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A PORTFOLIO APPROACH FOR THE TESOBONO PROBLEM IN MEXICO DURING 1994: A SIMPLE MODEL

by

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ABSTRACT

A PORTFOLIO APPROACH FOR THE TESOBONO PROBLEM IN MEXICO DURING 1994: A SIMPLE MODEL

by

Jesus Gonzalez-Lugo Lopez

During 1994 domestic and foreign investors in Mexico increased the share of TESOBONOS in their portfolios when they perceived the possibility of a future devaluation of the Mexican peso or, in other words, the abandonment of the controlled floating exchange rate regime. This work finds that both, domestic and foreign investors responded to monetary policies followed by Banco de Mexico after March 1994, when adverse political events occurred, keeping their investment in Mexico in TESOBONOS rather than leaving the country. Domestic and foreign investors did not have a high expected probability of devaluation, however, they were certain that if a devaluation was going to happen the size of it would be approximately a hundred percent.
Acknowledgments:

I would like to thank Dr. Peter R. Hartley for his kindness and for the excellent lesson of professionalism and patience he taught me while working on this thesis.

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I. INTRODUCTION

The purpose of this work is to analyze investors' behavior in the Mexican economy during 1994.

In particular, investment by domestic and foreign investors in Mexican government bonds deserves attention, since a Treasury Bond denominated in US dollars (TESOBONO) provided a hedging instrument against exchange rate movements. The presence of this instrument together with the Treasury Certificates denominated in pesos (CETES), exacerbated the financial liquidity crisis after the December 1994 devaluation. The TESOBONO AND CETES represented the two most important types of investment in the Mexican money market during 1994.

At this point it is useful to describe the aforementioned instruments. The CETES are the most commonly traded instrument in the money market in Mexico. Before December 1990 CETES were not part of the international money markets, because foreign investors who did not have legal residence in Mexico were restricted from trading in them. Nowadays they can trade CETES directly or indirectly through investment funds in the Mexican money market.

Like a United States Treasury Bill, a CETE is a zero coupon bond with a fixed return backed by the Mexican federal government goodwill and large credit. In a similar way to the Treasury Bills' market, Banco de
Mexico (Mexico's Central Bank) leads regular auctions on CETES. Every Tuesday, the central bank, acting as the financial agent of the federal government, sells a certain amount of CETES with maturities within a range of 28 to 364 days. The return on the CETES is the leading rate in the Mexican money market, as the T-Bill is for the United States.

The CETES are issued to the holder with a face value of 10 pesos. Even though this face value is very low, the minimum amount allowed per transaction in the interbank market is 100 pesos; in practice the minimum amount traded is 50,000 pesos at face value.

Financial institutions that buy CETES in an auction, in turn trade them among themselves, and with other economic agents such as the central bank, money market funds, firms, households and foreign investors, in the secondary market.

TESOBONOS also represent short term federal government debt that yields fixed returns. This type of bonds is, however, indexed to the Mexican money market value of the US dollar. When this instrument was created it had a maximum maturity of six months but later the maturity was extended to 360 days.

As illustrated in figures 1 and 2, after March 1994 domestic and foreign investors began to hedge against the devaluation risk by increasing the share of TESOBONOS in their portfolios. The focus of this paper is an attempt to model the hedging process followed by investors during 1994.
FIGURE 1

DOMESTIC INVESTMENT IN GOVERNMENT BONDS
FIGURE 2

FOREIGN INVESTMENT IN MEXICAN GOVERNMENT BONDS BY INSTRUMENT

MONTHLY STOCKS

TESOBONOS
AJUSTABONOS
BONDES
PAGAFES
CETES
II. THEORETICAL FRAMEWORK

This section will describe how an investor builds a portfolio when she is faced with financial assets denominated in different currencies.

Assume an economy in which the government finances its budget deficit by issuing two types of assets, one denominated in domestic currency and the other denominated in foreign currency.

The exchange rate between the domestic and foreign currencies is determined by a controlled floating mechanism, which keeps it within a range predetermined by the monetary authorities. Therefore, as long as the exchange rate is kept within the pre-established limits, there will be a relative certainty (up to the limits of the band) about the value, in terms of foreign currency, of both the principal and the return on assets denominated in domestic currency. If this condition does not hold, however, the investors will switch to foreign currency denominated bonds to avoid the devaluation risk accompanying bonds denominated in the domestic currency. One way to prevent or reduce this substitution of assets is to increase the returns yielded by the domestic currency denominated bonds.

Thus, we are lead to consider the investment choices described above for a representative investor who maximizes the expected utility of wealth with a utility function that can be written as:
\[ U(w) = \frac{W^{1-\gamma}}{1-\gamma} \]

where: \( \gamma \) is the constant degree of relative risk aversion

Assuming there are just two outcomes next period-devaluation or no-devaluation—the probability distribution of investor’s wealth next period can be written as:

\[
W = \begin{cases} 
W_0 \left[ \alpha \left( \frac{1 + r_u}{1 + i^e} \right) + \left( 1 - \alpha \right) \left( \frac{1 + r_m}{1 + i^e} \right) \right] & \text{with probability } \Pi \\
W_0 \left[ \alpha \left( \frac{1 + r_u}{1 + i^e} \right) + \left( 1 - \alpha \right) \left( \frac{1 + r_m}{1 + i^e} \right) \left( 1 - d \right) \right] & \text{with probability } 1 - \Pi
\end{cases}
\]

where: \( W_0 \) = investor’s initial wealth

\( \alpha \) is the proportion of the initial wealth invested in foreign currency denominated bonds, which lies in the (0,1) interval

\( r_u \) = nominal return on government bonds denominated in foreign currency. Note that this variable differs from the commonly used \( r^* \) return on foreign assets) because \( r_u \) is not a return determined in a foreign market
\[ r_m = \text{nominal return on government bonds denominated in domestic currency} \]

\[ d = \text{is the size of the devaluation of the domestic currency, if the exchange peg is abandoned. Note that it lies in the (0,1) interval} \]

\[ \Pi = \text{is the probability of non-devaluation of domestic currency. Since } \Pi \text{ is a probability it too lies in the [0,1] interval} \]

\[ i^e = \text{is the expected inflation rate} \]

The expected utility maximizing problem faced by the investor can be written as:

\[
\max_{\alpha} \frac{W_0^{1-\gamma}}{1-\gamma} \cdot \frac{1}{1+i^e} \left[ \Pi[\alpha(1+r_u)+(1-\alpha)(1+r_m)]^{1-\gamma} + (1-\Pi)[\alpha(1+r_u)+(1-\alpha)(1+r_m)(1-d)]^{1-\gamma} \right]
\]  \hspace{1cm} (1)

The First Order Necessary Condition for an interior solution for the proportion invested in government bonds denominated in foreign currency (\(\alpha\)):

\[
\frac{W_0^{1-\gamma}}{1-\gamma} \cdot \frac{1}{1+i^e} \left[(1-\gamma)\Pi[\alpha(1+r_u)+(1-\alpha)(1+r_m)]^{-\gamma}[(1+r_u)-(1+r_m)] + 
\right.
\]
\[
+(1-\gamma)(1-\Pi)[\alpha(1+r_u)+(1-\alpha)(1+r_m)(1-d)][(1+r_u)-(1+r_m)(1-d)] = 0
\]

\hspace{1cm} (2)
dividing by \( \frac{W_{\theta}^{1-\gamma}}{1-\gamma} \cdot \frac{1}{1+i^e} \) and rearranging it follows that:

\[
\frac{\Pi}{1 - \Pi} \left[ \frac{r_u - r_m}{r_u - r_m + d(1 + r_m)} \right] = \left[ \frac{\alpha(1 + r_u) + (1 - \alpha)(1 + r_m)}{\alpha(1 + r_u) + (1 - \alpha)(1 + r_m)(1 - d)} \right]^{\gamma}
\]

or

\[
\left[ \frac{\Pi}{1 - \Pi} \cdot \frac{r_m - r_u}{r_u + d - (1 - d)r_m} \right]^{1 - \gamma} = \frac{\alpha(1 + r_u) + (1 - \alpha)(1 + r_m)}{\alpha(1 + r_u) + (1 - \alpha)(1 + r_m)(1 - d)}
\]

Since the RHS of (3) must always be positive, for an interior solution we require:

\[
\left[ \frac{\Pi}{1 - \Pi} \cdot \frac{r_m - r_u}{r_u + d - (1 - d)r_m} \right]^{1 - \gamma} > 0
\]

If we did not have \( r_m > r_u \), the investors would not be willing to buy government bonds denominated in domestic currency. Also, by definition \( \Pi > 0 \) and \( d > 0 \). Therefore in order to have an interior solution it is necessary that:

\[
r_u + d > (1 - d)r_m
\]
Condition (4) can be rewritten as:

\[ d > \frac{r_m - r_u}{1 + r_m} \]  \hspace{1cm} (5)

Condition (5) implies that, to have non-zero investment in domestic bonds denominated in foreign currency, the anticipated size of devaluation should be bigger than the risk premium measured as a proportion of the total return (capital plus interest rate) yielded by domestic currency denominated bonds.

Define:

\[ x = \frac{\prod}{1 - \prod} \cdot \frac{r_m - r_u}{r_u + d - (1 - d)r_m} \]  \hspace{1cm} (6)

Equation (6) is simply the ratio of the expected return when no devaluation occurs to the expected return when it does occur.

Rewriting equation (3) using (6):

\[ \frac{1}{X^t[\alpha(1 + r_u) + (1 - \alpha)(1 + r_m)(1 - d)]} = \alpha(1 + r_u) + (1 - \alpha)(1 + r_m) \]  \hspace{1cm} (7)

From (7), when the proportion of initial wealth invested in foreign currency denominated bonds (\(\alpha\)) is interior, it will be given by:
\[
\alpha = \frac{(1 + r_m)[1 - X^\frac{1}{7}(1 - d)]}{X^\frac{1}{7}d(1 + r_m) - (1 - X^\frac{1}{7})(r_u - r_m)}
\] (8)

If we now allow the variables to change over time, equation (8) can be written as:

\[
\alpha_t = \frac{(1 + r_m_t)[1 - X_t^\frac{1}{7}(1 - d_t)]}{X_t^\frac{1}{7}d_t(1 + r_m_t) - (1 - X_t^\frac{1}{7})(r_u - r_m_t)} + \varepsilon_t
\] (9)

Equation (9) is a non-linear equation that will be tested empirically, as described in the next section.
III. METHODOLOGY:

The non-linear equation that describes the behavior of the share of investors' wealth allocated to domestic government bonds denominated in foreign currency:

\[
\alpha_t = \frac{(1 + r_{m_t})(1 - X_t \frac{1}{\gamma}(1 - d_t))}{X_t \frac{1}{\gamma}d_t(1 + r_{m_t}) - (1 - X_t \frac{1}{\gamma})(r_u - r_m)} + \epsilon_t \tag{9}
\]

It includes two explanatory variables \( \Pi \) (probability of non-devaluation) and \( d \) (the anticipated size of devaluation or capital loss), that cannot be observed empirically. We shall assume, however, that they depend on other variables that can be measured. Given that both variables, by definition, should lie in the \([0,1]\) interval, it is necessary to have a functional form that would give values for \( \Pi \) and \( d \) in such an interval.

In this work the Logistic Function:

\[
F(x) = \frac{1}{1 + e^{-x}}
\]

was used to guarantee that \( \Pi \) and \( d \) would be in the \([0,1]\) range.

Specifically we assumed that \( \Pi \) and \( d \) were logistic functions of the following explanatory variables:
\( r_m = \) monthly annualized return on domestic bonds denominated in domestic currency

\( r_u = \) monthly annualized return on domestic bonds denominated in foreign currency

\( \text{ex} = \) the relative price of foreign currency in terms of domestic currency. Thus, a devaluation corresponds to a rise in \( \text{ex} \).

\( \text{dumcol} = \) a dummy variable that captures the effect of the assassination of the Mexican presidential candidate in March 1994.

Thus \( \Pi \) and \( d \) can be written as:

\[
\Pi(r_m, r_u, \text{ex}, \text{dumcol}) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 r_m + \beta_2 r_u + \beta_3 \text{ex} + \beta_4 \text{dumcol})}} \tag{10}
\]

and

\[
d(r_m, r_u, \text{ex}, \text{dumcol}) = \frac{1}{1 + e^{-(\delta_0 + \delta_1 r_m + \delta_2 r_u + \delta_3 \text{ex} + \delta_4 \text{dumcol})}} \tag{11}
\]

Using these expressions, the values for both variables will lie between zero and one.
In the previous equations the parameter values for the betas in $\Pi$ and the
deltas in $d$ are unknown. The two functional forms for $\Pi$ and $d$ given by
equations (10) and (11) are used to rewrite equation (6) to obtain equation
(12):

$$
x = \exp(\beta_0 + \beta_1 r_m + \beta_2 r_u + \beta_3 e_x + \beta_4 d_{dumcol}) \\
\frac{r_m - r_u}{\exp(1 + \exp(-\delta_0 + \delta_1 r_m + \delta_2 r_u + \delta_3 e_x + \delta_4 d_{dumcol})) \cdot (1 - r_m \exp(-\delta_0 + \delta_1 r_m + \delta_2 r_u + \delta_3 e_x + \delta_4 d_{dumcol})) + 1 - \exp(\delta_0 + \delta_1 r_m + \delta_2 r_u + \delta_3 e_x + \delta_4 d_{dumcol})} \cdot \exp\left(\delta_0 + \delta_1 r_m + \delta_2 r_u + \delta_3 e_x + \delta_4 d_{dumcol}\right) - 1$$

Expression (12) will be used to empirically test equation (9). The values for
the beta and delta coefficients that describe the behavior of the share of
investors' wealth invested in domestic bonds denominated in foreign
currency, will be estimated using the nonlinear least squares.

III.1 NONLINEAR LEAST SQUARES ESTIMATION OF MORE
THAN ONE PARAMETER.

A brief description of an algorithm used to estimate equation (9) is now
presented, consider the following nonlinear model:

$$y_t = f(x_t, \beta) + e_t$$ (13)
which is dependent on a (Kx1) unknown parameter vector \( \beta \). Using matrix algebra notation, equation (13) can be rewritten as:

\[
y = f(X, \beta) + e
\]

(14)

It is assumed that \( E[e] = 0 \) and \( E[ee'] = \sigma^2 I \). The nonlinear least squares estimate of the vector \( \beta \) is that value of \( \beta \) which minimizes the residual sum of squares defined as follows:

\[
S(\beta) = e'e = [y - f(X, \beta)][y - f(X, \beta)]
\]

(15)

In this case there are \( K \) first-order conditions for a minimum, defined by setting the \( K \)-dimensional vector of derivatives \( \delta S/\delta \beta \) equal to the \( 0 \) vector. These first-order conditions are given by:

\[
\frac{\partial S}{\partial \beta} = -2\frac{\partial f(X, \beta)'}{\partial \beta}[y - f(X, \beta)] = 0
\]

(16)

where \( \delta f(X, \beta)/\delta \beta \) is a (KxT) matrix of derivatives with the (k,t)th element given by \( \delta f(X, \beta)/\delta \beta_k \). To denote the transpose of the matrix \( \delta f(X, \beta)/\delta \beta \) we use \( Z(\beta) \), this is:
When this matrix of derivatives is evaluated at a particular value for $\beta$, say $\beta_1$, it will be written as $Z(\beta_1)$. Using (17), the first order conditions for a minimum can be written as:

$$Z(\beta)'[y - f(X, \beta)] = 0 \tag{18}$$

To indicate how the Gauss-Newton algorithm can be used to find a solution to (18), we begin approximating $f(X, \beta)$ with a first-order Taylor series expansion around an initial point $\beta_1$. The approximation for the $r$th observation is given by

$$f(x_t, \beta) = f(x_t, \beta_1) + \left[ \frac{\partial f(x_t, \beta)}{\partial \beta_1} \bigg|_{\beta_1} \cdots \frac{\partial f(x_t, \beta)}{\partial \beta_k} \bigg|_{\beta_1} \right] \beta - \beta_1 \tag{19}$$

and including all $T$ observations yields:
\[ f(X, \beta) = f(X, \beta_1) + Z(\beta_1)(\beta - \beta_1) \]  \hspace{1cm} (20)

Substituting (20) into (14) yields:

\[ y = f(X, \beta_1) + Z(\beta_1)(\beta - \beta_1) + e \]  \hspace{1cm} (21)

from which we can construct the linear model:

\[ \bar{y} = Z(\beta_1)\beta + e \]  \hspace{1cm} (22)

where:

\[ \bar{y}(\beta_1) = y - f(X, \beta_1) + Z(\beta_1)\beta_1 \]  \hspace{1cm} (23)

The least squares estimate from the linear model in (22) provides a second round estimate for \( \beta \), namely,

\[ \beta_2 = [Z(\beta_1)'Z(\beta_1)]^{-1}Z(\beta_1)'\bar{y}(\beta_1) \]

or

\[ \beta_2 = \beta_1 + [Z(\beta_1)'Z(\beta_1)]^{-1}Z(\beta_1)'[y - f(X, \beta_1)] \]  \hspace{1cm} (24)

Continuing this process, the nth iteration of the algorithm is given by:
\[ \beta_{n+1} = \beta_n + [Z(\beta_n)'Z(\beta_n)]^{-1}Z(\beta_n)'[y - f(X, \beta_n)] \]  
(25)

When the process has converged \( \beta_{n+1} = \beta_n \), so, from (25), it follows that the first-order conditions for a minimum \( Z(\beta_n)'[y - f(X, \beta_n)] = 0 \) must be satisfied. In these circumstances the point \( \beta_n \) could correspond to a local minimum or the global minimum. It will not correspond to a maximum because the positive definiteness of \( [Z(\beta_n)'Z(\beta_n)]^{-1} \) ensures that the change \( \beta_{n+1} - \beta_n \) will always be in the right direction. Although one can never be sure the global minimum has been reached, the chances of missing the global minimum can be reduced by trying a number of different initial values \( \beta_1 \).

Under appropriate conditions the least squares estimate \( \hat{b} \) will be approximately normally distributed with mean \( \bar{b} \) and a covariance matrix that is consistently estimated by:

\[ \hat{\Sigma}_b = \hat{\sigma}^2 [Z(b)'Z(b)]^{-1} \]  
(26)

where

\[ \hat{\sigma}^2 = \frac{S(b)}{T - K} \]  
(27)

A set of sufficient conditions that is required for the asymptotic theory relating to \( b \) to be valid needs to be framed in terms of:
1. The sequence of independent variables $x_t$
2. The function $f(x_t, \beta)$
3. The errors $e$

To begin with the last condition, we have assumed that the $e_t$ are independently, identically distributed with 0 mean and variance $\sigma^2$. These assumptions are sufficient if appropriately combined with conditions for the $x_t$ and $f(x_t, \beta)$.

With respect to $f(x_t, \beta)$, we have used differentiability of $f(x_t, \beta)$, with respect to $\beta$, in the foregoing derivations. To establish the asymptotic normality, it is convenient to assume that $f(x_t, \beta)$ is continuous in both arguments and at least twice continuously differentiable with respect to $\beta$.

Also, we have used the invertibility of $[Z(\beta)'Z(\beta)]$. In fact, as long as we are only concerned with the asymptotic behavior of the model it suffices to require

$$\frac{1}{T}[Z(\beta)'Z(\beta)] \quad (28)$$

to be non-singular in the limit for $T \to \infty$. Although this is not easy to verify since it depends on the sequence of independent variables $x_t$, $t=1,2,\ldots,T$, which is sometimes violated. This problem is similar to multicolinearity in linear models.
The conditions for such sequence are such that it is bounded and well behaved as $T$ approaches infinity.

If the above conditions hold it can be said that the non-linear least squares estimator $b$ is consistent, and that:

$$\sqrt{T}(b - \beta)$$  \hfill (29)

has a limiting normal distribution with mean 0 and variance $\sigma^2[\lim z(\beta)'z(\beta)/T]^{-1}$. Thus, equations (26) and (27) are going to be used to compute the standard error of the coefficients in equation (12) to estimate equation (9).
IV. EMPIRICAL ANALYSIS

We obtained data on weekly holdings of CETES and TESOBONOS from January 1994 to December 1994.

Holdings of CETES and TESOBONOS, described in the introduction, are used to define alpha as follows:

\[ \alpha_t = \frac{\text{Non-banking sector holdings of TESOBONOS at time } t}{\text{Non-banking sector holdings of CETES at time } t + \text{Non-banking sector holdings of TESOBONOS at time } t} \]

In fact \( \alpha_t \) can be calculated in two ways depending on whether face value or market value is used. Furthermore \( \alpha_t \) can be split by type of investor, domestic or foreign.

Therefore six definitions of \( \alpha_t \) are used to estimate the coefficients in equation (9):

\[ \text{alfand} = \frac{\text{Face value of domestic investors' holdings of TESOBONOS}}{\text{Face value of domestic investors' holdings of CETES} + \text{face value of domestic investors' holdings of TESOBONOS}}. \]
\( \alpha_{mf} = \frac{\text{Face value of foreign investors' holdings of TESOBONOS}}{(\text{Face value of foreign investors' holdings of CETES} + \text{face value of foreign investors' holdings of TESOBONOS})}. \)

\( \alpha_{fn} = \frac{\text{Face value of total non-banking sector holdings of TESOBONOS}}{(\text{Face value of total non-banking sector holdings of CETES} + \text{face value of total non-banking sector holdings of TESOBONOS})}. \)

\( \alpha_{md} = \frac{\text{Market value of domestic investors' holdings of TESOBONOS}}{(\text{Market value of domestic investors' holdings of CETES} + \text{Market value of domestic investors' holdings of TESOBONOS})}. \)

\( \alpha_{mf} = \frac{\text{Market value of foreign investors' holdings of TESOBONOS}}{(\text{Market value of foreign investors' holdings of CETES} + \text{Market value of foreign investors' holdings of TESOBONOS})}. \)

\( \alpha_{m} = \frac{\text{Market value of total non-banking sector holdings of TESOBONOS}}{(\text{Market value of total non-banking sector holdings of CETES} + \text{Market value of total non-banking sector holdings of TESOBONOS})}. \)

Four definitions are used for the returns on the government bonds:
\[ r_m = \text{CET28} = \text{annualized interest rate on a one month Mexican Treasury Certificate.} \]

\[ r_m = \text{CET91} = \text{annualized interest rate on a three month Mexican Treasury Certificate.} \]

\[ r_u = \text{TES91} = \text{annualized interest rate on a three month Mexican Treasury Bond.} \]

\[ r_u = \text{TES182} = \text{annualized interest rate on a six month Mexican Treasury Bond.} \]

For the exchange rate just one definition can be applied:

\[ \text{ex} = \text{tcfix} = \text{is the exchange rate used to pay federal government liabilities denominated in US dollars.} \]

**IV.1. EMPIRICAL RESULTS**

Only two of the previous definitions for alpha yield converging results for the minimization problem used in a Non-linear least squares estimation. While reading Tables 1-2, it is important to keep in mind that the BETA coefficients affect \( \Pi \) (probability of non-devaluation) and the DELTA coefficients affect \( d \) (size of devaluation or capital loss). The estimated coefficients when the "alfamd" definition is used are shown in Table 1:
### TABLE 1
ALPHA COMPUTED AT MARKET VALUE OF DOMESTIC INVESTORS' HOLDINGS OF CETES AND TESOBONOS

<table>
<thead>
<tr>
<th>Coeff.</th>
<th>ALFAMD</th>
<th>SSE 1</th>
<th>SEC 2</th>
<th>R²</th>
<th>t-ratio Coeff/SEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma$(RISK)</td>
<td>1.2104</td>
<td>.5079</td>
<td>0.9052</td>
<td>0.7940</td>
<td>1.3371</td>
</tr>
<tr>
<td>$\beta_0$(Cons)</td>
<td>20.8996</td>
<td></td>
<td>12.8176</td>
<td></td>
<td>1.6305</td>
</tr>
<tr>
<td>$\beta_1$(CET28)</td>
<td>19.7454</td>
<td></td>
<td>19.7217</td>
<td></td>
<td>1.0012</td>
</tr>
<tr>
<td>$\beta_2$(TES91)</td>
<td>-20.2017</td>
<td></td>
<td>27.8283</td>
<td></td>
<td>-0.7259</td>
</tr>
<tr>
<td>$\beta_3$(TCFIX)</td>
<td>-5.7934</td>
<td></td>
<td>4.0580</td>
<td></td>
<td>-1.4276</td>
</tr>
<tr>
<td>$\delta_0$(Const)</td>
<td>12.8838</td>
<td></td>
<td>6.8171</td>
<td></td>
<td>1.8899*</td>
</tr>
<tr>
<td>$\delta_1$(CET28)</td>
<td>49.1447</td>
<td></td>
<td>7.7268</td>
<td></td>
<td>6.3602**</td>
</tr>
<tr>
<td>$\delta_2$(TES91)</td>
<td>-49.1487</td>
<td></td>
<td>20.8666</td>
<td></td>
<td>-2.3553**</td>
</tr>
<tr>
<td>$\delta_3$(TCFIX)</td>
<td>-4.7135</td>
<td></td>
<td>2.1669</td>
<td></td>
<td>-2.1751**</td>
</tr>
</tbody>
</table>

---

1 SSE=Sum of Squared Residuals  
2 SEC=Standard Error of the Coefficient  
* Significant at 5%  
** Significant at 2.5%
The estimated coefficients when the "alfamf" is used are shown in Table 2:

### TABLE 2

**ALPHA COMPUTED AT MARKET VALUE OF FOREIGN INVESTORS' HOLDINGS OF CETES AND TESOBONOS**

<table>
<thead>
<tr>
<th>Coeff.</th>
<th>ALFAMF</th>
<th>SSE$^3$</th>
<th>SEC$^4$</th>
<th>$R^2$</th>
<th>t-ratio Coeff/SEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma$ (RISK)</td>
<td>0.8811</td>
<td>0.37441</td>
<td>0.5103</td>
<td>0.8773</td>
<td>1.7263*</td>
</tr>
<tr>
<td>$\beta_0$ (Const)</td>
<td>13.4519</td>
<td>9.3442</td>
<td></td>
<td></td>
<td>1.4396</td>
</tr>
<tr>
<td>$\beta_1$ (TES91)</td>
<td>-19.7015</td>
<td>12.7714</td>
<td></td>
<td></td>
<td>-1.5426</td>
</tr>
<tr>
<td>$\beta_2$ (TCFIX)</td>
<td>-2.3946</td>
<td>2.4181</td>
<td></td>
<td></td>
<td>-0.9903</td>
</tr>
<tr>
<td>$\beta_3$ (dumco)</td>
<td>-1.0239</td>
<td>0.7565</td>
<td></td>
<td></td>
<td>-1.3534</td>
</tr>
<tr>
<td>$\delta_0$ (Const)</td>
<td>2.1999</td>
<td>11.9674</td>
<td></td>
<td></td>
<td>-0.1838</td>
</tr>
<tr>
<td>$\delta_1$ (CET28)</td>
<td>54.1282</td>
<td>18.2376</td>
<td></td>
<td></td>
<td>2.9679**</td>
</tr>
<tr>
<td>$\delta_2$ (TES91)</td>
<td>-145.8346</td>
<td>97.6949</td>
<td></td>
<td></td>
<td>-1.4927</td>
</tr>
<tr>
<td>$\delta_3$ (TCFIX)</td>
<td>0.9608</td>
<td>3.4060</td>
<td></td>
<td></td>
<td>0.2820</td>
</tr>
<tr>
<td>$\delta_4$ (dumco)</td>
<td>-1.0270</td>
<td>1.6163</td>
<td></td>
<td></td>
<td>-0.6353</td>
</tr>
</tbody>
</table>

---

$^3$ SSE=Sum of Squared Residuals
$^4$ SEC=Standard Error of the Coefficient
* Significant at 5%
** Significant at 2.5%
The $R^2$ is defined as follows:

Total sum of squares (TSS) = Regression sum of squares (RSS) + Error sum of squares (SSE) or

$$(y - \bar{y})'(y - \bar{y}) = (\hat{y} - \bar{y})'(\hat{y} - \bar{y}) + \hat{e}'\hat{e}$$

And the t-ratio is defined as:

$$t = \frac{b_i}{\sqrt{\hat{\sigma}^2[Z(b)'Z(b)]_{ii}^{-1}}}$$

This value is compared to another value from the t-student distribution with (T-K) degrees of freedom.
V. CONCLUSIONS

From Tables 1 and 2 in the previous section, it is possible to say that domestic and foreign investors had similar degrees of risk aversion, being statistically significant for the later.

There are two differences regarding the variables used to estimate alpha for each type of investor, while the return on CETES was included in \( \Pi \) as well as in \( d \) in the case of domestic investors, this return is excluded from \( \Pi \) when the parameters were estimated for foreign investors. The second difference is that in the case of foreign investors, a dummy variable was included to model the effect on this investors' expectations of the assassination of the presidential candidate and the subsequent political instability it generated. These variables were excluded from the domestic model after the appeared to be statistically insignificant. What is more important, their inclusion created numerical problems and made it difficult to optimize the objective function and find standard errors.

Domestic investors perceived an increase in the returns on CETES as signaling a decrease in the probability of devaluation.

Both, domestic and foreign investors perceived an increase in the returns on TESOBONOS as an increase of the probability of devaluation. Also, an increase in the exchange rate was interpreted in the same way by both investors.
An increase of political instability increased the perceived probability of devaluation for foreign investors.

Domestic and foreign investors interpreted an increase in the returns on CETES as an increase in the expected devaluation size. On the other hand, both investors interpreted an increase in the returns on TESOBONOS as a factor likely to decrease the expected size of devaluation.

Foreign investors perceived an increase in the exchange rate as increasing the expected devaluation size, while domestic investors viewed it as signalling the opposite. However, the coefficient for foreign investors is not statistically significantly different from zero.

Finally foreign investors interpreted an increase in political instability as signaling a decrease in the expected devaluation size.

As shown in Figures 3 and 7, the model does not capture accurately the effect of March 1994 adverse political events (see weeks 12 to 15).

Figures 4 and 8, show that the model fits better for foreign investors than it does for domestic.

The estimated devaluation size was higher most of the time in the case of foreign investors than it was for domestic (see figures 5 and 9).
The estimated devaluation probability increased faster for domestic investors than it did for foreign investors (see figures 6 and 10).

Finally, as shown in figure 11, aggregation of domestic and foreign investors’ data is not possible because they behaved in different ways.
FIGURE 3

RESIDUALS FOR DOMESTIC INVESTORS
FIGURE 4

ESTIMATED AND ACTUAL PROPORTIONS FOR DOMESTIC INVESTORS
FIGURE 5

ESTIMATED DEVALUATION SIZE BY DOMESTIC INVESTORS
FIGURE 6

ESTIMATED DEVALUATION PROBABILITY BY DOMESTIC INVESTORS

[Graph showing estimated devaluation probability over time]
RESIDUALS FOR FOREIGN INVESTORS
FIGURE 8

ESTIMATED AND ACTUAL PROPORTIONS FOR FOREIGN INVESTORS

- - FORACTUAL
- - FORESTIMATED
FIGURE 9

ESTIMATED DEVALUATION SIZE BY FOREIGN INVESTORS
FIGURE 10

ESTIMATED DEVALUATION PROBABILITY BY FOREIGN INVESTORS
ALPHAS FOR DOMESTIC AND FOREIGN INVESTORS COMPUTED AT MARKET VALUE

FIGURE 11

PERCENTAGE

0.8

0.7

0.6

0.5

0.4

0.3

0.2

0.1

0

1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49

WEEK

- ALFAMF
- ALFAMD
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