The Recovery of Mexican Investment after the Tequila Crisis: Basic Economics or "Confidence" Effects?

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Abstract

The stylized facts show that investment was at the heart of the Mexican economic recovery after 1995. This study provides an empirical investigation of the determinants of the growth rate of fixed investment in Mexico, with special attention given to the aftermath of the crisis. It uses quarterly data for 1980-1999. Most of the analysis is based on a structural model of Mexican investment, but additional model-free analyses are also used to further explore some key issues. The paper uses the Generalized Method of Moments estimator with instrumental variables to determine if the behavior of Mexican investment can be explained with a standard investment function. The only addition to standard models of investment in developing countries (which consider cost, scale and uncertainty factors) is the assumption that tradable and non-tradable output growth have different multiplier effects on Mexican investment growth. The authors search for "confidence" effects, to assess whether the basic model of investment was operational during times of crisis. The main findings are that the basic model does quite well in predicting the recovery of investment during 1996 and 1997; "confidence" effects only seem to be present during 1982-1983. The story that emerges is that Mexican investment growth declined during 1995 due to the currency depreciation's impact on the relative price of capital goods, but eventually the recovery was driven by the high multiplier effect from the growth of tradable output and declining real interest rates.

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INTRODUCTION

The Mexican economy experienced a sharp contraction in 1995, after the *Peso* devaluation of December 22, 1994. The GDP growth rate reached an annualized rate of -6.2% in 1995, and became positive again during the first three quarters of 1996. In 1996 and 1997 the Mexican economy grew at healthy rates of 5.1% and 6.8% respectively. It has been suggested by some authors that the decisive response of the fiscal and monetary authorities supported by a generous financial package of billions of dollars announced in March 9, 1995, were crucial for a rapid recovery of lost investor confidence. These observers further argue that these policies prompted a rapid stabilization of the currency and a turnaround in investment and economic activity.[1]

The aim of the present paper is to examine if the behavior of investment in Mexico during 1995-99 can be explained by simple economic models. Section I begins by establishing the stylized facts regarding the contribution of fixed investment to GDP growth rate since 1993. A simple decomposition analysis shows that economic growth in Mexico after the tequila crisis recovered primarily due to the behavior of fixed investment. The investment growth rate declined drastically during the crisis year, but subsequently rose to levels exceeding pre-crisis levels. Hence the remaining analyses focus on the determinants of the growth rate of fixed investment.

Section II focuses on possible determinants of the fixed investment growth rate in Mexico, and proposes a standard model of investment behavior, where the only addition to standard models is that aggregate investment depends differently on the output of tradable and

[1] For example, the IMF (1996: 25) wrote that "In Mexico, tight fiscal and monetary policies helped reduce actual and expected inflation in the first half of [1995], contributing to further gains in confidence, declines in interest rates, and the stabilization of the peso."

non-tradable goods. To complement this analysis, a technical appendix included at the end of the paper develops a basic model of investment behavior by a representative firm, which shows that the magnitude of the income accelerator effect depends on the capital intensity of the firm's output.

Section III describes the data used in the empirical implementation of the basic model. Section IV reviews the estimation strategy, which relies on the General Method of Moments (GMM) estimator to control for the possible endogeneity of the explanatory variables. In addition, the estimation strategy includes three specification tests: A Wald test is used to assess whether the sectoral multipliers are statistically different; Hansen's J-statistic is used to determine the validity of the set of instrumental variables used in the GMM regressions; and the Q-statistic is used to determine if the model specifications suffer from serial correlation among the errors. In addition, this section presents results of seasonal unit root tests for all variables in levels, following the methodology proposed by Hylleberg et al. (1990). Most of the variables in levels seem to have either zero-frequency unit roots or some form of seasonal roots. The exceptions are the real interest rates, the volatility of the real exchange rate (RER), and the RER itself. These results influenced the estimation strategy by statistically justifying the use of the year-on-year differences of the variables.

The GMM regression results are presented in Section V. The basic investment function has as the dependent variable the growth of Mexican of fixed investment. The explanatory variables include the growth of the sectoral GDPs, the domestic real interest rate, changes in RER volatility, variations in the relative price of capital, and the lagged dependent variable. This function is estimated for the whole sample (1980-1999:Q3) and for a restricted sample (1980-1994) used to conduct an out-of-sample forecast. The basic model is then extended along four dimensions: We first add the inflation differential between tradable and non-tradable goods to the set of explanatory variables, and secondly we include the US real interest rate. Third, we include two measures of credit availability (the growth rates of total domestic credit and credit to the private sector issued by commercial banks), in order to assess whether Mexico has suffered from credit rationing. Finally, we test the stability of the coefficient on the domestic real interest rate during periods of crisis.

The results indicate that the tradable sector has a higher multiplier effect on Mexican investment than the non-tradable sector but this result is not always statistically significant. An important finding is that the domestic real interest is a significant determinant of Mexican investment, but the US prime lending rate deflated by the inflation rate of US imports is also significant. The relative price of capital and the volatility of the real exchange rate usually have negative effects on investment. The basic model provides a good explanation of the growth of fixed investment in Mexico, especially in the aftermath of the 1995 crisis. Evidence of this is provided by the out-of-sample forecast of the growth rate of fixed investment. An specification of this model that includes variables that capture credit availability instead of real interest rates presents similar results. We were unable to confirm or reject the hypothesis of credit rationing but when we include credit availability instead of real interest rates, this variable has a positive effect on the rate of growth of fixed investment. Finally, results on the stability of the coefficient on the domestic real interest rate during periods of crisis indicate that a confidence effect may have been present only during the 1982-1983 crisis but not in 1995.

Section VI presents model-free, or non-structural, analyses that address three key questions: (1) Was the tradable sector a leading sector? (2) What was the dynamic relationship between fixed investment and the real exchange-rate? (3) Were there short-term substitution effects of RER variations? The first question is addressed by Granger causality tests that aim to assess whether the growth of tradable output "Granger-causes" the growth of both non-tradable output and fixed investment. The results show a high level of endogeneity on this group of variables and as a result we cannot conclude that the tradable sector was a leading sector. The second and third questions are addressed by examining the impulse-response functions (IRFs) of investment and sector outputs to exogenous shocks of the RER. For example, in order to capture dynamic effects of the real exchange rate on the growth rate of fixed investment, we estimated a Vector Auto-Regressive (VAR) system that included several exogenous variables as well as the three endogenous variables (the differenced log of the level of fixed investment, the relative price of capital and the RER). The results show that an appreciation of the RER initially has an expansionary effect, but its effect becomes contractionary after about 5 quarters. An appreciation also seems to have significant short-term substitution effects in favor of the tradable sector. More generally, the story that emerges is that Mexican fixed investment growth declined during 1995 due to the devaluation's impact on the relative price of capital and the negative income effect, but the eventual recovery was driven by the high multiplier effect from the tradable sector and declining interest rates.

I. Growth Decomposition: The Stylized Facts

The decomposition of the GDP growth rate into the contributions of its aggregate demand components comes from a transformation of the basic macroeconomic identity: Y=C+I+X-M, where Y is the level of output, C is the sum of private and public consumption, I is the level of investment, X stands for exports, and M for imports. By first differencing each element, dividing by the ex-ante level of Y, and some simple manipulations, the growth of output can be decomposed into the contributions of the growth rates of each of its components:

(1) $\Delta Y/Y_{t-1} = (C_{t-1}/Y_{t-1})\bullet\Delta C/C_{t-1} + (I_{t-1}/Y_{t-1})\bullet\Delta I/I_{t-1} + (X_{t-1}/Y_{t-1})\bullet\Delta X/X_{t-1} - (M_{t-1}/Y_{t-1})\bullet \Delta M/M_{t-1}$.

This expression can be easily expanded to include the contribution of more disaggregated demand components. For example, the contribution of gross investment can be further decomposed into the sum of the contribution of fixed investment and inventory accumulation. Figure 1 shows the growth rates of GDP and fixed investment, as well as the latter's contribution to GDP growth, on the basis of year-on-year (i.e., seasonally-adjusted and annualized) growth rates. The graph shows that fixed investment played a key role during and after the tequila crisis. Fixed capital accumulation declined more than any other demand component during 1995, but also recovered briskly afterwards.[2] Moreover, the rate of growth of investment during 1996-1997 was significantly higher than during 1993-1994. Although these stylized facts are illustrative, the growth decomposition exercise suffers from the fact that the growth rates of the demand components and GDP are all endogenous. In the following sections we analyze the determinants of the growth rate of fixed investment in a simultaneous equations framework.

II. A Mexican Investment Function

The growth decomposition exercise indicates that fixed capital formation was at the heart of the economic recovery in Mexico after 1995. Also, there seems to be some evidence that Mexican investment may be linked to the performance of the tradable sector (Krueger and

[2] A companion paper (Lederman et al. 2000) compares the contribution of fixed investment with those of other demand components.

Tornell 1999). We can model Mexican investment as a function of the output of tradables and non-tradables, where we expect to find different sector multiplier effects:

(2) $$I = \bar{I} + m_T \bullet Y_T + m_{NT} \bullet Y_{NT} + I(RIR, p_K, \sigma_{RER})$$

where I is the (log of the) level of private fixed investment at constant prices; $\bar{I}$ is a constant, minimum level; and the m's are the corresponding sector multipliers. The last term on the right-hand side is the portion of the investment function that is determined by "cost factors," including the real interest rate (RIR), the relative price of capital goods (p_K) and an uncertainty variable, which we identify with the volatility of the real exchange rate (σ_{RER}). This simple model is broadly consistent with standard empirical models of investment behavior in developing countries (see Rama 1993), except for the assumption regarding the two sectors' multipliers. The Appendix presents a stylized model of a representative firm's investment behavior, which highlights the effect of firm's factor intensity of production on its income multiplier. The model also shows how investment cost factors (such the discount rate and relative price of capital) affect the firm's decisions.

According to Servén (1998), there are no predominant theoretical arguments to expect a particular sign for the relationship between uncertainty measures and investment. Nonetheless, in his empirical exercise this author finds a strong negative effect of real exchange-rate uncertainty on investment-output ratios in a cross-country panel framework. This effect could be an important explanation of the fall of investment during 1995 in Mexico, and even of the downfall of investment during the debt crisis of 1982-1983. Also, it is necessary to consider this effect in order to be able to isolate the direct effect of changes in the level of the real exchange rate on

Mexican fixed capital formation. Moreover, the consideration of RER uncertainty is consistent with two plausible assumptions. First, domestic investors can be risk-averse, thus uncertainty may adversely affect private investment. Second, it is also possible that at least portions of private investments are irreversible and contribute to sunk costs. Under these circumstances, macroeconomic uncertainty can be associated with swings in the value of private firms, thus hampering productive investment by firms (Pyndick 1988). If the tradables sector is a leading sector, then the uncertainty of the RER could also have an indirect effect on investment through its effect on the output of tradables. As argued by Maloney and Azevedo (1995), uncertainty about expected returns of producing for domestic versus export markets will affect the composition of output.

If the output multipliers are constant over time, then in terms of growth rates, or in differences of the logs, the investment function can be re-written as follows:

(3) $$g_I = m_T \bullet g_T + m_{NT} \bullet g_{NT} + g\left(RIR, g_{pK}, \sigma_{RER}\right)$$

where the g's denote growth rates of the corresponding variables. In this specification, the multipliers are analogous to the standard income accelerators that are standard in empirical investment functions (Rama 1993, Servén 1998). The main complication of this function is that the growth rates of Y_T, Y_{NT}, and P_K are determined simultaneously by certain common factors. For example, the growth rate of the tradable sector can be expressed as a function of changes in the real exchange rate, and foreign demand (mostly US income in the case of Mexico):

(4) $$g_T = g\left(g_{RER}, g_{USY}\right)$$

In contrast, the growth of non-tradable income can be specified as a function of relative prices, such as the real exchange rate and the real interest rate, plus domestic aggregate demand factors:

(5) $$g_{NT} = g\left(g_{RER}, RIR, g_T, g_I, g_G\right)$$

where g_G is the growth rate of real government consumption. In addition, as is common in developing countries that import capital goods, Mexican investment could be sensitive to changes in the relative price of capital goods. In fact, Mexico's average ratio of imports of capital goods to gross domestic fixed investment during 1993-98 was 37.4 percent.[3] The growth rate (or changes in the log) of the relative price of capital will, in turn, depend on changes in import tariffs and the real exchange rate:

(6) $$g_{pK} = g\left(g_{tariff}, g_{RER}\right)$$

In a previous study of Mexican investment during the 1982-83 crisis, Warner (1994) found that the fall of investment was indirectly associated with a decline in Mexico's terms of trade. In our model, this effect is captured through the variations in the RER. Following Warner, in the empirical implementation of the investment function we use a measure of Mexico's terms of trade as an instrumental variable.

III. The Data

The empirical analyses rely purely on publicly available data, primarily from the Mexican statistical agency (INEGI) and the International Monetary Fund. A description of the variables (and their sources) is presented in Table 1. All the data has a quarterly frequency and covers the period between 1980 and the third quarter of 1999.

The dependent variable. As mentioned, the main variable to be explained is the growth rate (e.g., log differences) of the quarterly level of gross fixed investment at constant prices. The data is available through the World Wide Web in INEGI's homepage.

The explanatory variables. The growth of tradable and non-tradable output, as well as the relative price of capital, appear as explanatory variables of the growth of fixed investment. As a proxy for the output of tradables we use INEGI's GDP series for manufactures, mining and agriculture. For non-tradables, we use construction, energy and water services. All series were expressed at constant prices in local currency units.

Regarding the relative price of capital, we use the ratio of the price index of capital goods (which is one of the components used by the Mexican authorities to calculate their producer's price index) relative to the consumer price index. The empirical investment function includes a "naïve" measure of volatility of the real exchange rate on the right-hand side, as proposed by Servén (1998). This variable measures the standard deviation of the change in the natural logarithm of the real exchange rate during six month periods.[4]

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[3] Serven (1999) shows that the average for developing countries in 1990 was 31.1 percent and 29.3 percent for industrial countries.
[4] See data description in Table 1.

Real interest rates are expected to have a negative effect on investment. Yet it is commonplace to find no significant relationship between real interest rates and investment-output ratios in cross-country studies (Agosín 1996, Servén 1998), as well as in studies of Mexican investment (Warner 1994).[5] One possible explanation for this common finding is that it is difficult to ascertain which real interest rate is the one being used by domestic borrowers, and therefore the usual average rates reported by Central Bank may not provide an accurate indicator of the real cost of borrowing. In the Mexican case, for example, it is possible that large Mexican firms actually finance their investment activities by tapping U.S. financial markets directly (Krueger and Tornell 1998). For this reason, the basic empirical model is extended to consider both the average quarterly domestic rate and the corresponding U.S. rate. As a proxy for the domestic nominal interest rate, we use the money market rate as reported by the IMF's International Financial Statistics. For the U.S. rate, we use the prime lending rate. To derive the real interest rates, the money market rate was deflated by the inflation of consumer prices, and the U.S. rate was deflated by the inflation of U.S. import prices. In an extension of the basic model, we also include the difference between the inflation of tradable and non-tradable output to assess whether variations in this relative price have an effect on Mexican fixed investment. As a proxy of the unit price of tradable and non-tradable goods we use the corresponding GDP deflators.

In searching for "confidence" effects, we extend the basic model to include crisis dummy variables interacted with the domestic real interest rate. During the period under analysis, Mexico had two crisis: the debt crisis (1982:Q3 to 1983:Q4) and the Tequila crisis (1995:Q1 to1995:Q4).

[5] Mussalem (1989) did find a negative relationship between real domestic interest rates and private investment in Mexico with annual data for 1960-1987. This author used the "ex-post after tax average real interest rate on banking instruments."

To explore the possibility that confidence effects were present during these times, we introduce three dummy variables for crisis periods one at a time, in each case interacted with the domestic interest rate. The first crisis dummy variable is triggered during both periods, while the other two are specific to each crisis. The analysis assesses whether the coefficient of the real interest rate changes sign (i.e., becomes positive) during the crises. That is, the presence of confidence effects is accepted when the estimated coefficient of the interacted term is positive, statistically significant, and larger in absolute value than the estimated coefficient of the domestic real interest rate.

IV. Estimation Strategy and Specification Tests

One of the first decisions taken was to choose between the estimation of the investment function in levels (equation 1) and the function in difference (equation 3). An important consideration is whether the variables in levels exhibit some form of unit roots. With this in mind, we conducted the zero-frequency and seasonal unit root tests suggested by Hylleberg et al. (1990). The so-called HEGY OLS regression estimated for each variable was:

(7) $$\Delta y = c + \alpha t + \pi_1 z_1 + \pi_2 z_2 + \pi_3 z_3 + \pi_4 z_4 + \beta \sum_{i=1}^{n} y_{t-i} + \mu_t + \varepsilon_t$$

The c is a constant and t stands for the time trend. The μ_t is a seasonal effect. It was an empirical question whether the data generation process for each variable includes these two elements. The inclusion of these elements affects the distribution of the t-statistics for the π's, which are the parameters to be tested. The z's in (7) are lagged polynomial representations of each variable (y) in levels:

(8) $z_1 = y_{t-1} + y_{t-2} + y_{t-3} + y_{t-4}$;

(9) $z_2 = -y_{t-1} + y_{t-2} - y_{t-3} + y_{t-4}$;

(10) $z_3 = -y_{t-2} + y_{t-4}$; and

(11) $z_4 = -y_{t-1} + y_{t-3}$.

There are not seasonal unit roots if π_2 and either π_3 or π_4 are different from zero. For a series to be stationary (i.e., without any unit root), each π must be different from zero. A series has no annual unit root if the F-statistic for the null that $\pi_3 = \pi_4 = 0$ is statistically significant. Hylleberg et al. (1990) provide the critical values for the t-statistics corresponding to the estimated π's and for the aforementioned F-statistic. The critical values depend on whether the estimated models include the intercept and/or the deterministic time trend and/or seasonal dummies.

The HEGY unit root test results are presented in Table 2. Only for a few variables we can reject the null hypothesis that they have some form of unit root. These are: the real interest rates, the US real interest rates, the real exchange rate (and its difference), and RER volatility (and its difference). Given this evidence, the investment function to be estimated is the one specified in year-on-year differences of the variables.

The building block of the model is the investment function expressed in equation (3). The model is "naïve," because it neglects money demand and/or supply, spreads, debt and other variables related to the financial sector. Our objective is simply to assess whether the recovery of Mexican investment after the Tequila crisis can be explained with real variables. In turn, we also test whether the basic model of investment behavior is able to predict the recovery of investment growth when it is estimated with data up to 1994. In other words, we also present the out-of-sample forecast of investment behavior for 1995-1998, and compare it to the actual observations.

The econometric models to be presented below were estimated using the General Method of Moments (GMM) estimator. This approach allows for the estimation of the structural coefficients using as instruments any exogenous and pre-determined variables, including the lagged dependent variables. One advantage of these estimates is that they are robust to heteroskedasticity and autocorrelation of unknown form. However, testing the validity of the moment conditions is crucial to ascertain the consistency of GMM estimates. If the regression specification "passes" the test, then we can safely draw conclusions taking the moment conditions as given. For instance, we can accept the statistical and economic significance of the estimated coefficient of the growth of the GDP of tradable goods and services as effects going from this variable to investment; alternatively, we can safely discard the possibility that this effect is due to some omitted variable correlated with the instruments. The specification test we use is the test of overidentifying restrictions introduced in the context of GMM by Hansen (1982) and further explained in Newey and West (1987). Intuitively, the fact that we have more moment conditions (instruments) than parameters to be estimated means that the estimation could be done with fewer conditions. The GMM approach uses this fact to estimate the error term under a set of moment conditions that excludes one instrumental variable at a time, and then the procedure tests the validity of the null hypothesis that each estimated error term is uncorrelated with the instrumental variable excluded from the corresponding instrument set. In other words, the null hypothesis of Hansen's test is that the overidentifying restrictions are valid, that is, the instrumental variables are not correlated with the error term. The test statistic is simply the sample size times the value attained for the objective function at the GMM estimate (called the J-statistic). Hansen's test statistic has a chi-square distribution with degrees of freedom equal to the number of moment conditions (instruments) minus the number of parameters to be estimated.

The level of output is expected to have a multiplier effect on the level of investment. However, in this case, the tradable sector is expected to be a leading sector, perhaps due to differences in the capital intensity of production -- see the model presented in the Appendix. In other words, we expect that the magnitude of the multiplier from the tradable sector's output will be larger than the effect from the non-tradable sector. To test this hypothesis directly, we rely on Wald tests of the specification restriction that the sectoral multipliers are equal (i.e., $m_T = m_{NT}$). More specifically, the tables with regression results report the p-value of the F-statistic for the null hypothesis that the sectoral multipliers are equal. Therefore a low p-value (below 0.10) indicates that the multipliers are not equal.

Due to the possibility that we have omitted variables in the specification of the Mexican investment function, the presentation of the regression results includes the p-value of the Q-statistic for serial correlation. The Q-statistic is a test of the null hypothesis that the correlation among error terms is zero. Therefore a high p-value (greater than 0.10) supports the specification of the model under examination. The tables with our regression results present the p-value of the Q-statistic corresponding to the correlation between the current error and its counterpart lagged 4 quarters. This choice was motivated by the quarterly frequency of the data, which may impose seasonal correlation among the errors. For this reason, most of our specifications of the empirical model also include seasonal dummies.

In most of the models estimated in this paper, the instruments for endogenous variables are the lagged values of the variables themselves, plus a set of exogenous variables that includes the U.S. real interest rate, the growth of U.S. GDP, and variations in Mexico's terms of trade. A difficulty arises when choosing the number of lags of the endogenous variables that are used as instrumental variables. We considered sets of 1, 4 and 8 lags for all instrumental variables in view of the seasonality of the quarterly time series. Regressions with instruments with 8 lags could not be run for all specifications of the model due to the limited number of observations relative to the number of instruments. With one lag, several specifications did not pass neither Hansen’s test for overidentification nor the Q-test for serial correlation. Consequently we were left with 4 lags of the endogenous variables to be used as their instruments. However, a specification with two lags for the instrumental variables is used for the out-of-sample forecast exercise, because the reduced sample covering the period between 1980 and the end of 1994 included only 50 observations (compared to 67) and hence we reduced the number of instruments to 15 from 25.

Our basic investment function has as the dependent variable the growth of Mexican fixed investment. The explanatory variables include the growth of the sectoral GDPs, the domestic real interest rate, RER volatility, variations in the relative price of capital, and the lagged dependent variable. This function is estimated for the whole sample (1980-1999:Q3) and for a restricted sample (1980-1994) used to conduct an out-of-sample forecast. The basic model is then extended along four dimensions: We first add the inflation differential between tradable and non-tradable goods to the set of explanatory variables, and secondly we also include the US real interest rate. Third, we include two measures of credit availability (the growth rates of total domestic credit and credit to the private sector issued by commercial banks). Finally, we test the stability of the coefficient on the domestic real interest rate during periods of crisis. We report the three specification tests (Hansen's J test for overidentifying conditions, the Wald test for equality of the sectoral multipliers, and the Q test for serial correlation) for all the extensions of the basic model. The following section presents the estimation results.

V. Results

A. Basic Results

The J-test of the investment function (first column, last row in Table 3) shows that the instrumental variables are not correlated with the error term: the p-value of the null hypothesis that the instruments are not correlated with errors is 0.85. Therefore we can interpret the coefficients as being the impact from the explanatory variables to the dependent variable.

An important result is that the multiplier effect of the tradable sector on investment clearly surpasses that of the non-tradable sector. Moreover, the p-value of the F-statistic for the null hypothesis that the two multipliers are equal is 0.01. The volatility of the real exchange rate has a negative coefficient, but the magnitude of this effect is not significantly different from zero. The relative price of capital (e.g., the ratio of the price index of capital goods over the CPI) has a negative sign and is significant at the 5 percent level. The coefficient implies that an increase of one percent in the growth rate of this relative price "causes" a reduction of 0.33 percent in the growth of fixed investment. The relationship between the variations in the RER and the investment growth is examined further in Section IV below. The coefficient of the domestic real interest rate has the expected negative sign in the estimation of the investment function using the whole sample (first column in Table 3), and it is statistically different from zero. The estimated coefficient implies that a one percentage point increase in the real interest rate leads to a 0.08 percentage points decline in the growth rate of fixed investment.

The results for the same regression estimated only for the 1980-1994 period is presented in the second column of Table 3. This model uses a reduced number of instrumental variables due to the also reduced sample size. The results are quite similar to those reported for the full sample. An important difference, however, is that the estimated negative coefficient of the real interest rate is larger than the one reported in the first column. Whether the coefficient on the domestic real interest rate is significantly different during crisis episodes will be explored in Section VD below. Another notable difference is that the estimation with the restricted sample shows a Wald test that does not reject the null hypothesis that the sectoral multipliers are equal -- its p-value is now 0.44.

To provide a visual illustration of the capacity of this basic model to explain the behavior of Mexican investment during and after the 1995 crisis, Figure 2 presents the forecasted and actual values for the year-on-year growth rate of Mexican fixed investment. The forecast presented here uses the dynamic approach to forecasting which calculates multi-step forecasts starting from the first period in the forecast sample (first quarter of 1995).[6] Figure 2 shows that this naïve model quite successfully explains the behavior of Mexican fixed investment, especially after 1995. The Theil inequality coefficient comparing the forecast with the observations is relatively low at 0.17 (a zero would indicate a perfect fit). More importantly, almost 80 percent of this inequality is due to the covariance between forecast and actual errors (or deviations from the corresponding means). This means that the lion's share of the inequality between the forecast and the actual observations is due to unsystematic error covariance.

At this point, it remains to be explored whether the recovery of Mexican fixed investment growth was due to the financial linkages with the U.S., as argued by Krueger and Tornell (1999). This question is further explored in the following section.

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[6] This method is less ‘accurate’ than the static approach, which calculates a sequence of one-step-ahead forecasts using actual, rather than forecasted values for the lagged values of fixed investment growth.

B. Domestic and U.S. Interest Rates, and Inflation Differentials

Table 4 shows the regression results for extended versions of the basic model that include the difference between tradable and non-tradable inflation rates and the U.S. real interest rate. These exercises aim to examine whether the domestic interest rate (the money market rate) deflated by domestic consumer price inflation is the discount rate that is more tightly associated with Mexican investment behavior. Both specifications pass the test for serial correlation. Also, in both cases, the multiplier from the tradable sector remains significantly higher than that of the non-tradable sector. All the other explanatory variables retain their expected signs, and the inflation differential comes out with a negative but insignificant coefficient.

When the U.S. real interest rate (that is, the prime lending rate deflated by the inflation of US import prices) is introduced into the model, as shown in the second column of Table 4, the domestic interest rate maintains its significance. The negative and significant coefficient is also present for the U.S. rate. This result provides strong evidence in favor of the Krueger-Tornell hypothesis that access to the U.S. financial market by Mexico's firms operating in the tradable sector was a key feature of the economic recovery after 1995.

C. Controlling for Credit Availability

Under credit rationing, investment could be driven by credit availability and not by real interest rates (Stiglitz and Weiss 1981). Table 5 presents the results of econometric models that extend the basic model to examine the effect of credit availability. The first column shows the results for the specification that includes the growth rate of total domestic credit at constant prices to the model; the second column shows the results for the model that includes the growth rate of credit to the private sector issued by private commercial banks. These variables control for the quantity of credit but they could reflect variations in either supply and/or demand. Neither specification passes the Q test for serial correlation, thus indicating that the introduction of credit quantities produces a mis-specified model. Due to this specification problem, the estimated coefficients cannot be easily interpreted, because serial correlation creates biases in the coefficients.

The third and fourth columns show the results for the specifications that include the growth rate of total domestic credit at constant prices and the growth rate of credit to the private sector issued by private commercial banks (also at constant local prices) as explanatory variables. Results for the Q test show that both specifications pass the test for serial correlation and therefore these models do not have specification problems. The availability of both types of credit has positive coefficients that are significantly different from zero. These coefficients imply that: (1) an increase of one percent in the growth rate of total credit leads to an increase of 0.03 percent in the growth of fixed investment, and (2) an increase of one percent in the growth rate of credit to the private sector leads to an increase of 0.04 percent in the growth of fixed investment. In both cases, the multiplier from the tradable sector remains significantly higher than that of the non-tradable sector, and the volatility of the RER presents negative coefficients that are significantly different from zero. The relative price of capital, on the other hand, has positive coefficients but with magnitudes not significantly different from zero. Credit availability could be considered an important determinant of fixed investment in Mexico and the decrease in the availability of credit during the crises negatively affected the growth of fixed investment. However, we cannot empirically distinguish between the effects of high real interest rates and low credit availability, because the model that includes both variables suffers from serial correlation as mentioned earlier. Therefore we were unable to confirm or reject the hypothesis that Mexico has suffered from credit rationing.

After having tested the basic investment growth function for Mexico by adding, sequentially, alternative interest rates, inflation rates, and credit availability, the following section examines the stability of the estimated interest-rate coefficient during periods of crisis. In other words, the following models search for evidence in favor of so-called "confidence effects."

D. Searching for "Confidence" Effects

This section aims to determine whether there is any evidence of the existence of "confidence" effects during times of crisis. A confidence effect would be present in times when increases in interest rates are associated with increases in the growth rate of investment. This phenomenon can theoretically arise when high interest rates signal that the monetary authorities are willing to defend the value of the currency, thus protecting the net worth of firms with liabilities denominated in foreign currency. As explained by Bernanke and Gertler (1989), if investment is limited by the wealth of firms (i.e., they cannot be infinitely leveraged), then a shock that deteriorates their net worth will lead to a fall of investment. Krugman (1999) suggests that this effect may have aided the recovery of Mexico after 1995 and Korea after 1998. The results are presented in Table 6. The estimation strategy is to include the crisis dummy variables both as mean shifters as well as interacted with the domestic interest rate. This approach is superior to the inclusion of the interacted term alone, because it prevents capturing a shift in the mean growth rate of fixed investment during crises that may not be due to a structural change in the interest-rate coefficient.[7]

In the first column, the coefficient for the interacted term with the dummy variable for both crises (1982:Q3-1983:Q4 and 1995) shows a positive and significant sign. The large size of the coefficient implies that the overall effect of increases in the real interest rate is actually positive during the crisis periods. For the rest of the sample, the model predicts a negative and significant effect of real interest rates on investment. All the other coefficients for the investment function have the expected signs, except RER volatility. However, in this specification the estimated coefficient of the growth of tradable GDP is significantly smaller than the growth of non-tradables. However, the Q test indicates that this is not a valid specification.

The second and third columns of Table 6 show the results for specifications with each interacted crisis dummy introduced separately. Results for the interacted dummy of the 1982 crisis are consistent with those discussed above; that is, there is evidence of a confidence effect. On the other hand, results for the 1995 crisis show a different story: the sign of the interacted dummy coefficient is negative. This suggests that there was no confidence effect during this crisis. Actually, the results would indicate that during this crisis investment was even more sensitive to increases in interest rates than during normal times. However, the Q test for serial correlation indicates that this model is also wrongly specified. Indeed, only the second column in Table 6 presents a model supported by all of our specification tests. Therefore the main conclusion that can be derived from this evidence is that we cannot reject hypothesis of the

[7] In any case, regressions without the crisis mean shifter produced very similar results.

presence of a structural break in the interest-rate coefficient during the 1982-83 crisis.[8] In contrast, we can reject the hypothesis that there was a similar break during 1995.[9]

VI. Non-structural Analyses

This section examines the relationship among key variables in model-free frameworks. The purpose is to attempt to answer three key questions that are essential for the interpretation of the structural model results.

A. Was the tradable sector a leader?

The results of the structural model presented in the first column of Table 3 indicated that the growth rate of tradable output was a leader in the sense that it is a significant determinant of fixed investment with a higher accelerator effect than non-tradable GDP. Here we ask ourselves if these results are supported in a framework that does not impose structural assumptions on the variables. For this purpose we conducted pairwise Granger causality tests, which are presented in Table 7. The results indicate that we cannot reject the possibility that the growth of tradable output was 'caused' by either the growth of fixed investment or the growth of non-tradables output. Moreover, we cannot confidently reject the possibility that all three variables are caused by the others. The use of the GMM estimator for the empirical fixed investment function is clearly justified by these results. Nevertheless, we cannot conclude that the tradable output

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[8] However, we acknowledge that this break may be due to other effects that are not really "confidence effects." For example, the banking system was nationalized during that time, and the change in the coefficient's sign during that crisis may be due to interest-rate controls.

[9] We also acknowledge that we cannot test for confidence effects with a duration of less than one quarter, given the frequency of the available data.

growth was a leader in the sense that it precedes variations in fixed investment and non-tradables output.

B. What was the dynamic short-term relationship between the real exchange-rate and investment growth?

None of our previous models examine the direct relationship between the RER and fixed investment. Here we use the impulse-response function (IRF) derived from Vector Auto-Regressions (VAR) to study the relationship between fixed investment and the RER. We ran a VAR with the growth rates of fixed investment, the relative price of capital goods, and the real exchange rate as endogenous variables. The choice of these variables is inspired on existing evidence for Mexico that indicates that the relative price of capital may be an important channel through which variations in the real exchange rate (and its determinants, such the terms of trade) affect domestic investment (Warner, 1994). We also included the following exogenous variables that are likely to affect these three variables: the growth of U.S. GDP, variations in public consumption, variations in the terms of trade, the U.S. real prime lending rate, the OPEN and NAFTA dummy variables, and a constant. Figure 3 shows the corresponding IRF assuming that the real exchange-rate is more exogenous than the relative price of capital, which, in turn, is assumed to be more exogenous than fixed investment. Twelve lags of the endogenous variables were included in the VAR, because the Akaike, Scwartz and Log Likelihood tests all indicated that this was the best distributed lag specification, when compared to 1, 4 and 8 lags. The IRF illustrates the effect on investment of a one standard deviation innovation in the real exchange rate. The results show that the response of investment to an *appreciation* of the real exchange rate is positive at first but becomes negative and significant during the second year, after approximately five quarters.

The finding that an *appreciation* of the RER in Mexico is associated with an expansion of the economy is consistent with the conclusions of other recent empirical studies. For example, Kamin and Rogers (1998) also find that appreciations (depreciations) have positive (negative) effects on output, but these authors argue that there are multiple channels through which this effect takes place, including its effect on government spending, monetary aggregates, and capital flows. In fact, Kamin and Rogers only tentatively reject the hypothesis that the channel is the inflation rate. Four quarters after the simulated appreciation the growth of fixed investment tends to decline. A plausible interpretation of these dynamic effects is that an appreciation has an initially positive effect that could be due to income effects (or positive net worth effects) and the reduction of the relative price of capital.[10] Later, as the substitution effect takes hold, and the tradable sector's influence on investment predominates, investment growth declines as a consequence of the real appreciation of the currency.

C. Were there short-term substitution effects of RER variations?

Based on pairwise VARs, the impulse-response functions presented in Figures 4A-C attempt to evaluate the interpretation presented above by looking at the effect of the RER on the relative growth of the tradable sector. Figures 4A through C are different only in the number of lags used in the VAR, because the Akaike, Schwartz and Log Likelihood tests provided support to different lag specifications. Figure 4A shows the IRF based on the one-lag specification that

[10] The companion paper (Lederman et.al. 2000) shows IRF for the effect of an appreciation on sectoral GDP growth rates. It finds that an appreciation tends to temporally raise the growth rate of the tradable and non-tradable sectors, this effect is larger for non-tradables. We interpret this differential as evidence of transitory substitution effects.

was supported by the Schwartz criteria; 4B is based on eight lags that was supported by the Akaike criteria; and 4C was derived from a VAR that used 12 lags of the endogenous variables, which was supported by the log likelihood test. All three IRFs provide evidence that variations in the RER did have significant substitution effects in the sense that it affected the composition of output: an appreciation decreases the rate of growth of tradables over non-tradables.

CONCLUSIONS

Since the eruption of the so-called Tequila crisis of 1995, and after the Asian crises of 1997, much has been written about the causes of financial crises in developing countries. Yet much less attention has been given to the evolution of the productive economy after these crises.[11] The stylized facts about the Mexican recovery show that fixed investment was at the heart of the recovery. This study provides an empirical investigation of the determinants of the growth rate of fixed investment in Mexico, with special attention given to the aftermath of the so-called Tequila crisis of 1995. Perhaps the only addition to basic models of investment in developing countries (which consider cost, scale and uncertainty factors) is the assumption that tradable and non-tradable output growth have different multiplier effects on Mexican investment growth. The main finding is that the basic model does quite well in predicting the recovery of investment during 1996 and 1997; evidence of "confidence" effects only seem to be present during 1982-1983, and high interest rates tended to hamper investment during most of the period under investigation. Naïve measures of real exchange-rate uncertainty were not robust determinants of Mexican fixed capital formation. Finally, the impact of variations of the real exchange rate seem to be dominated by income effects initially, but substitution effects predominate in the medium term. The story that emerges is that Mexican investment growth declined during 1995 due to the currency depreciation's impact on the relative price of capital goods and the income effect, but eventually the recovery was driven by the high multiplier effect from the growth of tradable output; declining domestic interest rates and low lending rates in the U.S.

[11] See Perry and Lederman (1999) for a comparison of the aftermath of Latin American and Asian Crises in the 1990s.

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Appendix: Optimal Investment Rules and the Capital Intensity of Output

This section presents a simple model of the decision to invest by a representative firm. The purpose of the model is to highlight the role played by the capital intensity of output in the determination of the optimal level of investment at a given point in time. More specifically, it attempts to show how the magnitude of the income accelerator depends on the capital intensity of production. The discussion begins with a general framework and simplifying assumptions are introduced sequentially.

In general, managers make investment decisions in order to increase the market value of the firm. The change in the market value of the firm can be expressed as a function of current profits and capital gains, minus the value of current investment, plus the discounted value of future profits and capital gains. This can be expressed in terms of a simplified version of Rama's (1993) general two-period model as follows:

$$(1)\quad \Delta V = \overline{Z} - P_t^K \cdot \left(\frac{I_t}{K_t} + \alpha \left(\frac{I_t}{K_t} \right)^2 \right) + \frac{1}{(1+i_t)} \cdot \left(p_{t+1} \cdot Q_{t+1} - w_{t+1} \cdot L_{t+1} \right) + \left(\frac{P_{t+1}^K \cdot K_{t+1}}{1+i_t} - P_t^K \cdot K_t \right)$$

The first term, $\overline{Z}$, in equation (1) represents the sum of current profits and capital gains (losses). It is given at time t, and therefore it is considered to be a constant. The second term in the right-hand side corresponds to the value of current investments, measured as a function of the current nominal price of capital, P_{t+1}^K, and is a convex function of the investment rate (i.e., the ratio between gross investment and the capital stock). The α parameter is assumed to depend on investment costs, which we will assume to be zero. The third terms represents the discounted value of future profits (i.e., revenues minus costs), where p_{t+1} is the nominal price of a unit of the firm's output. The final term in (1) reflects the discounted value of capital gains (losses) in the second period.

The firm faces the following constraints. First, by definition, the future capital stock is:

$$(2) \quad K_{t+1} = \frac{K_t + I_t}{1+\delta} = K_t \left(\frac{1 + \frac{I_t}{K_t}}{1+\delta} \right), \text{ and } \therefore K_t = K_{t+1} \left(\frac{1+\delta}{1+\frac{I_t}{K_t}} \right),$$

where δ is the capital stock depreciation rate. Equation (2) simply says that the capital stock in the second period will be equal to the current (at time t) capital stock plus current investment, adjusted for the depreciation rate of plant and equipment.

Second, the firm faces a technologically determined production function:

$$(3) \quad Q_{t+1} = K_{t+1}^{\frac{1}{\beta}} L_{t+1}^{\frac{1}{\gamma}}$$

In this specification, production is modeled as a standard Cobb-Douglas function, where the β and γ are the units of capital and labor needed to produce one unit of output, which are also technological features. Solving for L_{t+1},

$$(3') \quad L_{t+1} = Q_{t+1}^{\gamma} K_{t+1}^{-\theta}$$

where, $\theta = \frac{\gamma}{\beta}$ is the labor intensity of output (i.e., the ratio of the units of labor required to produce one unit of output divided by the units of capital required to produce one unit of output).

Third, the firm faces an aggregate demand function:

$$(4) \quad Q_{t+1} = \left(\frac{Y_{t+1}}{F}\right) \cdot \left(\frac{p_{t+1}}{P_{t+1}}\right)^{-\sigma}$$

where Y_{t+1} is total aggregate demand, and F is the total number of firms operating in this economy. $\frac{p_{t+1}}{P_{t+1}}$ is the <u>relative</u> price of the firm's output measured with respect to the consumer price index, for example. The σ parameter is the relative price elasticity of demand for the firm's output, and it will depend on the economy's market structure. Under perfect competition $\sigma \Rightarrow \infty$; under monopolistic competition $\sigma > 1$; and in an "effective demand" model $\sigma = 0$. The latter case can emerge in the context of binding contracts negotiated in the past, for example. Since our purpose here is to highlight the importance of factor intensities for investment determination, the effective demand model will be used for the rest of the analysis (see Rama 1993 for comparisons of the various models).

By inserting (2) into the last term in (1), and after some manipulations, the objective function of the firm becomes

$$(5) \quad \Delta V = \overline{Z} + \frac{1}{1+i_t} \cdot \left(p_{t+1}Q_{t+1} - w_{t+1}L_{t+1} - c_{t+1}K_{t+1}\right)$$

where $c_{t+1} \approx p_t^K \left(\delta + i_t - \left(\frac{p_{t+1}^K}{p_t^K} - 1 \right) \right)$, assuming that $\delta \cdot i_t = 0$. c_{t+1} is actually the user cost of capital, or the flow price of capital services. It is the nominal price of capital goods times the depreciation charge per unit of capital (δ) plus the nominal interest rate deflated by the inflation of capital goods $\left(i_t - \left(\frac{p_{t+1}^K}{p_t^K} - 1 \right) \right)$. And by inserting (3') and (4) -- with the assumption that $\sigma = 0$ -- into (5), the objective function of the firm becomes

(6) $$\Delta V = \bar{Z} + \frac{1}{1+i_t} \cdot \left(p_{t+1} \frac{Y_{t+1}}{F} - w_{t+1} \left(\frac{Y_{t+1}}{F} \right)^{\theta\beta} K_{t+1}^{-\theta} - c_{t+1} K_{t+1} \right).$$

The firm maximizes ΔV with respect to its future capital stock K_{t+1}. The first-order condition for this maximization problem is:

(7) $$K_{t+1}^{-(\theta+1)} = c_{t+1} \cdot \frac{1}{\theta} \cdot (1+i_t) \cdot + \frac{1}{w_{t+1}} \cdot \left(\frac{Y_{t+1}}{F} \right)^{-\theta\beta}$$

After taking the natural logarithms of both sides, and recognizing that $K_{t+1} \approx \frac{I_t}{K_t} - \delta$, then the optimal investment rule is:

(8) $$\frac{I_t}{K_t} = \delta - \frac{\ln\theta}{\theta+1} - \frac{1}{\theta+1} \cdot \ln\left(\frac{c_{t+1}}{w_{t+1}} \right) - \frac{1}{\theta+1} \cdot \ln(1+i_t) + \frac{\theta\beta}{\theta+1} \cdot \ln\left(\frac{Y_{t+1}}{F} \right)$$

To examine the role of the capital intensity of output, it is helpful to recall that $\beta = \frac{\gamma}{\theta}$, and (8) can be rewritten as:

(8') $$\frac{I_t}{K_t} = \delta - \frac{\ln\theta}{\theta+1} - \frac{1}{\theta+1} \cdot \ln\left(\frac{c_{t+1}}{w_{t+1}} \right) - \frac{1}{\theta+1} \cdot \ln(1+i_t) + \frac{\gamma}{\theta+1} \cdot \ln\left(\frac{Y_{t+1}}{F} \right).$$

In (8') we see that the optimal investment rate will depend on the level of aggregate demand, as reflected in the last term on the right-hand side. The magnitude of this effect is determined by $\frac{\gamma}{\theta+1}$. This expression says that as the units of capital required to produce one unit of output rises relative to required units of labor, the income accelerator is greater. In other words, higher capital intensity of production is associated with higher income accelerators.

Regarding the other elements in the right-hand side of (8'), this model predicts that investment by the firm will decline with increases in the expected relative user cost (price) of capital $\left(\frac{C_{t+1}}{W_{t+1}}\right)$ and with increases in the discount (interest) rate. The basic empirical model estimated in this paper includes proxies for these variables, as well as the output of two sectors (tradables and non-tradables).