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"Real Exchange Rate Response to Capital Flows in Mexico: An Empirical Analysis"

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Real Exchange Rate Response to Capital Flows in Mexico: An Empirical Analysis

by Marcelo Dabos and V. Hugo Juan-Ramon [1]

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I. Introduction

Mexico had relatively stable capital inflows until the early 1980s when it started experiencing large capital movements (Figure 1). The massive capital outflows that resulted from the debt crisis of 1982 began to subside in early 1984 and turned into inflows after 1988 in response to the implementation of a stabilization program, privatization, and structural reforms in mid 1980s. The inflows intensified following the Brady debt reduction agreement in early 1990. Again, capital flowed out during the 1994–95 crisis and it flew in back in 1997 as a result of successful stabilization measures and further structural reforms.

In most emerging economies, large capital inflows followed by sudden reversals (triggered by adverse shocks) have caused fluctuations in the real exchange rate. This paper examines the long-run response of the real exchange rate to capital movements in Mexico during 1970:1–97:4 and the subperiods prior and after the trade liberalization initiated in 1984. It also studies the short-run dynamic properties of a system involving capital inflow, the external terms of trade, and the real exchange rate. The paper does not address either the causes of capital movements, its composition, or its consequences across countries or regions, which have been dealt elsewhere in the literature (see Calvo, Leiderman, and Reinhart (1993b), and Khan and Reinhart (1995)).

The recent resumption of capital inflows in Mexico (and the decline in the terms of trade) has caused a market-driven real appreciation of the peso, that brought concerns about Mexico's external competitiveness (Figures 2 and 3). To cope with this "unsolvable problem," short- and medium-term strategies has been suggested, such as implementing a loose monetary policy to induce nominal and real depreciations, adopting a wide crawling band for the

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nominal exchange rate, introducing capital controls,[2] tightening the fiscal position, strengthening the financial system, deepening structural reforms, cutting red tape to reduce the "costs of doing business," and further opening the external current account.
The role of the degree of openness of the external current account in smoothing fluctuations in the real exchange rate caused by large capital movements has not received much attention lately. [3] Sjaastad and Manzur (SM) (1996) have brought this point to the forefront. Their hypothesis is that:

> "protection causes expenditure and production shifting to become less responsive to relative price changes, ... and hence the real exchange rate reacts more strongly to capital flows in highly protected economies than in those with more liberal commercial policies. ... this occurs because protection reduces not only the volume of trade (the scale effect) but also the margins of substitution between tradable and nontradable goods (the substitution effect). " [4]

SM (1996) found empirical support for their hypothesis in the cases they studied: a closed economy (Argentina in 1979:1–92:4), a semi-open economy (Australia in 1977:3–94:3) and an open economy (Canada in 1971:1–94:3).[5] In the Mexican case, the empirical evidence does not confirm the SM's hypothesis. In fact, we found that the real exchange rate is more

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[2] The crisis in Asia triggered a renewed interest in the question of whether capital controls may help reduce the risk of external imbalances and financial crises. At the 1998 World Economic Forum, the IMF First Deputy Managing Director, said that "For countries that can make them work, capital controls could be acceptable to the IMF for a transitional phase until the financial system of a country is sufficiently strong to deal with surges in short-term loans from abroad." The Chief Economist of the World Bank also favored considering capital controls, but the U.S. Deputy Treasury Secretary said that the issue required careful study, as there were also real risks that controls could delay or prevent more fundamental adjustments.

[3] Khan and Zahler (1983) provide a thorough and systematic analysis of the short-run effects of liberalization on both the current and capital accounts, as well as an analysis of the sequencing issue.

[4] The authors also draw conclusions on the issue of the proper sequencing of the liberalization of trade and capital accounts. As protection magnifies the response of the real exchange rate to capital flows, opening the current account should be completed before further opening in the capital account. The sequencing issue has resurfaced in the context of large-scale capital flows to emerging economies. A passage from a recent IMF Executive Board Meeting summing up report (SUR/97/137) illustrate this: "... a number of speakers argued that the emerging market countries should not liberalize their capital account prematurely and that, specially in light of the extension of the Fund's mandate to the capital account, there was a need to better understand the preconditions for an orderly liberalization, among which undoubtedly was a strengthening of the financial system."

[5] They measure the degree of openness by the ratio of exports plus imports to GDP, and

responsive to capital movements during the period of greater openness, which coincided with the time when financial and price liberalizations were implemented.

We also found that there is a long-run relationship between the ratio of capital inflows to GDP, the external terms of trade, and the export (and the true) real exchange rate; and that a once and for all increase in the ratio of quarterly capital inflow to quarterly (annualized) GDP by one unit would, other things equal, lead to a long-run real appreciation of the peso of about 21 percent (when defined by the export real exchange rate) or about 42 percent (when defined by the true real exchange rate). The model predicts that the expected capital inflow for Mexico of about US$16 billion in 1998, would cause a negligible real appreciation of the peso as measured by the true real exchange rate.

The estimated dynamic properties of the model suggest that the short-run relation among capital inflow, the external terms of trade, and the real exchange rate is stable in face of stochastic shocks.The estimated impulse response function indicates that deviations from equilibrium in the variables caused by stochastic shocks of one standard deviation will be corrected in about 14 quarters. Changes in the ratio of capital inflows to GDP causes changes in the export real exchange rate, and there is also evidence of feedback.

II. Degree of Openness

As suggested by the model given in the appendix, the degree of openness is defined as $(GDP/E \times p_X) - 1$; that is, the inverse of the share of exports of goods and nonfactor services to GDP minus one. Thus, the lower this measure is, the more open is the economy. The Mexican economy became more open over time (see Figure 4), and particularly after the early 1980s.[6]

For the sake of comparison, we calculated yearly and average values of the degree of openness of Argentina, Australia, Canada, and Mexico during 1970–96 (Table A-5). Openness is defined as the share of exports and imports of goods to GDP (in the case of Mexico it includes net exports of *maquilas*). In the subperiod 1985–94, on average, Canada had the most open economy followed by Australia, Mexico and Argentina. Mexico was 1.8 times more open than Argentina, but Australia was 1.3 times more open than Mexico and Canada was 2.1 times more open than Mexico. Thus, there is margin for Mexico to further open its economy.[7] In spite of the important progress that Mexico has done in the area of

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report that for the period of 1978-1990, this ratio was about 15 percent for Argentina, about 34 percent for Australia and about 52 percent for Canada. Thus, on average, Australia out traded Argentina by over two times, while Canada out traded Australia by one and a half times and Argentina by three and a half times.

[6] The hike in the degree of openness from 1994:4 onwards (Figure 4) reflects in part the increase of exports in terms of peso due to the large devaluation of late December 1994.

[7] Mancera (1997), in one of his latest speech as Governor of the Bank of Mexico, warned against vested interest groups that oppose free trade in all countries. For Mexico, he

trade liberalization since early 1980s, it remains to fully materialize the trade and financial integration with the United States and Canada (in the context of the North American Free Trade Agreement (NAFTA)) and with other nations.[8]

III. Data, variable definitions, and methodology

The data consist of quarterly observations (for the period 1970:1–97:4) for the natural logarithm of the real exchange rate relevant to the export sector (RERX), the natural logarithm of the external terms of trade (ETT), the ratio of quarterly net capital inflow to quarterly (annualized) GDP (k_y). Net capital inflow (denoted by k) is defined as the value of imports of goods and nonfactor services minus the value of exports of goods and nonfactor services.[9] The source for all the data is the Bank of Mexico.

To estimate the long-run response of the real exchange rate to capital inflows, we followed the Engle-Granger (1987) methodology to test for the existence of a long-run relationship (cointegration) between the true real exchange rate, capital inflows and the external terms of trade. The theoretical relationship between the logarithm of the true real exchange rate and k_y (derived in the appendix) is shown below:

(1) $TRER = constant + \Theta_y k_y$

where, TRER is the logarithm of the true real exchange rate, which is defined as the logarithm of the relative price of traded and home goods ($P_T - P_H$). And Θ_y is the long-run response of the true real exchange rate to changes in the ratio of capital inflow to GDP.

The true real exchange rate is difficult to construct because it requires estimating the price index of tradeables ($P_T = \omega P_M + (1-\omega) P_X$) using true weights ($\omega$, $1-\omega$). To estimate the key parameter Θ_y while avoiding the construction of TRER, we recast equation 1 (see the appendix for details). TRER can alternatively be expressed as $(1/w_H)(P_T - P)$, where P is the

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advocated to continue trade liberalization in the context of a floating exchange rate regime and price stability.

[8] Since 1993, Mexico's strategy as regards trade liberalization is centered on free trade agreements. Following NAFTA, Mexico concluded free trade agreements with five Central and South American countries and is currently negotiating agreements with several more. Mexico is scheduled to begin negotiations shortly on a trade agreement with the European Union, and it has shown interest in participating in the Asia-Pacific Economic Cooperation Council (APEC).

[9] Specifically, $RERX = E + P_x - CPI$; $ETT = P_x - P_m$; and $k_y = E (m\ p_m - x\ p_x) / GDP$; where E denotes the nominal exchange rate defined as Mex$ per US$, Px (Pm) stands for the logarithm of the dollar price index of exports (imports) of goods and nonfactor services, and net capital inflow (k) equals $m\ p_m - x\ p_x$.

logarithm of the consumer price index, which can be thought as a weighted average of home and tradeable goods indices ($P = w_H P_H + (1-w_H) P_T$). And introducing these definitions, obtains: $TRER = (1/w_H) [(\omega P_M + (1-\omega) P_X) - P] = (1/w_H) [(P_X - P) - \omega (P_X - P_M)]$. Defining $RERX = P_X - P$ and $TT = P_X - P_M$, yields $TRER = (1/w_H) [RERX - \omega TT]$. Using the relation between the logarithm of the external terms of trade (ETT) and the logarithm of the internal terms of trade (TT): $TT = a + ETT$, TRER can be written as $(1/w_H) [RERX - \omega (a + ETT)]$. And substituting it in equation 1 obtains the equation to be estimated.

$$(1') \quad RERX = C + \beta_y k_y + \omega ETT$$

where $C = w_H$ constant $+ \omega a$, and $\beta_y = w_H \Theta_y$.

First, we test whether the variables in (1') are cointegrated—using Engle-Granger (1987) methodology and also the Johansen cointegration test—to then estimate the long-run relationship among the variables in (1') and an error-correction model to assess the dynamic properties of the system.

IV. Empirical Results

A. Sample Period: 1970: 1-97:4

First, we test for the order of integration of RERX, k_y and ETT during the period 1970:1–97:4 using the Augmented Dickey-Fuller (ADF) Test with five lags.

Table 1. Augmented Dickey-Fuller Test on the Levels and on the First Differences of the Variables in Equation 1' for the period 1970:1–97:4

Variable	Test Value	1% Critical Value	5% Critical Value	10% Critical Value	Decision
RERX	-0.98	-3.49	-2.89	-2.58	Is not I(0)
k_y	-2.52	-3.49	-2.89	-2.58	Is not I(0)
ETT	-0.57	-3.49	-2.89	-2.58	Is not I(0)
ΔRERX	-4.76	-3.49	-2.89	-2.58	Is I(0) at 1%
Δk_y	-4.62	-3.49	-2.89	-2.58	Is I(0) at 1%
ΔETT	-4.91	-3.49	-2.89	-2.58	Is I(0) at 1%

The ADF test (Table 1) reveals that the three variables in equation 1' are integrated of order one (I(1)). Thus, we test for the existence of a long-run relationship (cointegration) among those variables by running an OLS regression of (1') and by testing the order of integration of the regression's residuals. If the estimated regression's residuals (interpreted as deviations of the RERX from its long-run equilibrium) were integrated of order zero (I(0)), then it would exist a long-run relationship among the variables in equation 1'.

APPENDIX

The OLS estimation of equation 1‘ is:

$$RERX = 0.10 - 15.65\ k_y + 1.01\ ETT \qquad \text{Adj. R-sq.} = 0.90.$$
$$(5.9)\ \ (-15.8)\qquad (28.5)$$

where t-statistic are in parentheses.

Table 2. Augmented Dickey-Fuller Test on the Levels of the Residuals in Equation 1‘

Variable	Test Value	1% Critical Value	5% Critical Value	10% Critical Value	Decision
Estimated Residuals	-3.05	-3.73	-3.17	-2.91	Is I (0) at 10%

Note: the special critical values for the test, given the estimated residuals, can be found in Walter Enders, *Applied Econometrics Time Series*, Wiley, 1995, page 383.

The ADF test shows that the estimated residuals are I(0) at the 10 percent significance level (Table 2). Thus, the variables in equation 1‘ exhibit a strong long-run relationship given the high values of the t-tests and adjusted R-squared.[10]

We also examined the subperiods 1970:1–84:1 and 1984:2–97:4 to take into consideration the turning point in capital outflows that began in early 1984 and the trade liberalization process that started about the same time.

[10]We confirmed that equation 1` represents a cointegrated relationship using the Johansen test. The likelihood ratio test indicates one cointegrating equation (involving the three variables considered) at 5% significance level.

B. Subperiod Prior to Trade Liberalization: 1970:1-84:1

Table 3. Augmented Dickey-Fuller Test on the Levels and the First Differences of Variables in Equation 1‘ for the subperiod 1970:1–84:1

Variable	Test value	1% Critical value	5% Critical value	10% Critical value	Decision
RERX	-2.71	-3.56	-2.92	-2.60	Is not I (0) at 5% level
k_y	-0.87	-3.56	-2.92	-2.60	Is not I (0)
ETT	-2.57	-3.56	-2.92	-2.60	Is not I (0)
ΔRERX	-3.65	-3.56	-2.92	-2.60	Is I (0)
Δk_y	-2.98	-3.56	-2.92	-2.60	Is I (0) at the 5% level
ΔETT	-3.46	-3.56	-2.92	-2.60	Is I (0) at the 5% level

The variables under considerations are also I(1) in this subperiod (Table 3), and the OLS estimation of equation 1‘ yields:

RERX = 0.08 - 12.4 ky + 0.88 ETT; Adj. R-sq. = 0.69
(3.6) (-10.3) (7.4)

where the t-statistics are in parentheses.

As the estimated residual of the regression are I(0) at the 5 percent critical level (the test value is -3.64 and the critical level at the 5 percent of significance is -3.17), there is a long-run relationship in this subperiod too.

C. Subperiod After Trade Liberalization: 1984:2-97:4

Table 4. Augmented Dickey-Fuller Test on the Levels and the First Differences of Variables in Equation 1‘ for the subperiod 1984:2–97:4

Variable	Test value	1% Critical value	5% Critical value	10% Critical value	Decision
RERX	-1.67	-3.55	-2.91	-2.59	Is not I (0)
k_y	-2.23	-3.55	-2.91	-2.59	Is not I (0)
ETT	-2.56	-3.55	-2.91	-2.59	Is not I (0)
ΔRERX	-3.34	-3.55	-2.91	-2.59	Is I (0) at the 5% level
Δk_y	-3.66	-3.55	-2.91	-2.59	Is I (0)
ΔETT	-3.76	-3.55	-2.91	-2.59	Is I (0)

In this subperiod, the variables considered are I(1) (Table 4) and the OLS estimation of equation 1‘is:

$$\underset{\quad}{RERX} = \underset{(-1.2)}{-0.10} \; \underset{(-11.6)}{- 20.97\, k_y} + \underset{(5.7)}{0.71\, ETT}; \quad \text{Adj. R-sq.} = 0.87$$

where the t-statistics are in parentheses.

The estimated residual of this regression are I(0) at the 1 percent critical level (the test value is -3.75 and the critical level at the 1 percent of significance is -3.73), implying that equation 1‘ is a long-run relationship in this subperiod too.

D. Interpretation of the Empirical Results

The table below summarizes the long-run estimation of β_y for the sample period and the two subperiods considered.

Table 5. Summary of Estimated Long-Run Relations

	βy	**t-test**	**ω**	**t-test**	**Adj. R-sq**	**Θy**
Mexico						
1970:1-1997:4	-15.6	-15.8	1.0	28.5	0.90	-31.2
1970:1-1984:1	-12.4	-10.3	0.9	7.4	0.70	-24.8
1984:2-1997:4	-20.9	-11.6	0.7	5.7	0.87	-41.8

The estimated parameters (β_y and Θ_y) for the subperiod 1984:2–97:4 indicate that a once and for all increase in the ratio of quarterly net capital inflow to quarterly (annualized) GDP of unity, would cause a long-run real appreciation of the peso of 21 percent (when measured by the export real exchange rate), or 42 percent (when measured by the true real exchange rate). The latter uses the share of home goods in the CPI (w_H) of 50 percent, which is the weight that the Bank of Mexico assigns to home goods in the consumer price index.

The expected capital inflow in Mexico during 1998 should cause only a negligible appreciation of the Mexican peso as measured by the true real exchange rate. The ratio of the quarter- average capital inflow in 1998 to quarter-average (annualized) GDP is expected to be about 0.0091, which implies an increase of 0.005 with respect to the value it had in the fourth quarter of 1997 (0.0041).[11] This increase and the estimated Θ_y of -41.8 indicate that the long-run effect on the true real exchange rate of the expected capital inflow should be negligible (a fall of about 0.21 percent).

To assess the influence of the degree of openness on the response of the real exchange rate to capital flows, we estimated the relevant coefficients for the subperiods prior and after trade liberalization: 1970:1–84:1 and 1984:2–97:4.[12] Contrary to the theoretical presumption, the estimated Θ_y for both subperiods indicate that in Mexico the export (and the true) real exchange rate were more responsive to capital flows during the period of greater openness. It is possible that the greater responsiveness reflects the structural reforms carried out by Mexico in mid 1980s, including financial liberalization, reforms to the foreign investment and tax regime, privatization, deregulation, and price and exchange rate liberalizations.[13]
To assess the dynamic properties of the variables in equation 1‘, we use the residuals from the equilibrium regression of equation 1‘ (as the variables are cointegrated) to estimate an error-correction model.

E. Dynamic Analysis for the Sample Period: 1970:1-97:4

[11] The expected levels of capital inflow and GDP in 1998 are US$16 billion and US$438,7 billion, respectively.

[12] The first stage of trade liberalization in Mexico started in 1983, but the bulk of the measures were implemented between July 1985 and December 1987 (Mancera (1997) and Juan-Ramon (1992)).

[13]For example, Mussa (1982) has pointed out that in most counties the purchasing power parity (PPP) real exchange rate has become quite volatile since fixed parities among the major currencies were abandoned in early 1973. It is also argued that the persistent variability in PPP real exchange rate is largely due to inappropriate government policies that influence the allocations of spending in traded and home goods and services.

$$(a)\quad \Delta RERX_t = \alpha_{11} + \alpha_{12}\hat{U}_{t-1} + \sum_{i=1}^{i=5} \alpha_{13}(i)\,\Delta RERX_{t-i} + \sum_{i=1}^{i=5} \alpha_{14}(i)\,\Delta k\,y_{t-i} + \sum_{i=1}^{i=5} \alpha_{15}(i)\Delta ETT_{t-i} + \varepsilon_1$$

$$(b)\quad \Delta ky_t = \alpha_{21} + \alpha_{22}\hat{U}_{t-1} + \sum_{i=1}^{i=5} \alpha_{23}(i)\,\Delta RERX_{t-i} + \sum_{i=1}^{i=5} \alpha_{24}(i)\,\Delta k\,y_{t-i} + \sum_{i=1}^{i=5} \alpha_{25}(i)\Delta ETT_{t-i} + \varepsilon_{2t}$$

$$(c)\quad \Delta ETT_t = \alpha_{31} + \alpha_{32}\hat{U}_{t-1} + \sum_{i=1}^{i=5} \alpha_{33}(i)\,\Delta RERX_{t-i} + \sum_{i=1}^{i=5} \alpha_{34}(i)\,\Delta ky_{t-i} + \sum_{i=1}^{i=5} \alpha_{35}(i)\Delta ETT_{t-i} + \varepsilon_{3t}$$

Table 6. Estimated Parameters of Equations (a) to (c)

RHS variables	Equation (a) LHS: Δ(RERX)	Equation (b) LHS: Δ(KY)	Equation © LHS: Δ(ETT)
U (-1)	-0.10 (-3.28)	0.003 (3.15)	-0.03 (-1.63)
Δ(RERX(-1))	0.36 (2.47)	-0.03 (-5.33)	0.008 (0.09)
Δ(RERX(-2))	0.13 (0.80)	-0.01 (-2.39)	0.02 (0.19)
Δ(RERX(-3))	0.21 (1.29)	-0.02 (-2.39)	-0.009 (-0.09)
Δ(RERX(-4))	0.12 (0.71)	-0.003 (-0.53)	0.05 (0.52)
Δ(RERX(-5))	-0.02 (-0.10)	-0.003 (-0.60)	0.01 (0.11)
$\Delta(k_y(-1))$	4.93 (1.45)	-0.07 (-0.58)	0.69 (0.32)
$\Delta(k_y(-2))$	3.11 (0.99)	-0.36 (-3.23)	1.92 (0.98)
$\Delta(k_y(-3))$	-2.19 (-0.68)	-0.19 (-3.23)	-1.06 (-0.52)
$\Delta(k_y(-4))$	4.50 (1.43)	0.25 (2.28)	0.40 (0.20)
$\Delta(k_y(-5))$	-5.49 (-1.86)	-0.04 (-0.41)	-2.15 (-1.17)
Δ(ETT(-1))	-0.17 (-0.80)	0.03 (3.79)	0.26 (1.95)
Δ(ETT(-2))	-0.34 (-1.51)	0.01 (1.84)	-0.26 (-1.83)
Δ(ETT(-3))	-0.22 (-0.93)	0.02 (2.04)	0.14 (0.96)
Δ(ETT(-4))	-0.31 (-1.38)	0.02 (2.15)	-0.29 (-2.09)
Δ(ETT(-5))	-0.30 (-1.29)	0.008 (0.99)	-0.17 (-1.14)
Constant	-0.007 (-0.85)	-0.00001 (-0.04)	-0.005 (-1.04)
Adj. R-squared	0.0813	0.4364	0.0764

The estimated parameters of equations (a), (b) and (c), reported in Table 6, suggest the following:

(i) As α_{12} , α_{22} and α_{32} are different from zero, have the right sign, and are smaller than unity in absolute terms, the system is a true error correction model.

(ii) Given that α_{12} and at least one the α_{14} (*i*)s are different from zero, changes in the ratio of capital inflows to GDP (Δk_y) cause changes in the real exchange rate ($\Delta RERX$).

(iii) As expected, the coefficient of Δ(RERX(-1)) to Δ(RERX(-5)) and $\Delta(k_y(-1))$ to $\Delta(k_y(-5))$ in equation © are not significantly different from zero. Given that Mexico is price taker in international markets, changes in those variables do not have any effect on the external terms of trade.

(vi) Lutkepohl and Reiners (1992) show that innovation accounting (i.e., impulse responses) can be used to obtain information concerning the interactions among the variables. Since all variables in equations (a) to (c) are I(0), the impulse responses converge to zero. Thus, a temporary exogenous shock (ε) produces only a temporary effect on the variables.

The speed of adjustment coefficients (α_{12} , α_{22} , and α_{32}) are of particular interest in that they have important implications for the dynamics of the system. As specified, the model indicates the response of the real exchange rate, capital inflows and the external terms of trade to stochastic shocks and to the previous period's deviation from long-run equilibrium. Given that α_{12} is not zero, the change in RERX reacts to deviations from long-run equilibrium originated in the previous quarter. For example, equation (a) shows that impact effect on the change of the RERX of a given deviation from equilibrium ($\acute{U}_{t-1}$) will be -10 percent of the deviation.

V. Conclusions

After the 1980s, capital flows have accelerated in the less developed countries and since Salter's seminal paper in 1959, it has been widely accepted that the real exchange rate respond to capital flows. Based on a simple model derived by Sjaastad and Manzur (1996) along the lines of Salter (1959) and Rodriguez (1994), we estimated the long-run response of the export (and true) real exchange rate to capital inflows in Mexico for the period 1970:1–97:4, and for the subperiods prior and after the trade liberalization and other structural reforms initiated in 1984. We have also examined the short-term dynamic properties of a system involving capital inflows, the external terms of trade, and the real exchange rate and found that the system is a stable, true error correction model, and that deviations from equilibrium due to exogenous shocks are corrected in about 14 quarters.

The empirical findings suggest that there exists a long-run relationship between the ratio of capital inflows to GDP, the external terms of trade, and the export (and the true) real exchange rate. Based on the estimated relationship for the subperiod of greater openness (1984:2–97:4), a once and for all increase in the ratio of capital inflow to GDP by one unit

would, other things equal, lead to a long-run real appreciation of the peso of about 21 percent (when defined by the export real exchange rate) or about 42 percent (when defined by the true real exchange rate). Considering the expected capital inflow for Mexico in 1998 of about US$16 billion, the model predicts a negligible real appreciation of the peso (as measured by the true real exchange rate) of about 0.21 percent.

The estimated dynamic properties of the model suggest that (i) it is a true error correction model since all of the coefficients of the estimated error terms are different from zero (it is required that at least one of them being different from zero), (ii) given that the impulse response functions converge to zero, the system is stable in face of a stochastic shocks. That is, a stochastic shock will perturb the variables under consideration only temporarily as they will return to their long-run equilibrium levels, (iii) changes in the ratio of capital inflows to GDP cause changes in the export real exchange rate, and there is also evidence of feedback, (iv) As expected, given that Mexico is a price-taking country, changes in the export real exchange rate and in capital inflows do not influence the external terms of trade.

We split the sample in two subperiods: 1970:1–84:1 and 1984:2–97:4 to take into consideration the turning point in capital outflows that began in early 1984 and the trade liberalization process that started about the same time. First, we tested the difference of means in the degree of openness in both subperiods and found that the greater degree of openness observed in the second subperiod is statistically significant (see appendix).

We tested the SM's (1996) hypothesis that (because protection reduces not only the volume of trade but also the margins of substitution between traded and nontraded goods) capital movements have less impact on the real exchange rate (thus, it exhibits less variability) when the economy is more open. Our findings do not support this hypothesis. In fact, the long-run response of the real exchange rate to capital movements is greater in the second subperiod when the economy was more open. In this connection, we also conducted variance tests of the export real exchange rate and the ratio of capital inflow to GDP and accept the hypothesis of no difference between the variances across subperiods for these two variables at the 1 percent significance level (see appendix).

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Derivation of the Relationship Between the True Real Exchange Rate and Capital Inflows

The basic model used to derive the theoretical relation between capital inflows and the true real exchange rate is borrowed from Sjaastad and Manzur (1996).To study the effect of capital flows rather than secular economic growth on the real exchange rate, the model has three goods, importables, exportables and home goods, and hence two relative prices. The price indices in domestic currency for imports of goods and nonfactor services, exports of goods and nonfactor services, and home goods are denoted by p_M, p_X and p_H, respectively; and the value of imports and exports of goods and nonfactor services are m p_M and x p_X, respectively. y and y^e denotes GDP and expenditures on goods and nonfactor services, thus $y^e = y + (m\ p_M - x\ p_X)$. Net capital inflow, denoted by k, is defined as the capital account surplus minus net factor service payments abroad, $k = y^e - y = m\ p_M - x\ p_X$. The ratios of net capital inflow to the value of exports of goods and nonfactor services and to GDP is defined

$$m\ p_M = C\ (\frac{p_M}{p_H})^{-\alpha_H}\ (\frac{p_M}{p_X})^{-\alpha_X}\ (\frac{y^e}{y})^{\eta_M}\ y^e$$

by $k_x = k/x\ p_X$ and $k_y = k/y$, respectively.

$$x\ p_X = C'\ (\frac{p_X}{p_H})^{\beta_H}\ (\frac{p_X}{p_M})^{\beta_M}\ (\frac{y}{y^e})^{\eta_X}\ y$$

Expressing the system in a log-linear form (using upper case for natural logarithms), obtains:

$$M + P_M = \text{constant} + Y - (\alpha_H + \alpha_X)\ P_M + \alpha_H\ P_H + \alpha_X\ P_X + (1 + \eta_M)\ \ln\ (1 + k_y)$$

$$X + P_X = \text{constant} + Y + (\beta_H + \beta_M)\ P_X - \beta_H\ P_H - \beta_M\ P_M - \eta_X\ \ln\ (1 + k_y)$$

$$m\ p_M = x\ p_X + k = x\ p_X\ (1 + k_X)$$

$$M + P_M = X + P_X + \ln\ (1 + k_X)$$

Where α_H and α_X are the elasticities of import demand with respect to the price of imports relative to home goods and exports, respectively; and β_H and β_M are the elasticities of export supply with respect to the price of exports relative to home goods and imports; and, in the

absence of complementarity, αs and βs are defined to be positive. Solving the log-linear system for P_H, yields the following reduced form:

$$P_H = \text{constant} + \Theta \left[(\eta_X + \eta_M + 1) \ln (1 + k_y) - \ln (1 + k_X) \right] + \omega P_M + (1 - \omega) P_X$$

where $\Theta = -1/(\alpha_H + \beta_H)$ and $\omega = (\alpha_H + \alpha_X - \beta_M) / (\alpha_H + \beta_H)$. The absence of complementarity (i.e., given P_M and P_X, a change in P_H shifts expenditures and production in the "right" directions) ensures that $\alpha_H + \beta_H > 0$, which implies that Θ is negative. Moreover, ω, the elasticity of the price of home goods with respect to import prices, is the well known "shift" parameter in the theory of the incidence of protection (Sjaastad (1980) and Rodriguez and Sjaastad (1979)).

The final term in the latter equation, $\omega P_M + (1 - \omega) P_X$, turn out to be exactly the appropriate price index for traded goods, and hence that equation is an implicit relationship between the *true* real exchange rate and capital inflows. The true real exchange rate, trer, is merely the relative price of traded goods to home goods and is defined, in logarithm, as $TRER = P_T - P_H$. The index P_T is a weighted average of P_X and P_M . Sjaastad and Manzur (1996) show that if the homogeneity postulate is to be satisfied, then $dP_T/dP_M = \omega$ and $dP_T/dP_X = 1- \omega$, and therefore $P_T = \omega P_M + (1 - \omega) P_X$ and the $TRER = \omega P_M + (1 - \omega) P_X - P_H$. Accordingly, the above reduced form can be written as an explicit relationship between the true real exchange rate and capital inflows:

$$TRER = \text{constant} + \Theta \{ \ln [(1 + k_X)/(1 + k_y)] - (\eta_X + \eta_M) \ln (1 + k_y) \}$$

Since η_X and η_M are likely to be small, their sum also is likely to be small; in addition, since $\ln (1 + k_y)$ is approximately k_y which also is small, the product $(\eta_X + \eta_M) \ln (1 + k_y)$ will be neglected in what follows. Moreover, as $\ln [(1 + k_X)/(1 + k_y)]$ is approximately $k_X - k_y$, the reduced form can be written as:

(A–1) $TRER = \text{constant} + \Theta (k_X - k_y)$

Defining $z = E \times p_X/GDP$, then $k_X - k_y = [(1 -z)/z] k_y$ and replacing the last expression, obtains equation (1) of the text:

(A–2) $TRER = \text{constant} + \Theta_y . k_y$

where $\Theta_y = \{(1-z)/z\} \Theta$. The ratio of Θ_y to Θ , which can alternatively be expressed as $(GDP/E \times p_X) - 1$, measures the degree of openness of the economy. The lower this ratio is, the more open the economy.

Derivation of the Equation to be Estimated

The model's equations (A–1) or (A–2) involves the logarithm of the true real exchange rate (defined as $P_T - P_H$), which is difficult to construct because it requires estimating the indices of tradables and home goods. First, we define the real exchange rate (in logarithm) as

RER≡ $P_T - P$, where P is the consumer price index defined as a weighted average of home and tradable goods $P = w_H P_H + (1 - w_H) P_T$. Thus $RER \equiv P_T - P = P_T - (w_H P_H + (1 - w_H) P_T) = w_H (P_T - P_H) = w_H$ TRER. And substituting RER for TRER in (A–2), obtains:

(A–3) $RER = w_H$ constant + $w_H \Theta_y k_y$

RER still involves the price-good of tradables, which is defined as a weighted average of importables and exportables ($P_T = \omega P_M + (1 - \omega) Px$). And replacing the definition of P_T in RER yields:

$RER = P_T - P = \omega P_M + (1 - \omega) Px - P = (Px - P) - \omega (Px - P_M)$

and defining the logarithm of the exports real exchange rate (RERX) as Px - P, and the logarithm of the domestic terms of trade (TT) as $Px - P_M$, we have:

$RER = RERX - \omega TT$

Substituting RER in (A–3), yields:

(A–4) $RERX = w_H$ constant + $w_H \Theta_y k_y + \omega TT$

$$\frac{p_X}{p_M} = \left(\frac{Ex(1+s_X)}{E_M(1+t_M)} \right) \left(\frac{p^*_X}{p^*_M} \right)$$

The relation between the domestic and external terms of trade is given by:

where s_X is the average rate of subsidies on exports, t_M is the average rate of tariffs on imports (including equivalent tariffs from quantitative restrictions to imports), and E_X (E_M) is the nominal exchange rate that applies to exports (imports). In logarithm form:

$$TT = a + ETT$$

where *a* is the logarithm of $[E_X (1+s_X)/E_M (1+t_M)]$ and $ETT = P^*_X - P^*_M$ is the logarithm of the external terms of trade. And replacing TT in (A–4), obtains the equation to be estimated:

$$RERX = C + \beta_y k_y + \omega ETT$$

where $C = w_H$ constant $+ \omega a$, and $\beta_y = w_H \Theta_y$

Variability of rerx and k_y Across Subperiods

In the second subperiod, Mexico underwent structural reforms including trade and price liberalization, as well as financial reforms. To assess the effect of these reforms on the variability of the real exchange rate and the ratio of capital inflow to GDP, we tested the null hypothesis of equality of the variances of rerx and k_y across the subperiods of 1970:1–84:1 and 1984:2–97:4 (it is not necessary to assume that the two samples have equal means). We compute the ratio of the sample variances, which follows an F distribution, and reject the null hypothesis if this ratio is either unusually large or unusually small. The critical region for a 5 percent level of significance and for 57 and 55 observations in the first and second subperiods (or (56, 54) degree of freedoms) consist of values of $F > F .975 (56,54) = 1.67$ and $F < F .025 (56,54) = 0.6$. And for a 1 percent level of significance, the critical region consist of values of $F > F .995 (56,54) = 1.96$ and $F < F .005 (56,54) = 0.510$.

Table A–1. Variances and Ratios

	1970:1–84:1 Var_1	1984:2–97:4 Var_2	Ratio of variances (Var_1/Var_2)
Rerx	0.019219	0.032607	0.5894
k_y	0.000085969	0.000092563	0.92876

Table A–2. Tests for Equality of Variances

	F.005	F.025	Ratio of sample variances	F.975	F.995	Decision
rerx	0.510	0.600	0.5894	1.67	1.96	Reject equality at 5%. Accept equality at 1%.
k_y	0.510	0.600	0.92876	1.67	1.96	Accept equality at 5% and 1%

Regarding the variability of the ratio of capital inflow to GDP (k_y), the test accepts the null hypothesis of no difference between the variances across the subperiods at the 1 percent significant levels. Regarding the variability of the export real exchange rate (rerx), the test shows that the first subperiod is not more volatile than the second subperiod.

Difference in the Degree of Openness Across Subperiods

After 1984, Mexico started liberalizing its external current account. We constructed a series of a measure of the degree of openness given by (GDP/E x p_x) - 1. The means and variances of this series for the subperiods 1970:1–84:1, 1984:2–94:4, and 1984:2–97:4 are shown in Table A–3. (we included a subperiod ending in the fourth quarter of 1994 to avoid the effect of the large devaluation at end 1994 on the degree of openness.) The lower mean of the degree of openness after 1984 indicates that the economy was more open. To assess whether the greater openness was statistically significant, we tested the null hypothesis that the difference of the means prior and after trade liberalization is zero. We constructed the sampling distribution of the statistics z, which is normal distributed, and use a cumulative

$$z = (\mu_1 - \mu_2) / \sqrt{[\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}]}$$

normal distribution table to determine the critical region (Table A–4).

The test rejects the null hypothesis at the 5 percent and 1 percent significance level, which implies that the Mexican economy has had a higher degree of openness after 1984.

Table A–3. Level and Variability of the Degree of Openness

	Mean	Variance	Number of observations
1970:1–1984:1	9.12	5.06	57
1984:2–1994:4	6.19	1.52	43
1984:2–1997:4	5.61	2.42	55

Table A–4. Test for the Differences in Means

	Z.005	Z.025	Z value	Z.975	Z.995	Decision
1970:1–1984:1 vs 1984:2–1997:4	-2.55	-1.95	9.66	1.95	2.55	Reject equality at 5% and 1%
1970:1–1984:1 vs 1984:2–1994:4	-2.55	-1.95	8.34	1.95	2.55	Reject equality at 5% and 1%

Difference in the Degree of Openness Across Subperiods and Countries

To gain further insight, we compared Mexico's degree of openness with that of Argentina, Australia, and Canada (see Table A–5). Here, the degree of openness is defined as the share of exports and imports of goods in GDP. These figures show that, as noted before, although the Mexican economy has been more open after mid 1980s, it has not reached yet the degree of openness displayed by either Australia or Canada.