Stabilization Policy and the Costs of Dollarization

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Abstract

This paper compares the welfare costs of business cycles in a dollarized economy to those associated with several alternative monetary regimes belonging to three broad families: interest-rate feedback rules, inflation targeting, and money growth rate rules. The analysis is conducted within an optimizing model of a small open economy with sticky prices. The model is calibrated to the Mexican economy and is driven by 3 external shocks: terms of trade, world interest rate, and import-price inflation. We show econometrically that these shocks explain more than 75% of the observed forecasting error variance of Mexican output and the Mexican real exchange rate at 4- to 16-quarter horizons. The welfare comparisons suggest that dollarization is the least successful of the monetary policy rules considered: agents are willing to give up more than 2% of their non-stochastic steady-state consumption to see a policy other than dollarization implemented.

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1 Introduction

The idea of replacing the domestic currency with the U.S. dollar is being actively debated in a number of emerging market economies. This is particularly the case in Argentina and Mexico. Proponents of dollarization argue that by eliminating devaluation risk, dollarization will go a long way toward reducing country risk premia, thus lowering aggregate volatility. On the other hand, opponents of dollarization warn that this way of reducing country risk comes at a cost that may very well exceed its benefits.

At least three sources of costs associated with dollarization have been identified: One is the loss of seignorage revenue. When a country adopts the U.S. dollar as the sole legal tender, the stream of its seignorage revenue begins to flow to the U.S. central bank. Clearly, the magnitude of the cost of dollarization stemming from the loss of seignorage revenue for emerging market economies depends on their ability to negotiate a sharing agreement with the United States. Consequently, this is more a political issue than an economic one. From preliminary talks between the U.S. and Argentine authorities, it seems that the U.S. is reluctant to commit to any sharing rule. But an issue that must be addressed before a meaningful discussion on ways to allocate seignorage can be carried out is the determination of the magnitude of the resources that are at stake. Conventionally, the amount of seignorage revenue lost due to dollarization is measured by the interest income on the amount of foreign reserves required to convert the entire money base into dollars (Calvo, 1999a). In Schmitt-Grohé and Uribe (1999), we argue that this way of calculating the loss of seignorage may severely underestimate the actual loss in the presence of inflation and growth. For example, if the inflation rate is 1% per annum, the real interest rate is 4%, and the growth rate is 3%, then the correct measure of seignorage loss is five times as large as the conventional one.

A second source of cost is the lack of a lender of last resort. Under dollarization, the government loses the ability to inject liquidity into the financial system in the event of a banking crisis through money creation. However, as pointed out by Calvo (1999a,b), domestic banks can have access to liquidity through a variety of sources other than the printing press of the central bank. For example, commercial banks can procure emergency credit lines with international financial institutions, or the domestic government can provide credit by using its foreign reserves or by borrowing from domestic sectors that are not in financial distress, from international financial markets,
from foreign governments, or from international institutions such as the IMF or the World Bank. Therefore, dollarization does not imply the loss of a lender of last resort, but simply the disappearance of one particular source of liquidity, namely central bank credit.

A third cost of dollarization stems from the presence of asymmetric shocks. In economies with nominal frictions, monetary policy can play an important role in stabilizing business cycles. Under dollarization, however, the country relinquishes its ability to conduct cyclical monetary policy. To the extent that the shocks affecting the dollarized economy are different from those affecting the U.S. economy or affect the two economies asymmetrically, dollarization will come at the cost of higher macroeconomic instability. This is because U.S. monetary policy is likely to respond mainly to that country’s state of the business cycle.

The purpose of this paper is to quantify the cost of dollarization arising from the third source identified above, namely, the reduced ability to accommodate asymmetric shocks. Specifically, we set out to compare the level of welfare in a dollarized economy to the level of welfare in alternative economies that differ from the dollarized economy only in their monetary arrangements. The alternative monetary policy regimes we study belong to three broad families: interest-rate feedback rules, inflation targeting, and money growth rate rules.

The welfare-based evaluation of the alternative policy regimes involves four steps: the development of a utility-based theoretical framework that provides the metric for judging alternative policy specifications; the calibration of the structural parameters of the model; the identification and estimation of the sources of aggregate fluctuations; and the computation of the level of welfare associated with the alternative monetary policy arrangements.

The theoretical framework we use is an extension of a simpler one that has served as the workhorse in open economy macroeconomics since the seminal work of Calvo (1983). Specifically, we develop an optimizing dynamic general equilibrium model of a small open economy with endogenous labor supply and capital accumulation that produces exportables and non-tradables and absorbs exportables, importables, and non-tradables. In this framework, room for cyclical monetary policy arises from two sources: first, product prices in the non-traded sector are assumed to be sticky à la Rotemberg (1982). Second, there is a demand for money which originates from the assumption that real balances facilitate transactions in final goods as in Kimbrough (1986).

These two sources of nominal rigidities create a tension for stabilization
policy. On the one hand, the presence of sticky prices in the home sector calls for policies that stabilize the non-traded component of CPI inflation. On the other hand, the fact that, via transaction costs, money acts as a tax on aggregate spending creates an incentive for the central bank to stabilize the opportunity cost of holding money, that is, the domestic nominal interest rate.

We calibrate our model to the Mexican economy using long-run data restrictions for the post-debt-crisis era. A recent literature on business cycles in emerging market economies has emphasized external shocks as the predominant source of aggregate fluctuations (Calvo, Leiderman, and Reinhart, 1993; Mendoza, 1995; Del Negro and Obiols-Homs, 1999). For example, Calvo, Leiderman, and Reinhart (1993) study the comovement between real exchange rates and U.S. interest rates for 10 Latin American countries between 1988 and 1992 and find that around half of the variance in real exchange rates can be explained by variations in U.S. interest rates. Mendoza (1995) presents a model-based evaluation of the contribution of terms-of-trade shocks to explaining output variability in developing countries and concludes that this type of shock accounts for around half of the variance of GDP. In a recent study of the Mexican economy, Del Negro and Obiols-Homs (1999) confirm these results by showing that over the period 1970 to 1997 most shocks to output and prices originated in the foreign sector in the form of shocks to U.S. industrial production, interest rates, and consumer and commodity prices. Based on this body of evidence, we focus on three external shocks as the principal sources of aggregate uncertainty: world-interest-rate, terms-of-trade, and world inflation shocks.

We estimate the stochastic processes followed by these three shocks using data from the Mexican economy. The estimated processes serve as the driving force of business cycles in our theoretical model. To gauge the relative importance of the external shocks for observed Mexican business-cycle fluctuations, we perform a variance decomposition analysis of the Mexican real exchange rate and output. We find that more than 75 percent of the 4- to 16-quarter-ahead forecasting error variance of these two variables can be explained by our three external shocks.

The welfare analysis suggests that dollarization is the least preferred of the various monetary arrangements we study. Specifically, we find that households are willing to give up more than 2 percent of the non-stochastic steady state stream of consumption to see a policy other than dollarization implemented. This finding quantifies the magnitude of the third source of cost.
associated with dollarization identified above. Taken at face value, it provides a none insignificant lower bound for the size of benefits that are required to make dollarization a socially viable proposal.

2 A small open economy with sticky prices

We consider a small open economy that produces two types of goods, exportables and nontradables, and absorbs three types of goods, exportables, nontradables, and importables.

2.1 The private sector

The economy is populated by a large number of infinitely-lived households, each of which is the monopolistic supplier of a differentiated non-traded good. Following Rotemberg (1982), we assume that the household faces convex adjustment costs when it changes the nominal price of the good it produces. Preferences are defined over processes of consumption, \( c_t \), labor effort, \( h_t \), and the growth rate of the price of the good produced by the household, \( \tilde{\pi}_t^n \equiv \tilde{P}_t^n/\tilde{P}_{t-1}^n \), and are described by the following utility function:

\[
E_0 \sum_{t=0}^{\infty} \beta^t \left[ U(c_t, h_t) - \theta(\tilde{\pi}_t^n) \right],
\]

where \( E_t \) denotes the mathematical expectation conditional on information available in period \( t \), \( \beta \in (0, 1) \) denotes the subjective discount factor, and \( U \) takes the particular form

\[
U(c, h) = \frac{c^{\nu}(1-h)^{1-\nu}1-\sigma}{1-\sigma}
\]

with \( \sigma \geq 0 \) and \( \nu \in (0, 1) \). The function \( \theta \) measures the degree of nominal price stickiness. It is assumed to be strictly convex. We assume that \( \theta(\pi^n) = 0 \), where \( \pi^n \) denotes the steady-state inflation rate of non-tradables, so that at the steady-state rate of inflation price-stickiness imposes no welfare costs to households. In addition we require that \( \theta'(\pi^n) = 0 \), which implies, as we shall see shortly, that in steady state firms set prices so as to equate marginal cost to marginal revenue.

Households have access to two financial assets: domestic money, \( M_t \), and a foreign-currency denominated bond, \( B_t \), that pays the interest rate \( r_t \) between
periods $t$ and $t+1$. In addition, households hold physical capital, $k_t$. Capital depreciates at the constant rate $\delta \in (0, 1)$ per period and is subject to convex adjustment costs. Specifically, the law of motion of $k_t$ is given by

$$k_{t+1} = (1 - \delta)k_t + \phi \left( \frac{i_t}{k_t} \right) k_t,$$

where $i_t$ denotes gross investment and $\phi$ is an increasing and concave function satisfying $\phi(\delta) = \delta$ and $\phi'(\delta) = 1.$

Following Kimbrough (1986), domestic money demand is motivated by assuming that purchases of final goods are subject to a proportional transaction cost, $s(v_t)$, that is increasing in money velocity, $v_t$, which in turn is defined as

$$v_t = \frac{p_t(c_t + i_t)}{m_t},$$

where final goods prices, $p_t$, and real balances, $m_t$, are expressed in units of importable goods, that is, letting $P_t$ and $P_t^{m}$ be the price of final and importable goods in terms of domestic currency, $p_t \equiv P_t/P_t^{m}$ and $m_t \equiv M_t/P_t^{m}$. The representative household’s period-by-period budget constraint is given by

$$p_t(c_t+i_t)(1+s(v_t))+m_t+b_t+\tau_t \leq u_t k_t+w_t(h_t-\tilde{h}_t^n)+\frac{r_{t-1}b_{t-1}}{\pi_t^{m*}} + \frac{m_{t-1}}{\pi_t^{m*}} + \tilde{p}_t^n F^n(\tilde{h}_t^n).$$

The left-hand side of (4) represents the uses of wealth in period $t$ expressed in terms of importables: consumption and investment purchases (including transaction costs), real balances, and real bond holdings, $b_t \equiv B_t/P_t^{m*}$, with $P_t^{m*}$ denoting the foreign-currency price of importables, and real payments of lump-sum taxes, $\tau_t$. The right-hand side of (4) represents the sources of wealth. Each period $t \geq 0$, the household starts with money balances carried over from the previous period, whose real value is given by $M_{t-1}/P_t^{m*} = m_{t-1}/\pi_t^{m}$, where $\pi_t^{m} \equiv P_t^{m}/P_{t-1}^{m}$ denotes domestic import price inflation. The household also receives the principal and interest on bonds acquired in period $t-1$ in the amount of $r_{t-1}b_{t-1}/\pi_t^{m*}$, where $\pi_t^{m*} \equiv P_t^{m*}/P_{t-1}^{m*}$ is the foreign import price inflation. The right-hand side of (4) also includes the household’s current income, which consists of wage earnings for hours worked outside the household, income from the rental of physical capital, and sales

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1In a small open economy model capital adjustment costs are necessary to avoid excess volatility of investment.
of nontradables, where $w_t$, $u_t$, and $\tilde{p}^n_t$ denote, respectively, the wage rate, the rental rate of capital, and the relative price of the differentiated good produced by the household, all expressed in terms of importables.

The production technology for the differentiated nontradable good takes the form $F^n(\tilde{h}^n_t)$, where $F^n$ is a positive, increasing, and concave function and $\tilde{h}^n_t$ denotes hours allocated to the production of the household’s differentiated non-traded good. The household faces the demand function $q^n_{nt}d(\tilde{p}^n_t/p^n_t)$ for the good it produces, where $q^n_{nt}$ denotes the level of aggregate demand for nontradables, $p^n_t$ is a price index of nontradables expressed in terms of importables, and $d$ is a positive and decreasing function satisfying $d(1) = 1$ and $d'(1) < -1$. The firm takes both $q^n_{nt}$ and $p^n_t$ as given. Such a demand function can be derived by assuming that final nontradable goods are a composite produced from differentiated intermediate goods via a Dixit-Stiglitz production function. The restriction imposed on $d'(1)$ is necessary for the household’s price-setting problem to be well defined in a symmetric equilibrium. Households must set nominal prices one period in advance and current output is demand determined, so that

$$F^n(\tilde{h}^n_t) = q^n_{nt}d(\tilde{p}^n_t/p^n_t)$$

(5)

The household chooses stochastic processes for $\{c_t, h_t, \tilde{h}_t, k_{t+1}, b_t, m_t, u_t, \tilde{p}^n_t\}$ so as to maximize (1) subject to (2)-(5) and some borrowing limit that prevents it from engaging in Ponzi-type schemes taking as given the sequences $\{p_t, p^n_t, q^n_t, u_t, w_t, r_t, \pi^m_t, \pi^m_{nt}\}$. The associated first-order conditions are

$$U_c(c_t, h_t) = \lambda_t p_t [1 + s(v_t) + v_t s'(v_t)]$$

$$-U_h(c_t, h_t) = \lambda_t w_t$$

(6)

(7)

$$\mu^k_t = \beta E_t \left[ \lambda_{t+1} u_{t+1} + \mu^k_{t+1} \left( 1 - \delta + \phi \left( \frac{i_{t+1}}{k_{t+1}} \right) - \phi' \left( \frac{i_{t+1}}{k_{t+1}} \right) \frac{i_{t+1}}{k_{t+1}} \right) \right]$$

(8)

$$\lambda_t = \beta E_t \lambda_{t+1} \left( \frac{r_t}{\pi^m_{nt}} \right)$$

(9)

$$\lambda_t \left[ 1 - v^2_t s'(v_t) \right] = \beta E_t \left( \frac{\lambda_{t+1}}{\pi^m_{t+1}} \right)$$

(10)

$$\lambda_t p_t [1 + s(v_t) + v_t s'(v_t)] = \mu^k_t \phi' \left( \frac{i_t}{k_t} \right)$$

(11)
\[ E_t \theta' (\tilde{\pi}^n_{t+1} - \pi^n_t) \tilde{\pi}^n_{t+1} = \beta E_t \theta' (\tilde{\pi}_{t+2}^n - \pi^n_t) \tilde{\pi}^n_{t+1} + E_t \lambda_{t+1} \tilde{p}^n_{t+1} F^n (\tilde{h}^n_{t+1}) \]

\[ -E_t \lambda_{t+1} \left[ \frac{w_{t+1}}{F^n'(\tilde{h}^n_{t+1})} - \tilde{p}^n_{t+1} q^n_{t+1} \frac{p^n_{t+1}}{P^n_{t+1}} q' \left( \frac{\tilde{p}^n_{t+1}}{P^n_{t+1}} \right) \right]. \]

The variable \( \lambda_t \) is the Lagrange multiplier on the budget constraint (4) and represents the marginal utility of wealth in terms of importables. The variable \( \mu^k_t \) is the Lagrange multiplier on (2). The ratio \( \mu^k_t / \lambda_t \) is the shadow price of installed capital in terms of importables, or Tobin’s \( Q \).

Final goods are assumed to be a composite of nontradable, exportable, and importable goods produced with a technology of the form

\[ q^f_t = F^f (a^n_t, a^x_t, a^m_t), \]

where \( F^f \) is an homogeneous-of-degree-one production function and \( a^n_t, a^x_t, \) and \( a^m_t \) denote, respectively, domestic absorption of nontradable, exportable, and importable goods in period \( t \). The market for final goods is perfectly competitive and prices are fully flexible. Thus, the representative firm’s demands for inputs satisfy

\[ p_t F^n_1 (a^n_t, a^x_t, a^m_t) = p^n_t \]

\[ p_t F^x_1 (a^n_t, a^x_t, a^m_t) = p^x_t \]

\[ p_t F^m_1 (a^n_t, a^x_t, a^m_t) = 1, \]

where \( F^i_1 \) denotes the partial derivative of \( F^f \) with respect to \( a^i \) for \( i = n, x, m \) and \( p^x_t \equiv P^x_t / P^m_t \) denotes the relative price of exportables in terms of importables, or the terms of trade.

Like the final goods producing sector, the sector producing export goods is perfectly competitive and prices are fully flexible. Exportable output, \( q^x_t \), is produced using capital, \( k_t \), and labor services, \( h^x_t \), according to the following homogeneous-of-degree-one technology:

\[ q^x_t = F^x (k_t, h^x_t) \]

Each period, firms choose capital and labor services so as to maximize profits, which are given by \( p^x_t q^x_t - u_t k_t - w_t h^x_t \), subject to the above technology. Input demands must then satisfy the following efficiency conditions:

\[ p^x_t F^x_1 (k_t, h^x_t) = u_t \]

\[ and \]

\[ p^x_t F^x_2 (k_t, h^x_t) = w_t \]
2.2 The government

For simplicity, we will assume that government consumption and government bond holdings are zero at all times. In this case, the consolidated government budget constraint can be written as

\[ \tau_t = m_t - \frac{m_{t-1}}{\pi_t^m} \]  

and implies that the government rebates any seignorage revenue to the public through lump-sum transfers. Thus, \( \tau_t \) is endogenously determined.

We characterize monetary policy as a feedback rule whereby the devaluation rate of the domestic currency is set as a linear function of past devaluation rates and current and past values of CPI inflation and GDP. In particular, letting \( E_t \) denote the nominal exchange rate defined as the domestic-currency price of one unit of foreign currency, the gross devaluation rate, \( \epsilon_t \), is given by \( E_t/E_{t-1} \). We denote gross CPI inflation in period \( t \) by \( \pi_t \) and define it as \( P_t/P_{t-1} \). Real GDP is given by the sum of value added in the export and non-traded industries measured in terms of final goods and is denoted by \( y_t \). The feedback rule then takes the form

\[ \hat{\epsilon}_t = \sum_{j=1}^{n^\epsilon} a_j^\epsilon \hat{\epsilon}_{t-j} + \sum_{j=0}^{n^y} a_j^y \hat{y}_{t-j} + \sum_{j=0}^{n^\pi} a_j^\pi \hat{\pi}_{t-j} + \eta_t^\epsilon, \]  

where \( \hat{\epsilon}_t, \hat{y}_t \) and \( \hat{\pi}_t \) denote the log-deviations of the gross devaluation rate, real GDP, and the gross rate of CPI inflation from their respective non-stochastic steady-state values \( \epsilon, y, \) and \( \pi, \) respectively; \( \eta_t^\epsilon \) is an exogenous random shock representing the non-systematic part of monetary policy. We consider this class of monetary policy rules because in developing countries, and particularly in Latin America, policymakers have traditionally favored the exchange rate as the nominal anchor (see Kiguel and Leviatan, 1992, and the references cited therein).

Abstracting from its implications for seignorage revenue, dollarization can be interpreted as a perfectly credible currency board.\(^2\) We therefore define dollarization as a special case of the above policy rule in which \( a_j^k = 0 \) for all \( j, k, \) that is,

\[ \hat{\epsilon}_t = 0 \quad \text{for all } t \]  

\(^2\)For an analysis of the implications of dollarization for seignorage revenue, see Schmitt-Grohé and Uribe (1999).
In addition to the devaluation feedback rule (21), we consider four families of monetary policy specifications. The first family consists of rules in which the domestic nominal interest rate is the operating target of the central bank. In particular, we assume that the central bank sets the nominal interest rate on one-period, domestic, nominally risk-free bonds, which we denote by $i^d_t$, as a linear function of current and past values of deviations of domestic consumer price inflation and real GDP from their respective steady-state values. In addition, we allow the central bank to smooth interest rates by including lagged values of the nominal interest rate into the feedback rule. Formally, the class of interest rate feedback rules we consider can be expressed as

$$\hat{i}^d_t = \sum_{j=1}^{n^i} a^i_j \hat{i}^d_{t-j} + \sum_{j=0}^{n^y} a^y_j \hat{y}_{t-j} + \sum_{j=0}^{n^\pi} a^\pi_j \hat{\pi}_{t-j},$$

(23)

where $\hat{i}^d_t$ denotes deviations of the gross domestic nominal interest rate from steady state. This class of interest rate rules for the conduct of monetary policy has received much attention in the literature recently after John Taylor’s influential (1993) paper that shows that actual U.S. monetary policy can be well described by such a rule.\(^3\) Subsequent authors have established that a rule of this type also describes actual monetary policy in other large developed economies reasonably well (Clarida, et al., 1999). More importantly, it has been argued that such a rule, with appropriately chosen coefficients on inflation, output, and past values of the nominal interest rate, represents an optimal monetary stabilization policy, in the sense that it implements the Pareto optimal allocation (Rotemberg and Woodford, 1997).\(^4\) For estimates of Taylor-type interest rate rules for Latin American countries, see Restrepo (1999).

The second class of monetary policy rules we consider, is one in which the central bank directly controls the monetary aggregate by setting the growth rate of the money supply. Specifically, we consider simple rules of the type

$$M_t = (1 + \zeta)M_{t-1},$$

(24)

where $\zeta > -1$ is the rate of expansion of the money supply. Under this policy the nominal exchange rate floats freely, thus, it can be regarded as the polar

\(^3\)Taylor finds that U.S. monetary policy during the Volker-Greenspan era took the form given in (23), with $a^y_0 = 0.5$, $a^- = 1.5$, and $a^\pi_j = a^y_j = 0$ for all $j > 0$.

\(^4\)However, this result has been shown not to be robust to changes in model specification (Benhabib et al., 1999a) and to deviations from local analysis (Benhabib et al., 1999b).
case to dollarization.

The third type of monetary regime is one in which the monetary authority targets the CPI inflation rate,

\[ \hat{\pi}_t = 0. \]

(25)

This kind of policy has recently been advocated by a number authors, notably Bernanke (1998) and Svensson (1998). Inflation targeting has been put into practice by, for example, the central bank of New Zealand.

Finally, we will also study the stabilizing properties of a monetary policy that eliminates all inefficiencies stemming from nominal price rigidities. Specifically, we will study a policy that allows marginal costs to equal marginal revenues in the nontraded sector at all times and under all circumstances, that is,

\[ p^n_t = (1 + \mu)mc_t \]

(26)

where, as will be clear shortly, \( 1 + \mu = d'(1)/(1 + d'(1)) \) denotes the steady-state markup of prices over marginal costs in the nontraded sector, and \( mc_t \) are marginal costs in the nontraded sector in equilibrium.

2.3 Equilibrium

In a symmetric equilibrium, all firms in the nontraded goods sector set identical prices and quantities so that \( \tilde{p}^n_t = p^n_t, \tilde{h}^n_t = h^n_t \), and \( \tilde{\pi}^n_t = \pi^n_t \). The definition of inflation of nontradables then implies that

\[ \pi^n_t = \frac{p^n_t}{p^n_{t-1}} \pi^m_t \]

(27)

In turn, equations (5) and (12) can be written as

\[ q^n_t = F^n(h^n_t) \]

(28)

and

\[ E_t \lambda_{t+1} \theta'(\pi^n_{t+1}) \pi^n_{t+1} = \beta E_t \lambda_{t+2} \theta'(\pi^n_{t+2}) \pi^n_{t+2} - \frac{1 + \mu}{\mu} E_t \lambda_{t+1} q^n_{t+1} \left[ \frac{p^n_{t+1}}{1 + \mu} - mc_{t+1} \right], \]

(29)

where

\[ mc_t = \frac{w_t}{F^n(h^n_t)}. \]

(30)
In equilibrium the markets for labor, nontraded goods, and final goods must clear:

\[ h_t = h^n_t + h^x_t \]  \hspace{1cm} (31)
\[ q^n_t = a^n_t \]  \hspace{1cm} (32)
\[ q^f_t = (c_t + i_t)(1 + s(v_t)) \]  \hspace{1cm} (33)

The stock of foreign bonds evolves according to the following equation:

\[ b_t = r_{t-1}p_{t-1} + tb_t, \]  \hspace{1cm} (34)

where \( tb_t \) denotes the trade balance in units of importables in period \( t \) and is given by

\[ tb_t = p^n_t(q^n_t - a^n_t) - a^m_t \]  \hspace{1cm} (35)

We assume that the law of one price holds for tradable goods, that is, the domestic prices of importables and exportables, \( P^m_t \) and \( P^x_t \), are linked to the respective world prices, \( P^m_t \) and \( P^x_t \), by the relationships \( P^x_t = \mathcal{E}_t P^x_t \) and \( P^m_t = \mathcal{E}_t P^m_t \). The domestic economy takes world prices as exogenous. The first of the above relationships implies that domestic import price inflation equals the sum of foreign import price inflation and the devaluation rate, that is,

\[ \pi^m_t = \epsilon_t \pi^m_{t-1} \]  \hspace{1cm} (36)

Real gross domestic product and consumer price inflation, the arguments of the monetary policy rule (21), are defined, respectively, as

\[ y_t = \frac{p^n_t q^n_t + p^x_t q^x_t}{p_t} \]  \hspace{1cm} (37)

and

\[ \pi_t = \frac{p_t}{p_{t-1}} \pi^m_t \]  \hspace{1cm} (38)

Finally, we assume that the nominal interest rate at which the country can borrow internationally is given by the world interest rate plus a premium. The size of the interest rate premium is increasing in the country’s stock of foreign debt. Specifically, we assume that the gross interest rate on foreign-currency denominated bonds is given by

\[ r_t = r^* + (-bt) \]  \hspace{1cm} (39)
where $r_t^*$ denotes the world interest rate, which is taken as exogenous by the country, and $\rho$ is a positive and increasing function. The reason for introducing a debt elastic interest rate premium is purely technical. As is well known, small open economies that face a purely exogenous world interest rate display non-stationary dynamics in response to stationary exogenous shocks. As a result, the solution to a log-linearized equilibrium conditions may not be a valid approximation to the exact, non-linear equilibrium system. Since we wish to employ log-linear solution methods to characterize the equilibrium dynamics, we must eliminate the source of non-stationarity. One way of doing this is to assume a variable interest rate premium as in (39). To ensure that at business-cycle frequencies the model behaves as if the interest rate premium was constant, we will set the debt elasticity of the premium very close to zero.

We define a stationary rational expectations equilibrium as a set of stationary processes $\{v_t, p_t, c_t, i_t, m_t, h_t, \lambda_t, \mu_t^h, u_t, q_t^e, k_{t+1}, h^e_t, q^f_t, h^n_t, tb_t, b_t, a^n_t, a^n_t, q^n_t, p^n_t, \pi^n_t, \epsilon_t, r_t, \pi^n_t, \tau_t, y_t, \pi_t, mct\}_{t=0}^{\infty}$ satisfying (2)-(3), (6)-(11), (13)-(21), and (27)-(39), given exogenous processes $\{\pi^m_t, p^n_t, r_t, \eta_t\}_{t=0}^{\infty}$ and initial conditions $k_0, b_{-1}, \pi^m_0, r_{-1}$, and $p^n_{-1}$.

We characterized equilibrium dynamics by solving a calibrated, log-linear approximation to the equilibrium conditions around the non-stochastic steady state. The calibration exercise involves the use of long-run data and model restrictions so as to identify the deep structural parameters of the model. We turn next to this task.

### 2.4 Calibration

We calibrate the model to the Mexican economy. The log-linear approximation to the equilibrium conditions involves 16 free parameters, whose assigned values are presented in table 1 and 11 implied parameters, whose values are presented in table 2.

The time unit is chosen to be a quarter. Following Mendoza and Uribe (1999), we set the share of traded value added in GDP to 44.2%, the investment share in GDP to 21.7%, the trade balance share in GDP to 3.6%, the labor share in the traded sector to 21.6%, the labor share in the non-traded sector to 35.9% the real rate of return on foreign assets to 6.5% per year. We use the money demand estimates presented in Kamin and Rogers (1996) to set the log-log interest elasticity of money demand to -0.16. Annual GDP velocity was computed as the reciprocal of the average ratio of M1 to GDP.
over the period 1980:Q1 to 1999:Q2, which was found to be equal to 0.071. We assign a value of 24.0% to the share of exports to GDP, which corresponds to the Mexican average over the period 1993-1999. In calibrating the steady-state devaluation rate, we use the fact that over the period 1980:Q1 to 1999:Q2, the average annual devaluation rate of the Mexican peso vis-à-vis the U.S. dollar was 35%. The consumption elasticity of the marginal utility of consumption was set to -5 drawing on the empirical study of Reinhart and Végh (1995).

There is little empirical evidence on the degrees of price stickiness and imperfect competition in the Mexican economy. Thus, as a first pass, we set the average markup of price over marginal cost in the non-traded sector to 10%, which is consistent with estimates for the U.S. economy (e.g., Basu and Fernald, 1997). To calibrate the degree of price stickiness, we use Sbordone’s (1998) estimates of new-Keynesian Phillips curves like the one that arises from a log-linearization of our equilibrium condition (29), which takes the form

\[ E_t \hat{\pi}_{t+1} = \beta E_t \hat{\pi}_{t+2} - \frac{1}{\eta_0 \mu} (E_t \hat{p}_{t+1} - E_t \hat{m}_{t+1}), \]

where \( \eta_0 \) is a positive parameter increasing in \( \theta''(\pi^n) \). Using U.S. data, Sbordone finds that \( \eta_0 \mu \) equals 17.5, which, given our assumption that \( \mu = 0.1 \), implies that \( \eta_0 \) equals 175. As pointed out by Sbordone, in a Calvo-Yun staggered price setting model, this parameter value implies that firms change their price on average every 9 months. In the context of our model, this calibration of the degree of price stickiness implies that in response to a once-and-for-all devaluation of the Mexican peso, the adjustment of the Mexican CPI has a half life of approximately 6 months, and the index accomplishes 80% of its total adjustment after 12 months and 97% after 24 months (see also the row 5, column 3 of figure 1).

We set the elasticity of Tobin’s Q with respect to investment so as to match the relative volatility of investment to GDP observed in Mexico over the period 1993:Q1 to 1999:Q2, which was 4.5. To compute the relative volatility of investment to GDP predicted by the theoretical model, we use our estimates of the stochastic processes for the external shocks and Mexican monetary policy presented in section 3.

Finally, we assume that the debt elasticity of the interest rate premium is equal to 0.00001. As explained earlier, we pick such a small number as to ensure that at business-cycle frequencies the economy behaves as if the interest rate premium was constant.
3 Actual and predicted fluctuations

3.1 Basic equilibrium dynamics

As a way to gather some intuition about the basic workings of the model economy, figures 1 to 4, depict the model’s impulse responses to transitory and persistent devaluation, terms-of-trade, import-price-inflation, and world interest rate shocks, respectively. All shocks are assumed to follow exogenous univariate AR(1) processes with autoregressive coefficients of 0 (solid line) or 0.9 (dashed line).

Figure 1 displays the impulse responses to a unit innovation in the devaluation rate. Because the price level in the non-traded sector is sticky, the devaluation cause the real exchange rate to depreciate. The decline in the relative price of non-tradables induces an increase in the demand for this type of goods, which given the fact that non-traded output is demand-determined, raises production. This boom in the non-traded sector requires an increase in employment since labor is the only factor input. The elevated demand for labor pushes the wage rate up causing both an increase in total employment and a decline in hours in the traded sector. Because the capital stock is predetermined, the decline in employment in the traded sector is reflected in a diminished level of activity. A further consequence of the decline in the relative price of nontradables in terms of tradables is that domestic absorption of both importables and exportables falls.

To be added.

3.2 Sources of uncertainty in the Mexican economy

One important element in our evaluation of alternative monetary stabilization policies for Mexico is our maintained assumption about the sources of business-cycles in that economy. This is because our interest is to judge alternative monetary regimes on their ability to mitigate efficiencies that materialize only when the exonomy is pushed away from its deterministic steady-state path by fundamental shocks. In the context of our framework these inefficiencies are due to the presence of sticky prices and time varying transaction costs in final goods markets.

We consider three types of shock: terms of trade, the world interest rate, and import-price inflation. The first two kind of shocks have been extensively discussed in the empirical and theoretical literature on developing-country
macroeconomics and thus do not require much justification. With respect to nominal price shocks, in a world with nominal rigidities, such as the one described by the model presented in section 2, innovations in world inflation affect domestic real variables through two distinct channels: first, given the world nominal interest rate, they alter the real rate of return on foreign assets held by domestic residents. Second, given domestic non-traded goods prices and the terms of trade, changes in world nominal prices affect the real exchange rate.

We next attempt to determine econometrically the fraction of Mexican business cycle fluctuations that can be attributed to innovations in the terms-of-trade, the world interest rate, and import-price inflation. Specifically, we estimate the share of the k-quarter-ahead forecasting error in Mexican value added and the Mexican real exchange rate that can be explained by these three shocks.

Our data set consists of 78 quarterly observations beginning in the first quarter of 1980 and ending in the second quarter of 1999. We construct the terms of trade series from monthly observations on U.S. dollar export and import price indices for Mexico. The world nominal interest rate is approximated by quarterly averages of the constant maturity yield on 3-month U.S. Treasury bills. Import-price inflation is taken to be the geometric mean of the monthly change in the U.S. dollar import price index for Mexico. Mexican real output is measured by seasonally adjusted and linearly detrended gross domestic product at constant 1993 prices. The real exchange rate corresponds to the Peso/dollar real exchange rate, $e_t$, defined as $E_{peso/$P_{us}}/P_{mx}$, where $E_{peso/}$ denotes the peso price of one U.S. dollar, $P_{us}$ U.S. consumer price inflation, and $P_{mx}$ Mexican consumer price inflation. We associate this variable with $1/p_t$ in our theoretical model.\(^5\) Our empirical model consists of a vector auto regression in the logarithms of the terms of trade, $\tilde{P}_t^x$, gross import price inflation, $\tilde{\pi}_t^{mx}$, gross world nominal interest rates, $\tilde{r}_t^*$; the cyclical component of real gross domestic product, $\tilde{y}_t$, and the Peso/dollar real exchange rate, $\tilde{e}_t$.

The evolution of the external shocks is assumed to be exogenous to the Mexican economy. Moreover, we assume that innovations to import price

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\(^5\)The data source for the U.S. dollar export and import price indices for Mexico and Mexican GDP is INEGI; the Mexican peso-U.S. dollar exchange rate and the Mexican CPI were obtained from Banco de Mexico; the U.S. CPI was taken from the Bureau of Labor Statistics; and the 3-month Treasury bill from the Board of Governors of the Federal Reserve System.
inflation do not affect the terms of trade contemporaneously and that innovations to the 3-month Treasury bill rate have no contemporaneous effect on either Mexican terms of trade or Mexican import price inflation.\(^6\) These identification assumptions give rise to the following block recursive structure of the empirical model

\[
\begin{bmatrix}
 a_{11} & 0 & 0 \\
 a_{21} & a_{22}
\end{bmatrix}
\begin{bmatrix}
 \hat{p}_t^x \\
 \hat{\pi}^{m*}_t \\
 \hat{r}_t^* \\
 \hat{y}_t \\
 \hat{e}_t
\end{bmatrix}
= \begin{bmatrix}
 b_{11}(L) & 0 & 0 \\
 b_{21}(L) & b_{22}(L)
\end{bmatrix}
\begin{bmatrix}
 \hat{p}^{x}_{t-1} \\
 \hat{\pi}^{m*}_{t-1} \\
 \hat{r}^*_{t-1} \\
 \hat{y}_{t-1} \\
 \hat{e}_{t-1}
\end{bmatrix}
+ \begin{bmatrix}
 \epsilon^{p,x}_t \\
 \epsilon^{\pi,m*}_t \\
 \epsilon^{r,*}_t \\
 \epsilon^y_t \\
 \epsilon^e_t
\end{bmatrix}
\]

where \(a_{11}\) and \(a_{22}\) are lower triangular matrices whose diagonal elements are equal to 1. The disturbance vector \((\epsilon^{p,x}_t, \epsilon^{\pi,m*}_t, \epsilon^{r,*}_t, \epsilon^y_t, \epsilon^e_t)\) has mean zero and its variance/covariance matrix \(\Sigma\) is diagonal, so that its elements represent the true structural disturbances. Four lags were included in the vector autoregression.

A number of authors have pointed out that during the sample period considered in our regression analysis, the Mexican exchange rate regime changed at least three times, and the regime changes were typically associated with substantial macroeconomic volatility. For example, Del Negro and Obiols-Homs identify three regime shifts: The period 1982:Q4-1987:Q4 was characterized by a dual exchange rate regime with a pre-announced schedule for the official exchange rate. The period 1988:Q1-1994:Q4 corresponds to the exchange-rate stabilization program known as the Pacto de Solidaridad Económica. Finally, the collapse of the Pacto in December of 1994 was followed by a dirty float.

The stationary time series model we employ is not well equipped to handle these regime switches. To address the problem, we included three levels dummies in the equations describing the evolution of real GDP and the real exchange rate that correspond to the different monetary policy regimes identified by Del Negro and Obiols-Homs.

Table 3 shows the fraction of the k-quarter ahead forecasting variance of output and the real exchange rate that can be explained by the three external shocks and the two domestic shocks. At the 4-quarter horizon more

\(^6\)These latter two identification assumptions are somewhat arbitrary. One can show that our results regarding the fraction of output and real exchange rate volatility that is explained by external shocks is not affected by them.
than half of the forecasting error variance of output is due to terms of trade, import price inflation, or world interest rate shocks. For forecasting horizons of 2 years or higher at least 80 percent of the forecasting error variance is attributable to external shocks. A similar picture arises for the variance decomposition of the real exchange rate. At the 4-quarter horizon, 48% of the unforecastable variations in the real exchange rate are due to external factors and for horizons of 8 quarters or higher at least 75 percent are due to external shocks. We interpret these results as suggesting that the three external shocks we identified support the hypothesis that a large fraction of aggregate fluctuations at business-cycle frequencies in Mexico in the period 1980 to 1999 was driven by these external shocks.

Of the variance in forecastable errors explained by external shocks, the majority is attributable to terms-of-trade variations. At the 4 quarter horizon, terms of trade explain 52 percent of the forecasting error of Mexican output. This number rises to 70% and 67% at the 8 and 12 quarter horizons respectively. The terms of trade are equally important in explaining forecasting errors of the Mexican real exchange rate. At the 4-, 8-, and 12-quarter horizons, terms-of-trade account for, respectively, 46%, 70%, 70% of the variance of forecast errors. This results are somewhat dependent on our particular identification assumptions. However, irrespective of the order of the variables in the external block, the terms of trade always explain at least half of the variance of forecasting errors of Mexican output and real exchange rate explained by external shocks. We therefore conclude that terms of trade are the single most important external shock affecting the Mexican economy in the post-debt-crisis period.

The estimate of the external block in equation (40 forms the driving force of our theoretical model and is presented in table 4.

### 3.3 Mexican monetary policy

We estimate the exchange rate feedback rule, equation (21), using quarterly Mexican data for the period 1980:Q1 to 1999:Q2. We measure $\epsilon_t$ as the gross devaluation rate of the Mexican Peso against the U.S. dollar, $\pi_t$ as gross CPI inflation, and $y_t$ as described in subsection 3.2. The OLS estimate of the

---

7The data source for the devaluation and inflation rates is Banco de Mexico and for real GDP is INEGI.
monetary policy rule is:

\[
\hat{\epsilon}_t = 2.47 \hat{y}_{t-1} + 1.10 \hat{\pi}_t + \eta_t \quad \hat{R}^2 = 0.49 \quad \text{D.W.} = 1.75
\]

(41)

where the numbers in parenthesis denote estimated standard errors. Applying an instrumental variable technique to this equation using as instruments 1 to 4 lags of inflation and the devaluation rate and 2 to 4 lags of real GDP yields a similar estimate, suggesting that simultaneity may not be a serious problem.\(^8\) According to this estimate, over the last two decades, the Mexican exchange rate policy appears to be consistent with real exchange rate targeting as indicated by the fact that, given the state of the business cycle, changes in inflation were matched about one-for-one by changes in the devaluation rate. In addition, Mexico has followed the opposite of a beggar-thy-neighbor policy by letting the Peso appreciate in real terms during times of recession, and letting it depreciates during expansions. The fact that inflation enters contemporaneously while output enters with one lag seems in line with the fact that information on the former is more readily available than on the latter. Lagged values of \(\epsilon_t\) enter insignificantly on the right hand side of (21), which suggests that there was little devaluation rate smoothing over the sample period. Also, longer lags of \(\pi_t\) and \(y_{t-1}\) do not improve the fit of the feedback rule, indicating that the Banco de Mexico was not backward looking in conducting exchange rate policy. Finally, in estimating equation (21) we are ignoring the possibility of changes in the monetary policy regime within the sample period. However, as mentioned earlier, Mexico underwent significant exchange-rate regime changes since 1980. We find that regime dummies for the Debt Crisis, the Pacto years, and the free float post-pacto period add little explanatory power to our original estimate of the exchange-rate feedback rule, with the exception of the coefficient on inflation during the Pacto era, which drops from 1.10 to 0.76.

\(^8\)The IV estimate of equation (21) is

\[
\hat{\epsilon}_t = 2.73 \hat{y}_{t-1} + 1.27 \hat{\pi}_t + \eta_t \quad \hat{R}^2 = 0.46 \quad \text{D.W.} = 1.78
\]
3.4 Response of the Mexican and model economies to external shocks

To be added.

4 The welfare cost of dollarization

We are now ready to assess the welfare consequences of dollarization as compared to other possible monetary arrangements. We will conduct the welfare analysis using the theoretical model developed and calibrated in section 2. The sources of uncertainty driving business cycles are the three external shocks, terms of trade, import price inflation, and world interest rate, whose law of motion is estimated in subsection 3.2.

We measure the welfare costs of business cycles associated with a particular monetary policy regime by the fraction of non-stochastic steady-state consumption that households would be willing to give up in order to be indifferent between the corresponding constant sequences of consumption, hours, and non-traded inflation and the equilibrium stochastic processes for these three variables associated with the monetary policy under consideration. Formally, letting $c$, $h$, and $\pi^n$ denote the non-stochastic steady-state values of consumption, hours, and non-traded inflation and $\{c_t, h_t, \pi^n_t\}$ the equilibrium stochastic processes of consumption, hours, and non-traded inflation corresponding to a particular monetary policy, we measure the cost of business cycles under such policy by the number $\xi$ such that

$$U((1 - \xi)c, h) - \theta(\pi^n) = E[U(c_t, h_t) - \theta(\pi^n_t)]$$

where $E$ denotes the unconditional mathematical expectation. According to this expression, the business cycles associated with a particular monetary policy are costly if $\xi$ is positive and beneficial if $\xi$ is negative. Following Lucas (1987), we approximate $\xi$ by taking a second-order Taylor expansion of the above expression with respect to $(\ln c_t, \ln h_t, \ln \pi^n_t)$ around $(\ln c, \ln h, \ln \pi^n)$. In addition, we use the approximation $E \ln(y_t/y) = 0$ for $y_t = c_t, h_t, \pi^n_t$. Then defining $x_t = c_t^\nu (1 - h_t)^{1-\nu}$, $\xi$ is given by

$$\xi = 1 - [1 + a_1 \text{Var}(\hat{x}_t) + a_2 \text{Var}(\hat{\pi}^n)]^a$$

where a hat on a variable denotes its log deviation from the non-stochastic steady state and $\text{Var}(\hat{x}_t)$ and $\text{Var}(\hat{\pi}^n_t)$ denote the unconditional variances of
\( \hat{x}_t \) and \( \hat{\pi}_t^n \), respectively. Also,

\[
a_1 = \frac{(1 - \sigma)^2}{2} > 0
\]
\[
a_2 = \frac{(1 - \sigma)\eta \nu s_n(1 + s(v))}{2s_c(1 + s(v) + vs'(v))} > 0
\]
\[
a_3 = \frac{1}{\nu(1 - \sigma)} < 0
\]

Clearly, welfare costs are increasing in the unconditional variances of \( \hat{x}_t \) and \( \hat{\pi}_t^n \).

Table 5 presents the welfare costs associated with 8 alternative monetary policies. The welfare costs are comparable across policies because all policies are specified in such a way that they give rise to the same non-stochastic steady state. The policies considered are special cases of the ones described in subsection 2.2. The Taylor rules presented in the first two lines of the table deserve further explanation. The lag length of the explanatory variables included on the right-hand sides of the Taylor rules were chosen arbitrarily. The coefficients of Taylor rules, with and without smoothing, were chosen so as to minimize the welfare costs of business cycles. Thus, the resulting rules should be interpreted as constrained optimal interest-rate feedback rules.

Three main results arise from the horse race presented in table 5. First, dollarization is welfare inferior to any of the alternative non-estimated policies considered. Households are willing to give up more than 2% of their non-stochastic steady-state consumption to see a policy other than dollarization implemented. The intuition behind this result is simple. Consider the effect of a positive terms-of-trade shock—the most important source of aggregate uncertainty in our model—under each of the non-estimated policies. The responses are plotted in figure 5, with the case of dollarization shown with dashed lines. Under dollarization, given factor prices, producers of exportables will increase output and demand more labor. At the same time, the rise in the price of exportables in combination with the fixed exchange rate and the fact that the nominal price of nontradables is pre-determined implies that non-tradables and importables become cheaper relative to exportables. Consequently, the demand for non-tradables and importables increases. Because non-traded output is demand determined, production of this kind of goods increases. The expansion in the exportable and non-traded sectors drives the demand for labor and thus wages up. Here it is important to
note that the increase in production of non-tradables is larger than the one that would take place if the nominal price of non-tradables was flexible and could increase as wages rise. In short, the presence of a nominal rigidity amplifies the expansion in employment in the non-traded sector and dampens the boom in exportables vis-á-vis the response of an economy with flexible prices. If instead of keeping the nominal exchange rate constant the monetary authority would implement a nominal appreciation of the peso, then the increase in the relative price of exportables in terms of non-tradables induced by the terms-of-trade shock would be offset without altering the relative price of exportables in terms of importables. As a result, the real allocation would be closer to the one that would obtain in the absence of sluggish price adjustment. As can be seen in the last column of figure 5 all non-estimated policies other than dollarization feature an initial nominal appreciation of the peso in response to a positive terms-of-trade shock.

The second main result of table 5 is that the estimated Mexican monetary policy produces incredibly large welfare losses. The technical reason for this surprising result is that the estimated exchange-rate rule places the model economy very close to a bifurcation point at which a unique rational expectations equilibrium ceases to exist. The vicinity of such critical areas of the parameter space are typically associated with large fluctuation in endogenous variables in response to small perturbations in the underlying shocks.

It is noteworthy that the deleterious effects of the estimated monetary policy stem not from its random component, but rather from its systematic one. Comparing the last two rows of table 5 reveals that around 94 of the 97.7 percentage points of welfare costs of business cycles are attributable to the systematic component of the estimated monetary policy. It follows that this policy is destabilizing mostly because it amplifies the cycles generated by the external fundamental shocks. Therefore, empirical studies that evaluate the desirability of monetary policy on the basis of the relative magnitude of unforecastable monetary shocks may spuriously lead one to conclude that the conduct of Mexican monetary affairs was not as bad as to warrant its demise.

One interpretation of these large welfare costs is that actual Mexican policy in the past two decades has been extremely harmful. Under this interpretation, it is not difficult to explain the recent growing support for the replacement of the local currency in favor of a more stable one such as the U.S. dollar. However, jumping to such conclusion would be clearly misleading. For it is based on two important premises neither of which has been
rigorously tested in the present study: first, that the model provides an adequate account of Mexican business cycles; and second, that the specification of the monetary policy rule estimated in subsection 3.3 does indeed reflect the monetary conduct of the Mexican central bank over the past twenty years.

Third, the best of the monetary policy specifications considered is a Taylor rule with a significant smoothing coefficient, a large inflation coefficient, and a small coefficient on the output gap. This result is in line with the recent theoretical and empirical literature on Taylor rules that has focused on industrialized economies using closed-economy model specifications. Sack (1999), for example, estimates that in the United States, during the Greenspan era, the smoothing parameter was 0.65 and the inflation coefficient was 1.52. Sack also finds a value of 1.16 for the output coefficient, which is much larger than the one associated with the constrained optimal rule shown in the first row of table 5. However, theoretical welfare-based evaluations of U.S. monetary policy are still more in accord with our results, for they show that in addition to significant smoothing and inflation coefficients, the optimal rule also features a small output coefficient (e.g., Rotemberg and Woodford, 1997).

5 Conclusion

To be added.
References


Del Negro, M. and F. Obiols-Homs, “Has Monetary Policy been So Bad That It Is Better To Get Rid of It? The Case of Mexico,” mimeo, ITAM, Mexico City, September 1999.


### Table 1: Calibrated parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$s_x$</td>
<td>$\frac{p^x q^x}{GDP}$</td>
<td>0.442</td>
<td>share of traded value added in GDP</td>
</tr>
<tr>
<td>$s_{tb}$</td>
<td>$\frac{p^x (q^x - a^m)}{GDP}$</td>
<td>0.036</td>
<td>trade balance to GDP ratio</td>
</tr>
<tr>
<td>$s_{xx}$</td>
<td>$\frac{p^x (q^x - a^m)}{GDP}$</td>
<td>0.240</td>
<td>export share in value added</td>
</tr>
<tr>
<td>$\frac{r}{\pi_m}$</td>
<td></td>
<td>1.065</td>
<td>gross annual world real interest rate</td>
</tr>
<tr>
<td>$\epsilon$</td>
<td></td>
<td>1.35</td>
<td>gross annual devaluation rate</td>
</tr>
<tr>
<td>$s_{hx}$</td>
<td>$\frac{wh^x}{p^x q^x}$</td>
<td>0.261</td>
<td>labor share in exportable sector</td>
</tr>
<tr>
<td>$s_{hn}$</td>
<td>$\frac{wh^n}{p^n q^n}$</td>
<td>0.359</td>
<td>labor share in nontraded sector</td>
</tr>
<tr>
<td>$\eta_{mi}$</td>
<td>$\frac{\partial \ln m}{\partial \ln i}$</td>
<td>-0.16</td>
<td>log-log interest elasticity of money demand</td>
</tr>
<tr>
<td>$s_i$</td>
<td>$\frac{(1+s_i)(1+\frac{e}{m})}{\ln s_i}$</td>
<td>0.217</td>
<td>investment share in GDP</td>
</tr>
<tr>
<td>$\eta_{\phi}$</td>
<td>$\frac{\phi'(0)\delta}{\delta(\phi)}$</td>
<td>-2.5</td>
<td>elasticity of Tobin’s Q w.r.t. investment</td>
</tr>
<tr>
<td>$\mu$</td>
<td>$\frac{p^n - mc}{mc}$</td>
<td>0.1</td>
<td>markup of prices over marginal cost in the nontraded sector</td>
</tr>
<tr>
<td>$\eta_{\theta}$</td>
<td>$\frac{\theta''(0)q^n}{\lambda p^n q^n}$</td>
<td>175</td>
<td>markup coefficient in new-Keynesian Phillips curve</td>
</tr>
<tr>
<td>$\nu_{GDP}$</td>
<td>$\frac{P \cdot GDP}{M_1}$</td>
<td>14.12</td>
<td>annual money velocity</td>
</tr>
<tr>
<td>$\frac{1}{1-h}$</td>
<td></td>
<td>0.2</td>
<td>steady state labor-to-leisure ratio</td>
</tr>
<tr>
<td>$\eta_{cc}$</td>
<td>$\frac{U_{CC}}{U_C}$</td>
<td>-5</td>
<td>elasticity of marginal utility of consumption with respect to consumption</td>
</tr>
<tr>
<td>$\eta_{\rho}$</td>
<td>$\frac{\partial \ln \rho}{\partial \ln (-\rho)}$</td>
<td>$10^{-5}$</td>
<td>Debt elasticity of country interest rate premium</td>
</tr>
</tbody>
</table>

Note. $GDP = p^x q^x + p^n q^n$ denotes gross domestic product measured in units of the import good.
Table 2: Implied parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Restriction</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>$\pi^m/r$</td>
<td>$1 - s_x$</td>
<td>0.9844</td>
<td>steady-state discount factor</td>
</tr>
<tr>
<td>$s_n$</td>
<td>$\frac{p^n q^n}{GDP}$</td>
<td>$1 - s_x$</td>
<td>0.558</td>
<td>share of nontraded value added in GDP</td>
</tr>
<tr>
<td>$s_{hx}$</td>
<td>$\frac{uk}{p^x q^x}$</td>
<td>$1 - s_{hx}$</td>
<td>0.739</td>
<td>capital share in the traded sector</td>
</tr>
<tr>
<td>$s_h$</td>
<td>$\frac{wh^x + wh^n}{GDP}$</td>
<td>$s_{hx} s_x + s_{hn} s_n$</td>
<td>0.316</td>
<td>labor share in GDP</td>
</tr>
<tr>
<td>$s_c$</td>
<td>$\frac{(1+s(v))pc}{GDP}$</td>
<td>$1 - s_i - s_{tb}$</td>
<td>0.747</td>
<td>consumption-to-GDP ratio</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>$s(v) \equiv A v^\gamma$</td>
<td>$-\frac{1+\eta_{mi}}{\eta_{mi}}$</td>
<td>5.25</td>
<td>velocity elasticity of transaction cost</td>
</tr>
<tr>
<td>$\nu$</td>
<td>$\frac{p(c+1)}{m}$</td>
<td>$(1 - s_{tb}) v_{GDP} - \frac{rx - 1}{r \epsilon}$</td>
<td>3.39</td>
<td>steady-state absorption velocity of money</td>
</tr>
<tr>
<td>$A$</td>
<td>$s(v) = A v^\gamma$</td>
<td>$\frac{(rx-1) \eta_{mi}}{(r_{\gamma} v^{m-1}) s_i}$</td>
<td>$8.01 \times 10^{-6}$</td>
<td>Scale factor in transaction cost function</td>
</tr>
<tr>
<td>$\delta$</td>
<td>$\frac{1}{\nu}$</td>
<td>$\frac{\eta_{mi}}{s_{i}(1+s(v)) + s_{hn}(1+s(v))}$</td>
<td>0.109</td>
<td>annual capital depreciation rate</td>
</tr>
<tr>
<td>$\nu$</td>
<td>$1 + \frac{s_{t}}{\frac{\pi^m}{\nu^\gamma}} \frac{\eta_{ni}}{s_{i}(1+s(v)) + s_{hn}(1+s(v))}$</td>
<td></td>
<td>0.327</td>
<td>Preference parameter</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>$\frac{\eta_{mi}}{s_{i}(1+s(v)) + s_{hn}(1+s(v))}$</td>
<td>$1 - \frac{\eta_{mi}}{\nu}$</td>
<td>13.24</td>
<td>Preference parameter</td>
</tr>
</tbody>
</table>

Note. The period utility function is assumed to take the form

$U(c, h) = \frac{(c^{\nu}(1-h)^{1-\nu})^{1-\sigma}}{1-\sigma}$ with $\nu \in (0, 1)$ and $\sigma > 0$. 

Figure 1: Model’s response to a devaluation shock

Note: The serial correlation of the temporary shock is 0 and that of the persistent shock is 0.9.
Figure 2: Model’s response to a terms-of-trade shock

Note: The serial correlation of the temporary shock is 0 and that of the persistent shock is 0.9.
Figure 3: Model’s response to a import-price-inflation shock

Note: The serial correlation of the temporary shock is 0 and that of the persistent shock is 0.9.
Figure 4: Model’s response to a world-interest-rate shock

- - - Temporary shock    - - - - - - Persistent shock

Note: The serial correlation of the temporary shock is 0 and that of the persistent shock is 0.9.
Table 3: Variance Decomposition of Output and the Real Exchange Rate  
Sample: 1980:Q1 to 1999:Q2

<table>
<thead>
<tr>
<th>k</th>
<th>Output external shocks</th>
<th>Output domestic shocks</th>
<th>Real Exchange Rate external shocks</th>
<th>Real Exchange Rate domestic shocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>30</td>
<td>70</td>
<td>21</td>
<td>79</td>
</tr>
<tr>
<td>4</td>
<td>59</td>
<td>41</td>
<td>48</td>
<td>52</td>
</tr>
<tr>
<td>8</td>
<td>80</td>
<td>20</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>12</td>
<td>84</td>
<td>16</td>
<td>77</td>
<td>23</td>
</tr>
<tr>
<td>16</td>
<td>85</td>
<td>15</td>
<td>78</td>
<td>22</td>
</tr>
</tbody>
</table>
Table 4: The stochastic process for the external shocks
Quarterly data from 1980:Q1 to 1999:Q2

<table>
<thead>
<tr>
<th></th>
<th>( \hat{p}_t )</th>
<th>( \hat{\pi}_t^{\text{ms}} )</th>
<th>( \hat{r}_t^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \hat{p}_{t-1} )</td>
<td>1.048193</td>
<td>0.111002</td>
<td>0.013858</td>
</tr>
<tr>
<td>( \hat{p}_{t-2} )</td>
<td>-0.482816</td>
<td>-0.171055</td>
<td>-0.005895</td>
</tr>
<tr>
<td>( \hat{p}_{t-3} )</td>
<td>0.387332</td>
<td>0.099996</td>
<td>0.006921</td>
</tr>
<tr>
<td>( \hat{p}_{t-4} )</td>
<td>-0.097367</td>
<td>-0.043291</td>
<td>0.002934</td>
</tr>
<tr>
<td>( \hat{\pi}<em>t^{\text{ms}}</em>{t-1} )</td>
<td>0.067074</td>
<td>0.419208</td>
<td>0.051840</td>
</tr>
<tr>
<td>( \hat{\pi}<em>t^{\text{ms}}</em>{t-2} )</td>
<td>0.503838</td>
<td>0.071212</td>
<td>0.075766</td>
</tr>
<tr>
<td>( \hat{\pi}<em>t^{\text{ms}}</em>{t-3} )</td>
<td>-0.050068</td>
<td>0.025736</td>
<td>-0.022990</td>
</tr>
<tr>
<td>( \hat{\pi}<em>t^{\text{ms}}</em>{t-4} )</td>
<td>-0.163471</td>
<td>0.139571</td>
<td>0.070555</td>
</tr>
<tr>
<td>( \hat{r}<em>t^*</em>{t-1} )</td>
<td>0.006832</td>
<td>-0.569715</td>
<td>0.873182</td>
</tr>
<tr>
<td>( \hat{r}<em>t^*</em>{t-2} )</td>
<td>-0.220434</td>
<td>0.224171</td>
<td>-0.331984</td>
</tr>
<tr>
<td>( \hat{r}<em>t^*</em>{t-3} )</td>
<td>0.833303</td>
<td>-0.393634</td>
<td>0.338177</td>
</tr>
<tr>
<td>( \hat{r}<em>t^*</em>{t-4} )</td>
<td>0.085162</td>
<td>0.190836</td>
<td>-0.142850</td>
</tr>
<tr>
<td>( \epsilon_t^{p_x} )</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>( \epsilon_t^{\pi^{\text{ms}}} )</td>
<td>0.154496</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>( \epsilon_t^{r^*} )</td>
<td>0.024161</td>
<td>0.026124</td>
<td>1</td>
</tr>
<tr>
<td>( \bar{R}^2 )</td>
<td>0.94</td>
<td>0.38</td>
<td>0.94</td>
</tr>
<tr>
<td>D.W.</td>
<td>1.90</td>
<td>1.90</td>
<td>1.73</td>
</tr>
<tr>
<td>Nobs.</td>
<td>74</td>
<td>74</td>
<td>74</td>
</tr>
</tbody>
</table>

Note. Bold face indicates that the coefficient estimate is significant at the 10 percent level. \( \hat{p}_t \) denotes the logarithm of the terms of trade, \( \hat{\pi}_t^{\text{ms}} \) denotes quarterly changes in the logarithm of dollar import prices, and \( \hat{r}_t^* \) denotes the logarithm of the gross yield on 3-month U.S. Treasury bills. The standard deviations of \( \epsilon_t^{p_x} \), \( \epsilon_t^{\pi^{\text{ms}}} \), and \( \epsilon_t^{r^*} \) are, respectively, 0.048951, 0.021862, and 0.005810.
Table 5: The welfare costs of Mexican business cycles under alternative monetary policy regimes

(Measured as percentage points of non-stochastic steady-state consumption)

<table>
<thead>
<tr>
<th>Monetary Policy</th>
<th>Specification</th>
<th>Welfare cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taylor rule with smoothing</td>
<td>( \hat{i}_t^d = 0.005\hat{y}_t + 1.53\hat{\pi}<em>t + 0.95\hat{i}</em>{t-1} )</td>
<td>8.29</td>
</tr>
<tr>
<td>Taylor rule</td>
<td>( \hat{i}_t^d = 0.03\hat{y}_t + 9.46\hat{\pi}_t )</td>
<td>8.35</td>
</tr>
<tr>
<td>Inflation targeting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPI inflation</td>
<td>( \hat{\pi}_t = 0 )</td>
<td>8.38</td>
</tr>
<tr>
<td>Non-traded inflation</td>
<td>( \hat{\pi}_t^n = 0 )</td>
<td>8.47</td>
</tr>
<tr>
<td>Constant money growth rate</td>
<td>( M_t = (1 + \zeta)M_{t-1} )</td>
<td>8.61</td>
</tr>
<tr>
<td>Dollarization</td>
<td>( \hat{\epsilon}_t = 0 )</td>
<td>10.52</td>
</tr>
<tr>
<td>Estimated Mexican exchange rate policy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systematic component only</td>
<td>( \hat{\epsilon}<em>t = 2.47\hat{y}</em>{t-1} + 1.10\hat{\pi}_t )</td>
<td>93.88</td>
</tr>
<tr>
<td>Actual policy</td>
<td>( \hat{\epsilon}<em>t = 2.47\hat{y}</em>{t-1} + 1.10\hat{\pi}_t + \eta'_t )</td>
<td>97.75</td>
</tr>
</tbody>
</table>
Figure 5: Model’s response to a persistent terms-of-trade shock

- - - : Taylor rule with smoothing
- - - : Dollarization

- : Taylor rule
- - - : Dollarization

- : Targeting CPI inflation
- - - : Dollarization

- : Targeting non-traded inflation
- - - : Dollarization

- : Constant money growth rate
- - - : Dollarization

- : Estimated Mexican exchange rate policy
- - - : Dollarization