfrey Serial Correlation Test, 2 lags (p).

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>F-Statistic</td>
<td>0.724192</td>
<td>Probability</td>
<td>0.488527</td>
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<tr>
<td>N*R2</td>
<td>1.589073</td>
<td>Probability</td>
<td>0.451791</td>
</tr>
</tbody>
</table>

In auxiliary regression:
\[ e_t = \pi X + B_i \sum e_{t-p} + \zeta_t \]

Ho: \( \pi = B_i = 0 \) \( \forall i \) ➔ Serial Correlation does not exist.
Criterion: If \( (n-p)R^2 > \chi^2_p \) Reject Ho.
Critical value for \( \chi^2 \) at 5% significance level \( \approx 6 \)
Result: Fail to Reject Ho.
Further Analysis

1] Determination of “the” interest rate

Say that the interest rate follows

\[
\begin{align*}
    r^* &= r + \alpha_t \left[ \Pi_t - \Pi^m_t \right] + r^e_t + \nu_t \\
    r_t &= \rho^* r^* + (1 - \rho^*) r_{t-1} + \varepsilon_t
\end{align*}
\]

Long Run Equation.

Short Run adjustment of Interest Rate.

Where \( r^* \) is the long run interest rate, \( \pi \) represents inflation, \( \pi^m \) expected inflation, \( r \) bar a mean of the rate in the economy, \( \rho \) represent adjustment weights, and both \( \nu_t \) and \( \varepsilon_t \) represents normally distributed disturbances.

The topic of selecting “the” interest rate is somehow discretionary on behalf of the researcher; a proper approach will determine the main interest rate of the Mexican economy based upon the kind of monetary policy followed by BANXICO, that includes the an inflation target of gap (\( \pi - \pi^m \)) or DIFP, a representative international rate (The federal reserve representative rate, of FED), and a measure of real exchange rate (TCR94). The result for the case of the Mexican economy are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.364042</td>
<td>0.116127</td>
<td>-3.134854</td>
<td>0.0026</td>
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<tr>
<td>DIFP</td>
<td>-0.280498</td>
<td>0.094984</td>
<td>-2.953114</td>
<td>0.0044</td>
</tr>
<tr>
<td>FED</td>
<td>1.830691</td>
<td>2.201542</td>
<td>0.831549</td>
<td>0.4089</td>
</tr>
<tr>
<td>TCR94</td>
<td>12.11996</td>
<td>1.706856</td>
<td>7.100752</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

R-squared    0.713121
Adjusted R-squared    0.699239
S.E. of regression    0.065508
Sum squared resid    0.266063
Log likelihood    88.30145
Durbin-Watson stat    0.560878

Based upon (Corbo, 1982)
2) Contegration Matrix: Johansen’s Test

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>GDP</th>
<th>R</th>
<th>CPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>N.A.</td>
<td>Co-integrates**</td>
<td>Co-integrates*</td>
<td>Co-integrates*</td>
</tr>
<tr>
<td>GDP</td>
<td>N.A.</td>
<td>Co-integrates*</td>
<td>Co-integrates*</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>N.A.</td>
<td>Co-integrates**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPI</td>
<td>N.A.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* For all pairwise Hypothesized relationships, options employed in E-Views for the test are: Allowing a linear trend in the cointegrating equation and in the Vector Autoregressive Specification. This is one of the five cases considered by Johansen (1990) in his seminal work on Cointegration and Money Demand, the case not completely restrictive, but not the most permissive either. One example of the Eviews output for this test, for the pair (R, CPI) is given as example next:


* At 5% significance level  
** At 1% significance level
3) Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:

<table>
<thead>
<tr>
<th></th>
<th>F-statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.032965</td>
<td>0.967588</td>
</tr>
</tbody>
</table>

Obs*R-squared 0.072646  Probability 0.964329

Test Equation:

Dependent Variable: RESID

Method: Least Squares

Date: 04/11/05   Time: 22:51

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.020461</td>
<td>1.432912</td>
<td>-0.014279</td>
<td>0.9886</td>
</tr>
<tr>
<td>LOG(GDP)</td>
<td>0.002894</td>
<td>0.129070</td>
<td>0.022423</td>
<td>0.9822</td>
</tr>
<tr>
<td>LOG(CETES)</td>
<td>0.000313</td>
<td>0.027283</td>
<td>0.011465</td>
<td>0.9909</td>
</tr>
<tr>
<td>LOG(CPI/(CPI(-1)))</td>
<td>-0.007990</td>
<td>0.236968</td>
<td>-0.033719</td>
<td>0.9732</td>
</tr>
<tr>
<td>LOG(M1(-1))</td>
<td>-0.001136</td>
<td>0.044420</td>
<td>-0.025563</td>
<td>0.9797</td>
</tr>
<tr>
<td>RESID(-1)</td>
<td>0.022975</td>
<td>0.135636</td>
<td>0.169386</td>
<td>0.8660</td>
</tr>
<tr>
<td>RESID(-2)</td>
<td>-0.022308</td>
<td>0.125443</td>
<td>-0.177836</td>
<td>0.8594</td>
</tr>
</tbody>
</table>

R-squared 0.000969  Mean dependent var 4.87E-15

Adjusted R-squared -0.087181  S.D. dependent var 0.072017

S.E. of regression 0.075091  Akaike info criterion -2.251541

Sum squared resid 0.383431  Schwarz criterion -2.035242

Log likelihood 91.43277  F-statistic 0.010988

Durbin-Watson stat 1.992354  Prob(F-statistic) 0.999994
4) Durbin Watson Serial Correlation Test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.633916</td>
<td>1.379609</td>
<td>0.459489</td>
<td>0.6473</td>
</tr>
<tr>
<td>LOG(GDP)</td>
<td>0.230506</td>
<td>0.118149</td>
<td>1.950974</td>
<td>0.0551</td>
</tr>
<tr>
<td>LOG(CETES)</td>
<td>-0.067891</td>
<td>0.026876</td>
<td>-2.526113</td>
<td>0.0138</td>
</tr>
<tr>
<td>LOG(CPI/(CPI(-1)))</td>
<td>-0.424697</td>
<td>0.228520</td>
<td>-1.858467</td>
<td>0.0673</td>
</tr>
<tr>
<td>LOG(M1(-1))</td>
<td>0.802079</td>
<td>0.039167</td>
<td>20.47836</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

R-squared 0.981977
Adjusted R-squared 0.980948
S.E. of regression 0.074047
S.E. of regression 0.074047
Sum squared resid 0.383802
Log likelihood 91.39643

Durbin-Watson stat 1.951057

This number corresponds to the value that Eviews calculates for the DW statistic. Now we have to contrast this number with the $d_u$ and $d_l$ values from a statistic tableau:

In this case: $k=5$, $(k-4)$, n=75 $\Rightarrow$ $d_u=1.739$, $d_l=1.515$

![Diagram of decision zones for positive, no, and negative autocorrelation with values 1.515, 1.739, 2, 2.261, 2.485 and 2.34]

Therefore, according to DW statistic criterion, we fail to reject $H_0$ $\Rightarrow$ No Autocorrelation
5] Additional Estimation using M2 as an alternative Money Aggregate

Using as endogenous variable M2, a broader measure of money that includes saving accounts and other deposits, plus M1, we had the following results:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>1.342665</td>
<td>0.949671</td>
<td>1.413822</td>
<td>0.1630</td>
</tr>
<tr>
<td>LOG(DGP)</td>
<td>0.092866</td>
<td>0.079027</td>
<td>1.175123</td>
<td>0.2450</td>
</tr>
<tr>
<td>LNR</td>
<td>0.003612</td>
<td>0.011721</td>
<td>0.308170</td>
<td>0.7591</td>
</tr>
<tr>
<td>M2T0</td>
<td>0.853366</td>
<td>0.081774</td>
<td>10.43566</td>
<td>0.0000</td>
</tr>
<tr>
<td>DPIB</td>
<td>0.000296</td>
<td>0.000594</td>
<td>0.497904</td>
<td>0.6205</td>
</tr>
<tr>
<td>AR(5)</td>
<td>0.105016</td>
<td>0.111419</td>
<td>0.942529</td>
<td>0.3500</td>
</tr>
</tbody>
</table>

R-squared          | 0.924105     | Mean dependent var | 15.20202   |
Adjusted R-squared | 0.917206     | S.D. dependent var  | 0.054835   |
S.E. of regression | 0.015778     | Akaike info criterion | -5.367195  |
Sum squared resid  | 0.013692     | Schwar criterion    | -5.159568  |
Log likelihood     | 169.6994     | F-statistic         | 133.9378   |
Durbin-Watson stat | 2.063693     | Prob(F-statistic)   | 0.000000   |
Inverted AR Roots  | .64          | .20 -.61i           | .20+.61i   |
                  | -.52 -.37i   |                        |            |

Main Features of the model:

i. No spherical residuals. Serial correlation of higher level is found, i.e., even though DW statistic rejects the existence of an AR(1) process, Eviews finds evidence that the error term follows an AR(5) process.
ii. Main theoretical explanatory variables, as the interest rate, the lagged dependent variable and the GDP, are found to be statistically non significant. Overall, even though the model presents a high $R^2$, doesn’t seem to have nice econometric properties.