Private Saving in Mexico, 1980-95

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Abstract

This paper analyzes the behavior of private saving in Mexico from 1980 to 1995 using quarterly data. Simple regressions suggest that private saving to a large extent offsets changes in the government's budget balance. This is confirmed by vector autoregressions in which tax shocks are found to be the primary determinants of the ratio of private savings to GDP. Other important determinants of saving in Mexico are the shocks to the world oil price and to the level of output in the United States. A second goal of the paper is to understand this behavior of saving using a theoretical model. A simple monetary extension of a neoclassical small open economy model can rationalize many of the empirical findings in the paper, although there are several puzzles remaining.

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This paper explores the behavior of private saving in Mexico from 1980 to 1995. The paper examines private saving using two approaches, one purely empirical and the other more theoretical.

The empirical section of the paper begins by analyzing the correlation of the private savings with various macroeconomic time series. This reveals two interesting aspects of the data. First, private saving is strongly negatively correlated with the fiscal balance of the government. A second, and related fact, is that private saving is much more highly correlated with the level of private disposable income, which has significant cyclical components, than it is with GNP. This suggests that saving, rather than consumption, mops up transitory movements in income.

The paper then proceeds to a regression analysis in which the level of private saving is projected on a number of potential explanatory variables, such as income, the government’s budget balance, the real interest rate, and indicators of fiscal and monetary policy. While such regressions cannot identify a structural savings function, because the right-hand side variables are all reasonably thought of as endogenous, they do reveal one key fact: movements in the government’s budget balance are substantially offset by changes in private saving, so that national saving would remain roughly unaffected. This is a fairly robust finding, because it does not depend very sensitively on which other variables are entered into the regression.

Finally, the empirical section proceeds to a more structural analysis using vector autoregressions (VARs) to try to identify the exogenous shocks which ultimately determine the Mexican savings rate. The analysis assumes that there are external factors, such as the world price of oil, demand conditions derived from the state of the United States economy, and US interest rates, which drive some of the economic fluctuations in Mexico, and ultimately affect the savings rate. It also assumes that there are internal factors such as technology shocks and innovations to tax, spending and monetary policy. The key findings of this section are that, in support of the previous analysis, shocks to tax policy, which would drive the budget deficit holding spending constant, are the key determinants of the private savings rate. Other important determinants are the world oil
price (presumably through a wealth effect) and shocks to the level of US output other than those due to monetary policy.

The second part of the paper outlines a theoretical framework for gaining insight into changes in private saving. This framework is based on models used by Roldós (1995) and, more closely, Rebelo and Végh (1995), which are essentially monetary extensions of neoclassical small open economy models. While Rebelo and Végh’s model used two sectors (tradables and nontradables) to try to explain sectoral aspects of the effects of monetary stabilization programs, here a one sector model suffices. While assuming Ricardian equivalence, the model allows us to examine the effects of shocks to domestic productivity, government purchases, Mexican exchange rate policy, foreign interest rates, and external wealth, by computing impulse response functions of savings to exogenous shocks to these variables. The model is capable of explaining the qualitative aspects of several of the empirical findings, but it does not perfectly mimic the dynamic patterns in saving that we see in the data.

The first section of the paper discusses issues concerning the measurement of saving. It also discusses the sources of the data used in the empirical section. The second section of the paper derives the empirical results described above. The third section describes the theoretical model, and uses a calibrated version of it to explain the findings of the second section. Conclusions follow.

1 Data and Measurement

1.1 National Accounts Based Data

The main source of data for the empirical part of the paper is the quarterly information on national accounts aggregates prepared by INEGI. Given the historical nature of the study, and the fact that both nominal and real aggregates were needed, I chose to use only data from 1980 through mid-1995 that are based on raw figures provided by INEGI using the now superseded base year of 1980. INEGI’s newer published figures, which use 1993 as
a base year, did not include nominal aggregates at the time the empirical results were obtained for this draft.

The Mexican national accounts permit the separation of GDP into various components. Consumption purchases are split between the private and public sectors, while private purchases can be further subdivided into services, nondurables and durables. My measure of private consumption is the sum of the official measures of services, nondurables and durables. A more ideal measure of private consumption would exclude private durables purchases since these represent an addition to the stock of consumer durables, a form of physical capital. Furthermore, an ideal measure would include a consumption service flow derived from the stock of consumer durables. However, lacking data on durables stocks, I chose to follow the simpler approach of including durables purchases in the consumption measure.

My measure of private investment is the sum of private gross fixed investment and inventory investment. My measure of public sector investment is taken directly from the national accounts measure.

Imports and exports are obtained directly from the national accounts.

In order to obtain the difference between GDP and GNP, dollar-denominated measures of net foreign interest and other income, and net foreign transfers were obtained from quarterly figures in the *International Financial Statistics (IFS)*. These were converted to new pesos using the period average dollar exchange rate, also reported in the *IFS*.

INEGI publishes real and nominal versions of each of the series described above except the net foreign income that makes up the difference between GDP and GNP. To convert these flows to real terms I used the GDP deflator.

The raw quarterly data from the national accounts are highly seasonal. As a result, a simple deseasonalizing filter that is a variant of Census X11 was applied to all time series.

1.2 Government Budgetary Data
The government budget balance figures (economic, financial and primary balances) were obtained by calculating quarterly averages of monthly figures provided to the World Bank by the Mexican authorities. Total tax revenues were obtained in the same manner.

Budgetary figures are measured as nominal flows. To convert nominal flows to real flows I used the GDP deflator. However, budgetary data, unlike national accounts data, typically include large net interest flows from the government to the nongovernment sector. During a period of rapid inflation a large fraction of these interest flows does not represent real income to the recipients nor a real cost to the government. To take this inflation effect into account, the Mexican government produces its own measure of the inflation-adjusted budget balance on an annual, but not quarterly, frequency. As a result, here I perform conceptually equivalent inflation adjustments based on the following methodology.

An ideal measure of the budget balance should be measured as the decline in the real financial debt of the public sector:

\[
\Delta_t^* = -\left(\frac{B_t}{P_t} - \frac{B_{t-1}}{P_{t-1}}\right),
\]

where \(\Delta_t^*\) is the ideal measure of the nominal budget balance, \(P_t\) is the price level, and \(B_t\) is net outstanding public debt at the end of period.\(^1\) Given this concept of the real budget balance, the ideal measure of the nominal budget balance is

\[
\Delta_t = -\left[B_t - (1 + \pi_t)B_{t-1}\right],
\]

where \(\pi_t = P_t / P_{t-1} - 1\) is the inflation rate.

Standard measures of the budget balance correspond to

\[
\Delta_t = -(B_t - B_{t-1}).
\]

The difference between the ideal and standard measures is

\[
\Delta_t^* - \Delta_t = \pi_t B_{t-1}.
\]

\(^1\) Since standard measures of the deficit measure a financial flow, this discussion only concerns how that financial flow can best be adjusted to take inflationary effects into account. This discussion also assumes that the government only issues debt denominated in local currency, and does not index the face value of the debt to the price level. The discussion is based on that presented by Barro (1993).
From this discussion it becomes clear that if the government has a substantial quantity of outstanding debt, measures of its budget balance will depend greatly on whether inflation adjustments are applied to them. Since symmetric adjustments should be applied to private sector income, measures of private sector income may also be quite sensitive to whether inflation adjustments are made or not. Since Mexico experienced rapid inflation over much of the period examined in this paper, the data will be adjusted for inflation.

If the government issues debt denominated in foreign currency, the required adjustments are more complex. However, the reasons for the adjustments are the same. If there is a single type of foreign currency in which public debt is sometimes issued, then the ideal measure of the public sector balance is

\[ \Delta_i^t = \Delta_i + \pi_i B_{t-1} + (\pi_i - d_i) e_{t-1} B_{t-1}^f \]

where \( e_i \) is the nominal exchange rate, \( d_i \) is the rate of depreciation of domestic currency versus foreign currency between \( t-1 \) and \( t \), \( B_i \) is the net domestic debt of the public sector at the end of period \( t \), and \( B_{t-1}^f \) is the net foreign debt of the public sector (measured in foreign currency) at the end of period \( t \).

1.3 Measuring Private Saving and Income

In order to measure private saving, I start from a national accounts based measure of national saving. From an accounting perspective I define national saving simply to be the portion of national product plus net foreign transfers which is not consumed domestically. So national saving can be defined as \( S_N = GNP + NFT - C = I + NX + NFI \), where \( NFT \) is net foreign transfers from abroad, \( C \) is total (private and public sector) consumption, \( I \) is gross domestic investment, \( NX \) is net exports of goods and services and \( NFI \) is net income from abroad, including transfers.

In order to discuss the behavior of private saving we need to decompose national saving into its two components, private and public saving. One way to do this is to obtain
private saving, $S_P$, residually from the identity, $S_P = S_N - S_G$, using the national accounts measures of national saving and some measure of public sector saving, $S_G$. A time series on national saving can easily be computed using the national accounts measure of GDP published by INEGI, the official Mexican statistical agency, and using measures of net foreign income and transfers from IFS. The important second step is to measure public sector saving. This is traditionally done by summing some measure of the public sector budget balance, $\Delta$, and a measure of public sector investment, $I_G$. That is, $S_G = \Delta + I_G$.

To implement this measurement strategy one must choose a particular concept of the public sector budget balance. For Mexico, a number of choices are available. These include:

1. the financial balance of the consolidated public sector, which consists of the central government, its agencies, public sector enterprises and public sector financial intermediaries,
2. the economic balance, which drops the financial intermediaries from the definition of the public sector, and
3. the primary balance, which is the economic balance minus net interest payments.

The benchmark public balance concept used here is the inflation-adjusted version of the financial balance. The main reason for using the financial balance is that it is based on the most complete definition of the public sector. The reasons for the inflation adjustment were given above.

Once the measure of private saving is obtained residually from national and public sector saving as $S_P = S_N - S_G$ it is then possible to compute a measure of private disposable income, as simply the sum of private saving and private consumption: $Y_P = S_P + C_P$. A measure of private consumption, $C_P$, can be obtained directly from the national accounts.

1.4 Implementing the Inflation Adjustment to the Financial Balance

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2 Again, this discussion assumes that only nominal debt, either in domestic or foreign currency, is issued by the government. Indexed debt is ruled out by assumption.

3 Detailed data on the finances of state governments are not available for Mexico. Therefore, state governments are implicitly being excluded from the public sector.
Denoting the public-sector financial balance as $\Delta$, the inflation-adjusted measure of the public-sector financial balance is given by

$$\Delta^*_t = \Delta_t + \pi_t B_{t-1},$$

where $\pi_t$ is the rate of inflation of the GDP deflator, and $B_t$ corresponds to the end-of-period $t$ peso value of the consolidated domestic public debt (economica amplia) published by the Bank of Mexico in the Informe Anual. This measure of the public debt considers the public sector to be the federal government, parastatal organizations and enterprises, plus official financial intermediaries, and thus corresponds to the definition of the public sector used to construct the financial balance.

I chose not to make further adjustments to the financial balance to take into account the existence of foreign debt. This is justified whenever purchasing power parity approximately holds or when foreign debt is relatively small compared to domestic debt.

A further problem arises if some of the domestic public debt is held by foreigners. In this case, not only should the public sector balance and public saving be adjusted for inflation, but so should the measure of net foreign interest that is included in GNP. This portion of GNP should also be inflation adjusted if private debt denominated in pesos is held abroad. And, as mentioned above, strictly speaking, there are inflation adjustments which apply to foreign currency denominated debt as well. Since the detailed data on the holding of debt that would be needed to perform these calculations are not available, I did not try to make any of these further adjustments. The hope is that they are relatively insignificant compared to the adjustments made for domestic public debt.

1.5 Other Time Series

Other variables used in the analysis below include the depreciation rate of the peso, the domestic 3-month treasury bill rate, the domestic inflation rate, the 3-month treasury bill rate in the United States, the inflation rate in the United States, gross domestic product in the United States, the world price of oil, the monetary base, private domestic credit, and the population of Mexico.
The depreciation rate of the peso was measured as the percentage change, at an annual rate, between successive end-of-quarter values of the peso-dollar exchange rate obtained from the *IFS*.

The treasury bill rate was obtained from the IFS as the quarter-average nominal interest rate on Mexican Treasury bills, while the domestic inflation rate was taken to be the annualized rate of change of the GDP deflator.

The 3-month Treasury bill rate in the United States was obtained from the Chicago Fed’s online database. The inflation rate was measured as the annualized quarterly percentage change in the GDP deflator, which along with GDP was obtained from the St. Louis Fed’s online database.

The world price of oil was obtained from the IFS and was expressed in US dollars per barrel.

Finally, the monetary base and the level of private domestic credit were obtained from the *IFS*.

I also converted quantities into per capita measures. A quarterly series on the population was interpolated using the annual figures from the World Bank database. The method used assumed constant growth rates within each year. This is the optimal filter to use if the underlying true data follow a random walk with drift.

2 Empirical Findings

In this section I explore the data in four ways. First, I presents charts of time series for various macroeconomic aggregates in Mexico from 1980 through mid 1995. Second, I examine the pattern of cross correlation between private savings and other variables of interest. Third, I perform regression analysis, which is simply a way of computing partial correlations between private savings and the other variables. I interpret these findings in ways which are only valid under the assumption that the regression equation identifies a structural relationship among the variables.

Since a static regression using quarterly data is unlikely to actually identify a structural saving function, as an alternative, in the fourth section I use vector
autoregressions to examine the dynamic responses of private saving to a vector of shocks that may have a reasonable structural interpretation.

2.1 A Look at the Data

Figure 1 plots quarterly time series for Mexico over the period 1980Q1-1995Q2. The charts are drawn for the main macroeconomic aggregates. They show that GNP peaked in early 1982, and then, in association with the debt crisis and the subsequent economic turmoil, it fell until 1987. This was followed by a period of stabilization in which GNP, consumption and investment all rose at a fairly modest rate. Historically the current account in Mexico was in deficit, and it peaked in the leadup to the debt crisis. In the subsequent period it narrowed substantially and was actually in surplus. However, under the stabilization plan the current account again moved towards a deficit.

Figure 2 illustrates some time-series which are disaggregated into public and private components. These indicate several things. First, private consumption strongly co-moved with GNP over the period. Second, government consumption expenditure displayed little variation over the period with a slight, and apparently permanent, decline associated with the stabilization program of early 1988. Third, private investment has also strongly co-moved with output, but has been substantially more volatile. It dropped dramatically in the wake of the debt crisis and by 1994, unlike consumption, had not reached its peak value of 1982. Finally, public sector investment has fallen dramatically over time, especially in the post debt crisis period. By 1994 it was only one quarter of its peak level in 1981.

Figure 3 shows data on the public sector budget balance and private saving. The charts show that when the budget data are not adjusted for the inflation effects described earlier, a strong negative correlation between the budget balance and private saving results. However, despite the fact that this correlation appears weaker when the data are inflation-adjusted it actually remains quite strong. Another interesting feature of the data
is that the marked and gradual decline in private saving in the late 1980s turns out to be an artifact of the unadjusted figures.

2.2 Cross Correlations of Consumption and Saving

Table 1 provides the dynamic cross-correlations between private saving and the other variables to be used in the regression analysis. The cyclical components of the income measures are those implied by the Hodrick and Prescott (1997) (HP) filter.

The most striking finding from the correlation matrix is the strong negative contemporaneous correlation between private saving and the government budget balance. Although this correlation is not as strong at leads and lags, this finding hints at the possibility of approximate Ricardian equivalence.

Another interesting feature of the data is that there is a much stronger correlation between private savings and private disposable income than there is between private savings and GNP. To the extent that GNP reflects movements in permanent income more than private disposable income does, this finding would be consistent with a permanent income type theory.

Further evidence that hints at a permanent income type theory comes from the fact that the correlation between private savings and the cyclical component of private income is about the same as the correlation between private savings and private income as a whole. This suggests that the important movements in private savings are at cyclical frequencies, and that these comove strongly with temporary fluctuations in income.

In dynamic correlations asymmetries are often taken to be an indication of a lead-lag relationship between two variables. For example, were private savings more highly correlated with past income than future income, then we might say that income leads savings. There is little in the way of this sort of asymmetry in the data.

The simple correlations between private saving, the nominal interest rate, the inflation rate, the depreciation rate of the peso and the level of government consumption

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4 In fact, in nominal terms, the current account deficit became quite wide by 1994. This is not reflected by real figures because of the substantially different behavior of the deflators for imports and exports during
purchases are all quite small. Government purchases as a whole, rather than just purchases of consumables, are more highly correlated with private savings. This may reflect comovement between public and private investment.

We will see in the next section that the partial correlations uncovered by regression analysis are quite different than the simple correlations presented here.

2.3 Regression Analysis

This subsection presents results of regressions which seek to explain variation in private saving. These regressions should be interpreted cautiously. They do not identify causal links, since some of the right hand side variables are likely to be simultaneously determined. They are meant to be informative about what the sources of variation in the savings rate might be, and about the comovements between private savings and other macroeconomic variables.

The dependent variable in each of the regressions is the level of inflation-adjusted private savings (SP).\(^5\) The right-hand side variables in the benchmark regressions presented here were chosen from among

- GNP (Y),
- the trend in GNP (GNPTR) as defined by the HP filter,
- the cyclical component of GNP (GNPCY) as defined by the HP filter
- private disposable income (PDY),
- the trend in private disposable income (PDYTR) as defined by the HP filter,
- the cyclical component of private disposable income (PDYTR) as defined by the HP filter
- the ex-ante real interest rate on Mexican treasury bills (R),
- purchases of goods and services by the government (PURG),
- purchases of consumption goods and services by the government (CG),

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\(^5\) All quantity variables in the equations are measured in real per capita terms, except the monetary base and private domestic credit which were measured in nominal per capita terms.
• the inflation-adjusted financial balance of the public sector (GBAL),
• the depreciation rate of the peso (D),
• the annualized growth rate of the monetary base (MBG),
• the annualized growth rate of private domestic credit (PDCG),

Ideally the specification would be based on a theoretical relationship expressing private saving as some function of relevant exogenous and endogenous state variables. In a small open economy model, these would typically include the level of physical capital, the level of net foreign assets, the real rate of interest, the depreciation rate of the currency (or the growth rate of the money supply if this were the relevant monetary policy variable), government purchases of goods and services, and, possibly, various variables related to government budget financing.

Since not all of these variables are available for Mexico, certain compromises must be made. The trends and cyclical components in GNP and private disposable income are introduced as possible ways of disentangling the effects of permanent versus transitory income from one another. However, the HP filter-defined trends may be very imperfect proxies for permanent income or wealth.

The motivation for the real interest rate variable, R, is simply that saving or borrowing decisions are likely to be a function of the real interest rate. In a small open economy model, investment, consumption, the current account and subsequently saving, are all affected by the real interest rate. The \textit{ex-ante} real interest rate was measured by the difference between the nominal interest rate on Mexican treasury bills and the expected rate of inflation computed as the fitted values from a regression of the current inflation rate on past inflation, the past nominal interest rate and the past depreciation rate of the peso. I deemed this to be the appropriate real interest rate to use to explain private saving behavior.

Public sector purchases of goods and services (PURG), or alternatively public sector consumption purchases (CG), are included in the regression as these represent physical resources extracted by the government from real GNP. These are resources unavailable for private consumption, and permanently increased government purchases represent a decline in private wealth. Furthermore, a test of whether government
financing decisions matter requires government purchases to be entered as an explanatory variable. The distinction between consumption purchases and overall purchases may be necessary because overall purchases include public sector investment, which presumably, may augment the stock of physical capital used to produce private income.

The public sector budget balance, GBAL, is irrelevant for private consumption and GNP under the null hypothesis of Ricardian equivalence. So, everything else held equal, if the government chooses, in a nondistortionary way, to run a higher budget deficit, say for example by lowering lump-sum taxes and increasing private income, private saving should completely offset that higher deficit by absorbing any additional private income it generates. So the coefficient on the budget balance should be -1 under Ricardian equivalence.\(^6\)

The depreciation rate of the peso, D, is also included in the regressions. Fluctuations in the rate at which the peso depreciates can have effects because they affect the real return to holding peso balances. More rapid depreciation acts as a higher tax on peso balances. To the extent that these balances are useful in reducing transactions costs, this higher tax will have real consequences for consumption, investment, saving and output. The depreciation rate is also included in that it is an indicator of monetary policy.

As alternative measures of monetary policy I consider two other variables, the growth rate of the monetary base, MBG, and the growth rate of private domestic credit, PDCG. Both of these variables are problematic as measures of policy because of major changes in Mexico’s financial system during this period. It is often argued that the growth of credit in Mexico in the early 1990s led to a consumption boom, and ultimately to the peso crisis of late 1994. It will be of interest to examine the impact of credit expansion on saving.

The results of the regressions are presented in Table 2. The regressions use levels of the variables for two reasons. First, it is arguable that most of the quantity variables used in the regressions are stationary. There was little real per capita growth in Mexico

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\(^6\) For the regression to correctly identify the extent to which pure nondistortionary financing decisions matter, all distortions must be taken into account on the right-hand side. Without detailed information on marginal tax rates this is effectively impossible.
over the period being considered. Second, using levels preserves the equivalence of the units of measure of savings, income, and the various expenditure variables.

The benchmark regression is in column A and uses GNP as the income concept. The coefficient on GNP indicates that as GNP rises savings rises but much less than one-for-one with GNP. So holding the other variables equal, while savings rises with income, private savings as a fraction of GNP falls.

The real interest rate is insignificant in the regression, and remains so throughout all the regressions presented in Table 2, which may indicate that substitution and income effects associated with interest rate changes have a tendency to cancel one another out.

Government purchases enter strongly and negatively into the regression. The regression hold GNP and the budget balance constant, so a rise in government purchases in those circumstances would coincide with a rise in taxes and, as a consequence, a decline in private disposable income. A decline in savings might be the expected result, if private households smooth consumption and the rise in government expenditure and taxes is taken to be transitory.

The government’s budget balance enters into the regression with a coefficient of approximately -1. This is strongly suggestive of Ricardian equivalence. If government purchases and GNP are held constant, the most likely example of an improvement in the budget balance is an increase in taxes that is relatively nondistorting (hence the lack of any effect on GNP). These taxes would lower private disposable income, but since any rise in taxes now, with no change in government spending, would coincide with a later decline in taxes, consumption smoothing would imply that the private saving would absorb the entire decline in income.7

Finally, more rapid depreciation of the peso appears to lead to a rise in private saving. This could be explained in the following way. Suppose that peso balances are useful for making consumption purchases, say because holding them reduces shopping time or transactions costs. When the peso depreciates more rapidly, perhaps in an unanticipated way, this puts a tax on holding money and on consumption purchases. If the
period of more rapid depreciation is viewed as temporary, then consumers will intertemporally substitute higher consumption in the future for lower consumption now. If income does not decline, this implies an increase in current saving.

Column B indicates that the basic findings in column A are robust to using private income rather than GNP as the income concept. Fluctuations in the government’s budget balance are no longer offset one-for-one by private saving, but they are largely (90 percent) offset.

Columns C and D split the income concepts into their trend and cyclical components. As expected more cyclical fluctuations in income have a positive impact on private saving, while movements in the trends in income appear to have little impact on private saving.

Column E uses government consumption purchases in place of total government purchases as the measure of fiscal policy, and returns to using GNP as the income concept, so estimates should be compared to those in column A. Interestingly, the coefficient on GNP changes sign, indicating that increases in income lead to small decreases in private saving. The coefficient on government purchases itself is similar in magnitude to the coefficient in column A, but is estimated very imprecisely. The coefficient on the government budget balance is significantly different than -1, and indicates that private saving offsets about 75 percent of movements in the budget balance. The depreciation rate of the peso is neither quantitatively nor statistically significant in the regression. And finally, the fit of the equation is considerably poorer, indicating that government investment purchases have substantial explanatory power for private saving.

In column F, the growth rate of base money is substituted for the depreciation rate of the peso as the indicator of monetary policy. More rapid money growth, like more rapid depreciation of the peso tended to coincide with higher levels of private saving, perhaps for similar reasons.

Finally, in column G, in which the growth rate of private domestic credit was used as the indicator of monetary policy, we also find that rapid credit growth was associated

\footnote{Strictly speaking the regression doesn’t hold future government purchases constant, only current ones. This points to a generic problem in the interpretation of coefficients in static regressions such as the ones}
with higher levels of private saving. This is contrary to the notion that rapid credit expansion led to a decline in private saving in the 1990s.

At this point, a further discussion of the evidence regarding the Ricardian proposition is warranted. The results in Table 2 consistently suggest that private saving behavior offset the budgetary policies of the public sector in the 1980s and early 1990s in Mexico. However, there is a strong possibility that this result is driven by measurement error. For example, suppose our measure of national saving is correct, but that the measured budget balance, $S_t^*$, is measured with a white-noise classical measurement error. This will imply that $S_t^* = \Delta_t^* + \varepsilon_t$, where $\Delta_t^*$ is the true budget balance and $\varepsilon_t$ is a white noise error term uncorrelated with $\Delta_t^*$. Since national saving is measured correctly, this will imply that private saving is given by $S_{Pt} = S_{Pt}^* - \varepsilon_t$. In a simple regression of private saving on the budget balance the coefficient estimate would be given by

$$
\beta = \frac{\text{Cov}(S_{Pt}, S_t^*)}{\text{Var}(S_t^*)} = \frac{\text{Cov}(S_{Pt}^* - \varepsilon_t, S_t^*)}{\text{Var}(\Delta_t^*)} = \frac{\text{Cov}(S_{Pt}^*, \Delta_t^*) - \sigma_{\varepsilon}^2}{\text{Var}(\Delta_t^*) + \sigma_{\varepsilon}^2}.
$$

The noisier the budget balance data are, the further negative the bias in the regression coefficient. To check whether this was the source of my finding I smoothed the budget balance data, and computed private saving using these smoothed data and the original data on national saving. The very strong negative correlation between private saving and the budget balance remains.

Finally, it should be pointed out that the regressions cannot truly be given a structural interpretation. They describe a purely static relationship among the variables, and they do not identify the response of private saving to exogenous shocks to the Mexican economy. Most of the right-hand side variables in the equations could easily be thought of as simultaneously determined by a large number of common structural shocks.

presented in Table 2.
In the next section, I take a small step towards identifying these structural shocks and the response of private saving to them.

2.4 The Dynamic Responses of Private Saving to Shocks

In this section I use a VAR approach to modeling the response of private saving to various shocks to the Mexican economy. The shocks I attempt to identify are as follows: (i) wealth effects arising from exogenous fluctuations in the world price of crude oil, (ii) demand shocks resulting from the United States business cycle, (iii) monetary policy shocks in the United States, (iv) technology shocks in the Mexican economy, (v) exogenous innovations in government purchases in Mexico, (vi) exogenous innovations in tax financing in Mexico and (vii) exogenous changes in the rate of depreciation of the peso. These are assumed to comprise a complete set of the shocks which ultimately determine the aggregate level of private savings in Mexico.

The specification of three exogenous policy shocks (v)-(vii) is possible in an open economy, because the first two will determine the government’s financing requirement. The latter will endogenously determine the level of seignorage financing, leaving, as a residual, the level of debt finance required.

To identify the first three shocks I assume that they are determined entirely exogenously with respect to the Mexican economy. I specify a separate VAR for the logarithm of the world price of crude oil, the logarithm of per-capita GDP in the United States, and the 3-month treasury bill in the United States. Suppose we denote these three variables, in the same order, in vector form as $x_t$.

Ignoring the constant term, I estimate a VAR of the form

$$A_0 x_t = A_1 x_{t-1} + \cdots + A_p x_{t-p} + u_t,$$

where $A_0$ is assumed to be lower triangular with ones on the diagonal, and $u_t$ is assumed to be white noise. The assumption that the variables enter in the order I have described above means that shocks to the world oil price are determined prior to US interest rate policy, and prior to the determination of output in the US. However, the Fed, in setting
interest rate policy, is assumed to see the level of output (or its determinants in the current quarter). The lag length I used in practice was $p=4$.

Estimating the VAR for $x_t$ leads to a set of residuals $\hat{\mu}_t$ that we can think of as estimates of the shocks $\mu_t$.

In the second step I assume that Mexican data on government purchases of goods and services, output, taxes net of transfers and the depreciation rate of the peso can be used to identify the remaining shocks. I denote these variables as $y_t$. I assume that the error in the government purchases equation represents an exogenous shock to government purchases, that the error in the output equation represents an exogenous shock to technology, that the error in the tax equation represents an exogenous financing shock, and that the error in the depreciation equation represents an exogenous monetary policy shock. I choose the order of the variables in the VAR in order to reasonably argue that the errors in the estimated equations can be given this interpretation. The VAR I estimate is of the form

$$B_0 y_t = B_1 y_{t-1} + \cdots + B_p y_{t-p} + C_0 x_t + C_1 x_{t-1} + \cdots + C_p x_{t-p} + \nu_t$$

where $B_0$ is assumed to be lower triangular with ones on the diagonal, and $\nu_t$ is assumed to be white noise and is orthogonal to $\mu_t$.

I assume that the realities of fiscal policy are such that when the government determines its level of purchases of goods and services it does so absent knowledge about the current levels of technology, the level of taxes it may raise in the current quarter and the state of monetary policy. Second, I assume that output is then determined by the level of technology, all past information and any of the current shocks already discussed. Once output is determined, the level of taxes is determined, so taxes come after output in the ordering. Finally, monetary policy, or the determination of the exchange rate occurs once all these other shocks have been realized, so the depreciation rate of the peso comes last in the ordering. Subject to this ordering, the second VAR identifies estimates of the Mexican structural shocks, $\hat{v}_t$, which I denote $\tilde{v}_t$.

Once the shocks have been identified it is possible to determine the impulse response function of a variable, $z_t$, not included in the VARs, to the various shocks $\mu_t$. 

18
and \( v_t \) in a number of ways. Here I assume that it is sufficient to specify an ARMA model for \( z_t \) of the form

\[
z_t = \phi_1 z_{t-1} + \cdots + \phi_p z_{t-p} + \theta_0 u_t + \cdots + \theta_p u_{t-n} + \theta_0 v_t + \cdots + \theta_v v_{t-n}, \]

in order to obtain a good approximation to the moving average representation of \( z_t \). In practice I assumed that \( q = 4 \) and that \( n = 1 \).

I worked with two models one for the logarithm of real per capita private savings, and another for the share of private savings in GNP. The results I obtained were qualitatively similar for the two examples, so I used the model of the share of private savings in GNP (I call this the private savings rate) for better interpretability.

Figure 4 illustrates the estimated impulse response functions of the ratio of private savings to GNP with respect to the 7 shocks I have described above. The graphs illustrate the change in the savings rate, in percentage points, that occurs when there is a shock of each type. Each of the shocks has been normalized to be equal in size to the standard deviation of the relevant residual from the estimated VARs.\(^8\)

The first graph shows the response of private savings to an increase in the world price of oil. The shock to the price of oil assumed is about 12 percent, the standard deviation of the innovation to the oil price in the estimated VAR. Since an increase in the world price of oil, to Mexico, represents an increase in wealth, we might expect the savings rate to drop as a result. Indeed, we see that by the quarter after the shock, the private savings rate drops by about 1 percentage point. After that there is a gradual return of private savings to its previous value.

The second graph shows the response of the private savings rate to an innovation in US output of about one half of one percent of its GDP. I interpret this innovation as a shock to the demand for Mexican products. When this occurs we also see a decline in the private savings rate by just over one percentage point. Presumably, again, the increase in US demand leads to an increase in perceived wealth in Mexico. This increase in wealth

\(^8\) It is important to note than in estimating the equation for the ratio of private savings to GNP, a perfect fit is not obtained. In other words, the private savings rate cannot be perfectly explained by the 7 shocks that have been included in the VARs. We examine the unexplained component below.
precedes the subsequent increase in Mexican GNP, so the increase in consumption drives down savings initially.

The third graph illustrates the response of private savings to a US monetary policy shock in the form of an increase in the 3-month US T-bill rate of about 64 basis points. It is less easy to provide intuition for this finding. Higher interest rates in the US ought to translate into higher interest rates in Mexico, other things equal, and this is usually thought of as an incentive to save. Assuming that a higher T-bill rate in the US translates into a higher real cost of borrowing from abroad, there should be a negative wealth effect associated with the shock. This should cause consumption to fall, as well as investment, and a short run improvement in the current account and savings. Eventually, this effect will be reversed as output declines, and savings falls in line with the decline in investment. It is for this reason that the finding here seems puzzling.

The fourth graph illustrates the response of private saving to an innovation in government purchases of goods and services. The shock represents a roughly 2.5 percent increase in purchases. The private savings rate rises by about 0.5 percentage points as a result of the increase in government purchases, but quickly returns to its previous value. This result can be reconciled with our regression findings, which assumed that the increase in government purchases was accompanied by no change in the government’s budget balance, and therefore was accompanied by an increase in taxes. If taxes do not respond immediately to an increase in government spending, then private income may be largely unaffected by the increase in spending, whereas lifetime wealth will have declined. In this case, a decline in private consumption and an increase in private saving would not be surprising.

The fifth graph illustrates the response of private savings to a technology shock in Mexico representing a 0.8 percent outward shift in the production possibilities set. In neoclassical models, technology shocks raise the rate of return to investment, and lead to an increase in lifetime wealth. The consequent rise in consumption would outstrip the short-run increase in output and would cause private individuals to borrow from abroad in order to finance their consumption and investment purchases. As a result saving would fall in the short run. This effect would eventually be reversed. The estimate impulse
response function is puzzling because it indicates a very short-run increase in saving followed by a decline in saving that persists over several quarters. But we will see, in the theoretical section, that intuition about the effects of technology shocks is highly sensitive to the degree of persistence one assumes they have.

The sixth graph illustrates the response of private saving to a shock to the government’s tax revenue. The shock represents a roughly 4 percent increase in revenue. Recall that this is an increase in revenue that is not predicted by any prior change in the level of government spending, so we may think of it as an exogenous decision by the government to raise taxes now, and either raise expenditure in the future or have lower taxes in the future than would otherwise have been the case. It would appear that since the private savings rate falls substantially in its response to the tax shock, a rise in taxes now is taken to imply a decline in taxes in the future. Consequently lifetime wealth, and private consumption remain unchanged, and private savings falls (since income must have fallen by the amount of the taxes).

Finally, the seventh graph illustrates the response of saving to an unanticipated increase in the rate at which the peso depreciates. The shock to the peso represents a depreciation of 30 percent at annual rates. After a single period increase in the private savings rate, it declines by about 0.6 percentage points and then returns to its previous level. In some monetary models, more rapid depreciation of the peso can imply a negative wealth effect, which we would expect to lead to a short-run increase in saving.

The impulse response functions characterize the response of private saving to different kinds of shocks. We can decompose the variance of private saving (as a fraction of GNP), at various forecasting horizons, into components deriving from each of the 7 shocks. This decomposition is provided in Table 3. It illustrates that about a third of the variance in private saving at all horizons is due to the tax financing shock. In other words, private savings is largely driven by the government’s exogenous decisions regarding financing. The second most important shock is the one to US output. Fluctuations in US GDP act like an exogenous shock to the demand for Mexican products and clearly have an important impact on private saving in Mexico. And the third most important shock is movement in the world price of oil. Between them, these three shocks account for 60 to
70 percent of the variation in private savings in Mexico. Since between 12 and 27 percent of the variation in private saving is simply unexplained, this leaves very little to be accounted for by the other 3 shocks.

In the next section I present a theoretical model which incorporates the Ricardian proposition directly into the theory. Thus, it can immediately explain the importance of government financing decision for private saving. It will also be useful in gaining insight into how a modified neoclassical model can be used to try to understand the other findings in this paper.
3 A Model of Private Saving in Mexico

The previous section presented empirical evidence that suggested that in Mexico (i) private saving is largely driven by, and offsets, movements in the government budget balance, and (ii) private saving appears to decline when consumers are confronted by a positive shock to their wealth.

This section describes a model in which the first finding holds exactly by assumption (the government budget balance is irrelevant to private consumption). We will see whether the second finding is predicted by the model, and, in fact, what the model predicts for the reaction of private saving to several kinds of exogenous shocks to the economy.

The model in this section is derived from and is a simplification of the one presented by Rebelo and Végh (1995). The model describes an economy in which there are forward looking consumers who gain utility from a single consumption good and who suffer disutility from. In the version of model presented here, the labor market clears, so that the real wage is set equal to the marginal rate of substitution between consumption and leisure.

Production takes place in a single sector which produces a tradable good using capital and labor. Capital is accumulated using a standard investment technology which allows for adjustment costs.

The model treats Mexico as a small open economy, so that both the private and public sectors can borrow from the foreign sector at the world nominal interest rate measured in foreign currency. This does not allow the model to capture those aspects of international borrowing and lending relating to risk.

The exchange rate is treated as an exogenous policy variable, whose rate of depreciation is selected by the government according to a rule. This makes the supply of money an endogenous variable, since money must be allowed to adjust to sustain any particular value of the exchange rate. Money enters the model through a standard

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9 The opposite case where the money supply follows a rule and the exchange rate is endogenously determined can also be examined.
transactions technology. Purchases of consumption and investment have associated transactions costs which are smaller the greater are money balances.

A detailed description of the model is provided in section 3.1. Section 3.2 describes the numerical calibration of this model to Mexican data. Section 3.3 describes the first order conditions of the model, while section 3.4 describes a method for solving the model. Then section 3.5 analyzes how different exogenous shocks would impact on private saving if they were fed through the mechanism of the model. The extent to which the model is useful for gaining an understanding of savings behavior in Mexico is discussed.

3.1 The Model

The model is a dynamic optimizing model of a small open economy in which households own capital which is rented to firms owned by the households. The model is a one sector simplification of the two sector model of Rebelo and Végh (1995).

The Household Sector

There is a representative household which maximizes the discounted stream of its utility which is given by

\[ E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t), \]

where \( \beta < 1 \), \( C_t \) is consumption and \( N_t \) is labor supplied.

The utility function is assumed to be of the form

\[ U(C_t, N_t) = \frac{(C_t - \psi N_t^\sigma)^{1-1/\sigma}}{1 - 1/\sigma} - 1 \]

where \( \sigma > 0 \) is the intertemporal elasticity of substitution, and \( \psi \) determines the labor supply elasticity. This utility function, associated with Greenwood, Hercowitz and Huffman (1988) mitigates problems associated with unrealistic wealth effects on labor supply in dynamic optimizing models.

The household maximizes its utility subject to the budget constraint
\[ e_t B_t + C_t P_t + I_t P_t + S_t P_t + M_t = e_t B_{t-1}(1 + r^*_{t-1}) + M_{t-1} + W_t N_t + R_t K_{t-1} + \Pi_t - \Omega_t, \]

where \( e_t \) is the exchange rate in pesos per dollar, \( B_t \) is the households net foreign assets in dollars, \( P_t \) is the price level, \( I_t \) is investment, \( S_t \) is real transactions costs, \( M_t \) is net money holdings of the household sector, \( r^*_{t-1} \) is the dollar interest rate at \( t-1 \), \( W_t \) is the nominal wage rate, \( R_t \) is the rental rate of capital, \( K_{t-1} \) is the household’s capital stock chosen at \( t-1 \), \( \Pi_t \) is profits of the firms, and \( \Omega_t \) is net lump-sum taxes.

Capital is accumulated using a standard adjustment cost technology where the adjustment cost is a function of the size of investment relative to the existing stock of technology. So,

\[ K_t = \phi \left( \frac{I_t}{K_{t-1}} \right) K_{t-1} + (1 - \delta) K_{t-1} \]

where \( \phi(\delta) = \delta, \phi'(\delta) = 1, \) and \( \phi''(\delta) = \kappa / \delta, \) where \( \kappa \) is a free parameter.

Transactions costs are associated with purchases of consumption and investment goods. In this model these costs are assumed to be charged to the budget of the households. The costs are an increasing function of the value of household purchases but a decreasing function of the quantity of money balances held by the household relative to that value. In particular the real costs are given by

\[ S_t = \zeta_s (C_t + \theta I_t) v \left( \frac{M_t / P_t}{C_t + \theta I_t} \right) \]

where \( v(X) = X^2 - X + \zeta \). The parameter \( \theta \) denotes the fraction of investment purchases which are made less costly by the holding of money. This allows, for example, the model to deal with the fact that some investment purchases are not made by private households, but are, in fact, made by the government.

**Firms**

Producers maximize profits given by

\[ \Pi_t = P_t \zeta_t K_{t-1}^{1-a} N_t^a - W_t N_t - R_t K_{t-1} \]

where \( \zeta_t \) represents the level of TFP, \( K_{t-1} \) is the quantity of capital rented by producers at time \( t \) and \( N_t \) is the quantity of labor they hire.
Factor and output markets are assumed to be competitive and market clearing.

The Public Sector

The government makes exogenous decisions regarding its level of consumption expenditure, its level of foreign borrowing, net taxes paid by the household sector, the tax rate and the rate of depreciation of the peso. Given these decisions the money supply must adjust in order for the government’s budget to balance according to

\[ e_t F_t = e_t F_{t-1} \left(1 + r^*_t \right) + M_t - M_{t-1} + \Omega_t - P_t G_t, \]

where \( F_t \) is the government’s net foreign assets in dollar terms, and \( G_t \) is government purchases of consumable goods.

Equilibrium Relationships

A trade surplus at any point in time is associated with an accumulation of foreign assets so that in equilibrium the real trade balance is given by

\[ TB_t = B_t + F_t - \left(1 + r^*_t \right) \left(B_{t-1} + F_{t-1} \right). \]

This condition can derived by aggregating the household’s and the public sector’s budget constraints.

Finally, I assume that purchasing power parity holds so that the domestic price level is given by \( P_t = e_t P^*_t \) where \( P^*_t \) is the foreign price level. For simplicity I assume that \( P^*_t = 1 \) for all \( t \), so that the foreign inflation rate is zero, and the foreign nominal and real interest rates are equivalent.

3.2 Calibration of the Model’s Parameters

A number of choices must be made vis-a-vis the model parameters. The model was calibrated so as to match, as closely as possible, key features of the Mexican economy in the period 1980-87.

The intertemporal elasticity of substitution was set to \( \sigma = 0.2 \) a small value consistent with the evidence on intertemporal substitution for developing countries provided by Ogaki, Ostry and Reinhart (1995).
The parameter $\psi=22$ was used so that consumers would spend roughly 0.20 of their time endowment working (this is consistent with data on workweeks for the manufacturing sector in Mexico during the 80s), and $\nu=3$ was used to imply realistic labor supply elasticities.

The steady state rate of depreciation of the peso, $(e_{t+1} - e_t)/e_t$ was set to 0.154 which was the average quarterly rate at which the peso depreciated against the dollar in the period 1980-87. The steady state foreign real interest rate $r^*$ was set to 0.013, which was the difference between the average U.S. federal funds rate and the average U.S. inflation rate (both expressed in quarterly rates) in the period 1980-87.

The discount factor in the utility function was set so that $\beta=1/(1+r^*)$. This value is consistent with no per capita growth in consumption.

The transactions cost parameter was set to a constant $\zeta_s=2$. This was done in order that the model could replicate the degree to which the government relied on seignorage as a financing tool in the period 1980-87. The parameter $\theta$ was set to 0.7, since roughly 70% of Mexican investment is from the private sector. The parameter $\zeta$ was set equal to $1/4$ so that when the real interest rate is zero, the level of transactions costs associated with purchases is also zero.

The depreciation rate of capital was set to $\delta=0.02$, consistent with roughly 8% depreciation on an annual basis. The curvature parameter in the adjustment cost technology was set to $\kappa_{de}=-0.75$. This is a rather large value.

Labor’s share was set to $\alpha=0.6$, which according to the available evidence is a somewhat high value for Mexico in 1980.\(^{10}\) However, this value enabled the model to replicate the shares of private consumption and total investment in GDP in Mexico, which are about 0.64 and 0.21 respectively. $\xi$ was set equal to 1 in steady state.

The steady state level of net foreign assets was set to -30% of the domestic capital stock so as to be consistent with the size of the Mexican trade surplus relative to GDP in the period 1980-87, which was about 5 percent of GDP. Government consumption was

\(^{10}\) See Secretaria del Trabajo y Prevision Social (1993). For the industries covered in this report labor’s share averages about 0.42.
assumed to be about 9% of value-added in order to be consistent with the share of government consumption in GDP over the period 1980-87.

In steady state transactions costs represent about 0.2% of GDP. Government seignorage revenue represents 5% of GDP. These values are roughly consistent with average shares computed for Mexico over the period 1980-87.

3.3 Optimality Conditions

Here I define the level of real balances relative to the transactions they finance to be \( X_t = \left( \frac{M_t}{P_t} \right) \left( \frac{C_t + \theta I_t}{C_t} \right) \), and the level of output to be \( Y_t = \zeta \left( K_{t-1}^{1-\alpha} N_t^\alpha \right) \). I also note that if we have a constant elasticity of substitution function \( U(x) = \left( x^{1-1/\sigma} - 1 \right) / \left( 1 - 1/\sigma \right) \) then its first derivative is \( V(x) = x^{-1/\sigma} \). Hence I define \( V_t = \left( C_t - \psi N_t^\gamma \right)^{-1/\sigma} \).

The first order condition for consumption is

\[
V_t = \Lambda_t \left[ 1 + \zeta_s \left( \xi - X_t^2 \right) \right]
\]

where \( \Lambda_t \) is the Lagrange multiplier on the household’s budget constraint. The term on the left-hand side is the marginal utility of consumption while the term on the right is the marginal cost in terms of wealth, of an additional unit of consumption, the second part of which is the marginal transactions cost.

Similarly, the first order condition for labor supply is

\[
V_t \psi \nu N_t^{\nu-1} = \Lambda_t \alpha \frac{Y_t}{N_t}
\]

where the left-hand side is the marginal utility of an additional unit of leisure and the right-hand side is the marginal cost of obtaining it: the real wage times the marginal value of an additional unit of wealth.

If we define the Lagrange multiplier on the capital accumulation equation to be \( \Theta_t \), then the first-order condition for investment is given by

\[
\Theta_t \phi \left( \frac{I_t}{K_t} \right) = \Lambda_t \left[ 1 + \theta \zeta_s \left( \xi - X_t^2 \right) \right]
\]
where the left hand side represents the marginal value of the additional capital acquired through an additional unit of investment, while the right-hand side is the marginal cost of that unit.

Optimal intertemporal allocation of capital requires that the discounted marginal payoff (which will occur tomorrow) to obtaining an additional unit of capital today be equal to the marginal cost of obtaining it. In other words,

$$\Theta_t = \beta E_t \Theta_{t+1} \left[ \phi \left( \frac{I_{t+1}}{K_{t+1}} \right) - \phi' \left( \frac{I_{t+1}}{K_{t+1}} \right) \frac{I_{t+1}}{K_{t+1}} + (1 - \delta) \right] + \beta (1 - \alpha) E_t \Lambda_{t+1} \frac{Y_{t+1}}{K_{t+1}}.$$

The second term on the right-hand side is the discounted value of the marginal product of an additional unit of capital, while the first term on the right-hand side is the discounted marginal impact of an additional unit of capital on adjustment costs.

Optimal intertemporal allocation of foreign assets requires that the marginal cost of obtaining an additional bond be equal to its discounted payoff:

$$\Lambda_t = \beta E_t \Lambda_{t+1} \left( 1 + r^* \right).$$

Optimal intertemporal allocation of peso balances requires that the marginal value of an additional peso be equal to the discounted payoff to holding it for a period:

$$\Lambda_t \frac{1}{e_t} [1 + \zeta_s (2X_t - 1)] = \beta E_t \frac{\Lambda_{t+1}}{e_{t+1}}.$$

The aggregate resource constraint is

$$C_t + I_t + G_t + TB_t + S_t = Y_t$$

and the current account must equal the capital account

$$TB_t + r^*_t A_{t-1} = A_t - A_{t-1},$$

where $A_t$ is aggregate net foreign assets of the economy.

3.4 Solving the Model

There does not exist a closed-form solution to the model described above. In order to obtain an approximate solution to the model, I linearized the first-order conditions around an arbitrary initial steady state. This may produce erroneous results
because the model is inherently unstable: once a shock moves the economy away from the initial steady state, it never returns to it. The procedures used for linearizing and solving the model are described in great detail in Burnside (1997).

The first step involves finding the steady state. The first order condition for money holdings can be rearranged to show that in steady state the ratio of real balances to purchases is given by

\[ X = \frac{\beta / (1 + d) + \zeta_s - 1}{2\zeta_s} . \]

The first order condition for investment can then be solved for the ratio of the two Lagrange multipliers

\[ \frac{\Theta}{\Lambda} = 1 + \theta \zeta_s (\xi - X^2) . \]

The optimality condition for capital implies that the output-capital ratio is given by

\[ \frac{Y}{K} = \frac{\Theta}{\Lambda} \left[ 1 - \beta (1 - \delta) \right] \]

and that the capital-labor ratio is given by

\[ \frac{K}{N} = \left( \frac{Y / K}{\zeta} \right)^{-1/\alpha} . \]

But notice that the real wage is given by

\[ w = \alpha \left( \frac{K}{N} \right)^{\alpha-1} , \]

and that the first-order condition for labor supply implies that

\[ N = \left[ \frac{1 + \zeta_s (\xi - X^2) \psi \nu}{w} \right]^{1/(1-\nu)} . \]

At this point, with a value for \( N \), it is straightforward to determine \( K \) and \( Y \). Note also that \( I = \delta K \).

Since we will take the level of government purchases of goods and services to be exogenous, we will initially assume that \( G/Y \) is some arbitrary value calibrated to Mexican data. Furthermore, since the initial level of net foreign assets can be any value, we can set
the ratio $TB/Y = -r^* A/Y$ to an arbitrary value calibrated to Mexican data. Notice that the resource constraint implies that

$$C = \left(1 - \frac{G}{Y}\right) - \delta - \zeta_s \theta \delta (X^2 - X + \xi) \frac{K}{Y} - \frac{TB}{Y},$$

so that a value for $C$ is easily obtained. The steady state level of transactions costs can be obtained as a residual.

Once the steady state is determined a first-order approximation to each of the optimality and equilibrium conditions is obtained, and linear decision rules and laws of motion for each of the variables in the model can be obtained. These are used in the next section to describe the responses of saving to different shocks in the model.

3.5 The Effects of Shocks on Saving and other Macroeconomic Aggregates

This section describes the effects of different shocks on saving as well as various macroeconomic aggregates in the model. Since the model is one in which Ricardian equivalence holds, I ignore the distinction between public and private saving in the discussion. Instead I refer to domestic and national saving as if they were private saving.

The importance of any shock depends on its typical size and persistence. In the discussion that follows I describe the magnitude of the shocks I feed through the model, as well as assumptions being made about their persistence.

3.5.1 Shocks to Productivity

A positive shock to productivity raises the level of lifetime wealth and output as long as it is moderately persistent. The technology shock illustrated in Figure 5 is a permanent one, in the sense that is being modeled as a random walk. Each innovation to technology has a permanent impact on the level of productivity.

Since both output and lifetime wealth rise, consumption rises immediately in response to the shock. So does investment because the marginal product of capital has risen. In fact, in the short run, the additional domestic demand that this creates is met by a worsening of the trade balance. In fact, in the first few quarters, the trade balance
worsens by enough to overwhelm the increase in investment: domestic and national savings both fall, although the effect is modest.

In the long-run both domestic and national saving rise, but for many quarters the percentage increase in saving lags behind the percentage increase in output. So, if one was to consider the savings rate, defined as domestic savings or national savings as a fraction of GDP, a permanent technology shock would cause it to decline in the short and rise in the very long-run. Thus, the finding in the empirical section, that a positive technology shock causes a short-run increase in saving and a long-run decrease in saving appears inconsistent with the model.

However, the model has very different predictions if technology shocks are persistent but transitory. If the process for technology shocks is assumed to be a first-order autoregressive process (AR(1)) with a coefficient of 0.9, the responses to a technology shock are as illustrated in Figure 6. In this case, saving increases in the short-run and decreases in the long-run. The reasons are straightforward. Since the increase in the marginal product of capital is transitory, adjustment costs are severe enough that there is only a small increase in the desired level of investment. Lifetime wealth and consumption increase by much less than if the technology shock is persistent. In fact, the direct effect that the technology shock has on output is more than sufficient to meet the additional domestic demand, so the trade balance actually improves. Thus domestic and national saving both rise in the short-run. Since consumption rises permanently, but output does not, in the longer-run savings eventually falls. The pattern in the savings rates is similar.

So the findings in the empirical section are consistent with the model as long as technology shocks are not very persistent.

3.5.2 Shocks to Government Purchases

As Christiano and Eichenbaum (1992) discuss, shocks to government consumption have no effect on aggregate variables (such as output and hours worked) if government consumption is a perfect substitute for private consumption. To illustrate the maximum possible effect of government consumption shocks it is useful to assume that private consumers derive no utility from government consumption. While this is unrealistic,
government spending shocks have even less impact if government consumption directly provides utility.

When an increase in government purchases is permanent, as illustrated in Figure 7 where the increase in $G$ is about half a percent of GDP, households simply reduce their consumption by the amount of the increase in expenditure. This is because lifetime resources available to the consumer fall by $G$, and there are no wealth effects associated with labor supply in the model. So there is no impact on aggregate saving, although private saving would rise if the government did not finance the entire increase in $G$ with new taxes, but instead borrowed domestically.

When the increase in government purchases is transitory, but persistent, the effect are different. Suppose, as is illustrated in Figure 8, government purchases are an AR(1) process with parameter 0.95. What happens in this case is that households smooth the cost of the increase in government spending over their entire lifetimes, by reducing consumption permanently and persistently. This implies that the drop in consumption when the shock occurs is less than the rise in government purchases, so that initially aggregate saving declines. Eventually the decline in private consumption is greater than the rise in government purchases so the effect on saving is reversed. Since output never changes, the savings rate behaves exactly like the level of savings.

Both the permanent shock and the transitory shock scenarios can be made consistent with our empirical findings depending on how the government chooses to finance the increase in government expenditure. If new taxes are not raised to immediately cover the increased spending, then even the transitory shock scenario can be one in which private saving rises even though, in the short-run, aggregate saving declines.

3.5.3 Shocks to the Rate of Depreciation of the Peso

The real return to holding foreign assets is $r^*$, and is unaffected by changes in the rate of peso devaluation. The rate of return to holding peso cash balances is $-\pi$, where $s$ is the saved transactions cost of the marginal peso, and $\pi$ is the domestic inflation rate. But, since we are assuming no foreign inflation, $\pi=d$, through purchasing power parity.

A persistent rise in the rate of peso devaluation, $d$, would tend to lower the return to holding pesos, by increasing $\pi$ one-for-one. But, since the real return on all assets must
be equal, this decline in the return on pesos must be offset by an increase in \( \pi \). This takes place when households reduce their holdings of real balances relative to expenditure.

This reduction in real balances has further effects. It raises the transactions costs associated with a marginal investment purchase, denoted \( \tau \), thus reducing the return to investment, given by \( MPK - a - \tau \), where \( MPK \) is the marginal product of capital and \( a \) is the marginal adjustment cost resulting from an additional unit of investment. In order for the return on investment to remain equal to \( r^s \), investment and the level of capital must fall, so that the marginal product of capital can rise, offsetting the increase in \( \pi \).

This decumulation of capital has a significant impact on lifetime wealth, and leads to a decline in private consumption. These effects are illustrated in Figure 9, where a permanent and unanticipated doubling of the rate at which the peso depreciates is modeled.

Although employment and output also decline immediately, the short-run fall in output is much less than the decline in domestic demand, because it takes time to reduce the stock of productive capital. As a result, there is a short-run improvement in the trade balance that gradually goes away. In the very short-run, this improvement in the trade balance is actually larger than the decline in investment, so the level of domestic and national saving actually rises. Eventually, however, the behavior of saving mimics that of investment. It declines in the long-run.

Since output falls in the short run, the savings rates both rise in the short-run, and in fact, remain higher for several quarters after the arrival of the shock. Eventually the savings rates decline, since the incentive to invest in physical capital has been reduced.

In the empirical work we found that shocks to the rate of depreciation of the peso led to short-run increases in the savings rate, although these were very short-lived, and were followed by declines in the savings rate. This finding is broadly consistent with the theory presented here. Further experiments not illustrated here show that the period over which savings rates are higher than initially can be made quite short by reducing the persistence of shocks to the depreciation rate of the peso. However, for autoregressive parameters above 0.6, savings rates are always higher for at least 3 or 4 quarters before they fall below their initial values.
3.5.4 Shocks to the Foreign Interest Rate

Since all rates of return must be equated in the model, an increase in the foreign real interest rate, must be met by an increase in the rates of return to investment in physical capital and to holding peso balances. Intuitively, when the rate of interest on foreign bonds rises, capital and peso balances become less attractive, and households will reduce their holdings of them. This will cause their rates of return to rise and equilibrium to be restored.

As real balances fall relative to the purchases they finance (in other words as velocity increases), the marginal transactions cost associated with each purchase increases. This raises the rate of return on additional peso balances. The decline in real balances also raises the transactions costs associated with a marginal investment purchase, reducing further the return to investment. Thus, investment, and the stock of capital must decline sharply in order to raise the marginal product of capital and the return to investment in order to restore equilibrium.

Figure 10 illustrates the effects of a roughly 60 basis point increase in the real interest rate, which is assumed to be transitory with an AR(1) parameter of 0.9. Because the increase in the interest rate is persistent, but not permanent, the reduction in investment, though significant is only about 0.4 percent of initial GDP. Consumption falls, since there are also output losses as a result of the reduction in employment and investment. The short-run decline in investment and consumption outstrips the short-run decline in output. As a result, the trade balance improves, in fact, by enough that domestic and national saving actually rise initially.

The increase in domestic saving, and the domestic saving rate, is persistent, but the increase in national saving is very short-lived. This is because the rise in the real interest rate has by the second period, manifested itself in higher interest payments on existing foreign debt, and we have assumed that, initially, Mexico is a net foreign debt holder. Were Mexico a net foreign asset holder initially, the effect would be reversed.

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11 The interest rate shock cannot be permanent because the existence of a steady state requires that we tie the long-run real interest rate to the rate of time preference of households.
With both investment and consumption demand going up, and tradables output actually falling in the short-run (due to the effect on labor), this demand is met through a significant worsening of the trade balance. As a result there is a long-lived negative effect on domestic saving which is only reversed by the eventual increase in tradables output. The impact on national saving is not as severe, because the fall in interest rates reduces the magnitude of interest flows associated with existing foreign debt.\footnote{This follows from the assumption that when the shock occurs Mexico is a net foreign debtor. The impact on national saving would be more severe if Mexico were assumed to be a net foreign creditor at the}

The findings here with regard to national saving are consistent with the empirical section if we ignore the initial period in which debt service, at previously contracted interest rates, is not affected by the rise in the foreign interest rate. If foreign debt is largely short term then debt service is likely to be affected very quickly by interest rate shocks. In this case, the effect we would expect to see, would be a quick decline in national saving, as indicated in the empirical work.

\textbf{3.5.5 Exogenous Shocks to Foreign Assets}

In the empirical section we saw evidence in favor of the notion that positive shocks to the world oil price tend to decrease the private savings rate in Mexico. One way of thinking about such shocks in the context of the present model is to think of them as exogenous shocks to the stock of Mexico’s foreign assets. We can think of oil, a highly tradable commodity as a type of foreign asset, in which case, an exogenous increase in its price would cause an increase in wealth in Mexico, a country with substantial oil reserves.

Figure 11 illustrates the impact of an exogenous increase in foreign assets in Mexico equal to about 3 percent of GDP. Not surprisingly, since this shock does not operate on any margins, that is, it does not affect the rate of return to any asset, it does not have any impact on output or investment. But since national wealth has increased private consumption increases. Essentially, the one time increase in foreign assets of 3 percent of GDP is spread over a lifetime into increased consumption in the amount of about 1/25th of GDP per quarter. This is because it can effectively be rolled into a perpetuity (by purchasing foreign bonds) at about 1.3 percent per quarter, the steady state real rate of interest. Domestic savings falls by the amount that consumption increases,
because output is unaffected. But national savings remains unchanged because the increase in consumption is exactly matched by an increase in income from abroad.

In the empirical section, we found that increases in the price of oil decreased private saving. While this result is consistent with the effect described here for domestic saving, it is not consistent with the finding regarding national saving. It might be reconcilable with that finding if we explicitly assumed that the manner in which the increased wealth can be realized is not through purchases of foreign bonds, but is through exogenous and future exports of oil. In this case GNP will not rise in the short run, but will rise later, while consumption will jump immediately.

6 Conclusions

This paper has investigated the behavior of private saving in Mexico in the 1980s and first half of the 1990s.

There are three main findings to be highlighted. First, private saving behavior was largely driven by public budgetary policy. While the evidence may be tainted by the presence of measurement error, the findings in this paper with regard to budget deficits, are that they were largely offset of private saving. Second, the VAR model suggests that shocks to the world price of oil and demand shocks derived from the level of output in the United States were other important determinants of fluctuations in savings in Mexico. Third, while a simple monetary extension of a one sector, neoclassical model of a small open economy can be usefully used to interpret some of the empirical findings in the paper, it comes up short on some dimensions, especially when confronted by the findings regarding Mexican monetary policy shocks and the world oil price. It is also incapable of being used to understand the impact of demand shocks derived from the US economy, because it is a model price taking model in which net exports are determined by domestic factors given the world interest rate.
References

Banco de México. (various) Informe Anual, México, D.F.: Banco de México.
### Table 1

**Cross Correlations with Private Savings**

<table>
<thead>
<tr>
<th>$X_{t+i}$</th>
<th>Corr($S_p, X_{t+i}$)</th>
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<tr>
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<td>4</td>
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<tr>
<td>GNP</td>
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<tr>
<td>Cyclical component</td>
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<tr>
<td>Private disposable income</td>
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<tr>
<td>Cyclical component</td>
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<tr>
<td>T-bill rate</td>
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<tr>
<td>Inflation rate</td>
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<tr>
<td>Depreciation rate</td>
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<tr>
<td>Government purchases</td>
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<tr>
<td>Government consumption</td>
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<tr>
<td>Taxes net of transfers</td>
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<tr>
<td>Budget balance</td>
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<td>Private Domestic Credit</td>
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<tr>
<td>Monetary base</td>
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<tr>
<td>US T-bill rate</td>
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<tr>
<td>World price crude oil</td>
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_Play of Measurement_: All real quantity variables are measured in constant 1980 new pesos at annual rates, and are expressed in logarithms, except the budget balance which is expressed as a fraction of GNP. Interest rates, inflation rates and growth rates are expressed in decimal form at annual rates.
Table 2

Regressions using Private Savings

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<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
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<td>GNPTR</td>
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<td>GNPCY</td>
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<td>PDY</td>
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<td>PDYTR</td>
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<td>R</td>
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<td>PURG</td>
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<tr>
<td>CG</td>
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<td>GBAL</td>
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<td>-0.76</td>
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The dependent variable is SP. The sample is 1980Q2-1995Q2. Standard errors are in parentheses.

**Units of Measurement:** All real quantity variables are measured in constant 1980 new pesos at annual rates, and are expressed in levels. Interest rates, inflation rates and growth rates are expressed in decimal form at annual rates.
The variance decomposition indicates the fraction of the forecast error due to each type of shock if one were to forecast the ratio of private savings to GNP quarters ahead.
Figure 1

Basic National Accounts Aggregates

Note: All series are measured in constant (1980) new pesos per capita. One 1980 new peso (NS) = 43.6 1980 US$. Real GNP is real GDP plus nominal income and transfers divided by the GDP deflator. Consumption is the sum of private consumption and government consumption. Investment is the sum of private and government fixed investment, and inventory investment. The real current account is defined as real exports minus real imports plus nominal income and transfers divided by the GDP deflator.
Note: All series are measured in constant (1980) new pesos per capita. One 1980 new peso (N$) = 43.6 1980 US$. Real private consumption is the sum of real private consumption of durables, nondurables and services. Real government consumption is taken directly from the national accounts. Real private investment is the sum of private fixed investment, and inventory investment. Real public investment is government investment as defined in the national accounts.
Figure 3

Private Saving and the Public Sector Balance

Note: All series are measured in constant (1980) new pesos per capita. One 1980 new peso (N$) = 43.6 1980 US$. The real public sector balance is the financial balance, as defined in the text, divided by the GDP deflator. Real national saving can be defined as real investment plus the real current account (both as defined in Figure 1). Then real private saving is simply national saving minus the public sector balance minus real public sector investment. The inflation-adjusted figures are defined similarly.
Figure 4

Responses of Saving to Shocks Identified by the VAR Model

The graphs illustrate the responses of the ratio of private savings to GNP, measured in percentage points, to various structural shocks identified using the vector autoregressions described in the text.
The graphs illustrate the responses of output, private consumption, investment, the trade balance, domestic savings and national savings to a permanent increase (measured in percent) in the level of technology $\zeta_t$, illustrated in the upper left graph. Each of these responses is measured in percent of the initial level of GDP. The responses of the savings rates are measured in percentage points.
Figure 6

Responses to a Persistent but Transitory Technology Shock

The graphs illustrate the responses of output, private consumption, investment, the trade balance, domestic savings and national savings to a persistent but transitory increase (measured in percent) in the level of technology \( \zeta \), illustrated in the upper left graph. Each of these responses is measured in percent of the initial level of GDP. The responses of the savings rates are measured in percentage points.
The graphs illustrate the responses of output, private consumption, investment, the trade balance, domestic savings and national savings to a permanent increase (measured in percent of the initial level of GDP) in the level of government purchases $G_t$ illustrated in the upper left graph. Each of these responses is measured in percent of the initial level of GDP. The responses of the savings rates are measured in percentage points.
Figure 8

Responses to a Persistent but Transitory Increase in Government Purchases

The graphs illustrate the responses of output, private consumption, investment, the trade balance, domestic savings and national savings to a persistent but transitory increase (measured in percent of the initial level of GDP) in the level of government purchases $G_t$ illustrated in the upper left graph. Each of these responses is measured in percent of the initial level of GDP. The responses of the savings rates are measured in percentage points.
The graphs illustrate the responses of output, private consumption, investment, the trade balance, domestic savings and national savings to a permanent doubling of the rate at which the peso depreciates, $d_t$, illustrated in the upper left graph. Each of these responses is measured in percent of the initial level of GDP. The responses of the savings rates are measured in percentage points.
The graphs illustrate the responses of output, private consumption, investment, the trade balance, domestic savings and national savings to a transitory increase (measured in basis points) in the foreign interest rate $r_t^*$ illustrated in the upper left graph. Each of these responses is measured in percent of the initial level of GDP. The responses of the savings rates are measured in percentage points.
The graphs illustrate the responses of output, private consumption, investment, the trade balance, domestic savings and national savings to a transitory increase (measured in percent of the initial level of GDP) in the level of foreign assets, $A_t$, illustrated in the upper left graph. Each of these responses is measured in percent of the initial level of GDP. The responses of the savings rates are measured in percentage points.