Fiscal Policy and Inflation: Understanding the Role of Expectations in Mexico

Bernabe López Martín
Alberto Ramirez de Aguilar
Daniel Sámano

Abstract

We estimate a hidden Markov model where inflation is determined by government deficits financed through money creation and/or by destabilizing expectations dynamics (expectations can potentially divorce inflation from fundamentals). The baseline model, proposed by Sargent et al. (2009), is used to analyze the interaction between fiscal deficits, inflation expectations, and inflation in Mexico. The model is able to distinguish between causes and remedies of hyperinflation, such as persistent or transitory shocks to seigniorage-financed fiscal deficits, de-anchoring of inflation expectations from fiscal fundamentals, and cosmetic (non-fundamental) monetary reforms. The behavior of monetized deficits provides an adequate account of high inflation episodes and stabilizations for the period 1969-1994. We then extend

This research was developed within the framework of CEMLA’s Joint Research Program 2017 coordinated by the Central Bank of Colombia. We thank counselling and technical advisory provided by the Financial Stability and Development (FSD) Group of the Inter-American Development Bank in the process of writing this document. We are especially grateful to Daniel Chiquiar and our academic advisor Andrea Tambalotti, for their feedback during this project. We would like to thank, for thoughtful comments and suggestions, Nicolás Amoroso, Oscar Budar Mejía, Julio Carrillo, Alfonso Cebreros, Gerardo Hernández del Valle, Juan Ramón Hernández, Raul Ibarra, Emiliano Luttini, André Martínez-Fritscher, Felipe Meza, Alberto Ortiz-Bolaños, Fernando Pérez-Cervantes, Manuel Ramos-Francia, Juan Sherwell, our discussant Christian Velásquez, and the participants of the CEMLA Research Network and the XXII Annual Meeting of the Central Bank Research Network (Bogota, 2017). The opinions expressed in this publication are those of the authors and do not reflect the views of CEMLA, the FSD Group, the Inter-American Development Bank, or those of Banco de México. E-mails: bernabe.lopez@banxico.org.mx, aramirezd@banxico.org.mx, and dsamano@banxico.org.mx.
the model to analyze the possibility that fiscal policy can affect inflation expectations in a context of Central Bank independence, as is the case of Mexico after 1994. We find evidence that the exchange rate and sovereign interest rate spreads influence the evolution of aggregate prices.

Keywords: inflation, inflation expectations, fiscal policy.

1. INTRODUCTION

As in other countries in Latin America during the second half of the twentieth century, Mexico suffered several episodes of annual inflation rates above one hundred percent. These high inflation episodes were typically accompanied by elevated levels of public deficit financed with monetary expansions.¹ Until 1994, a regime of fiscal dominance prevailed, where the Central Bank adjusted its monetary policy to the financial requirements of the fiscal authority. Thereafter, the autonomy of Banco de México was established and inflation started a process of moderation.

To analyze the interaction between inflation, inflation expectations, and fiscal deficits in Mexico, we utilize the model developed by Sargent et al. (2009). This model has been used to infer the determinants of hyperinflations and stabilizations in different countries in Latin America (Argentina, Bolivia, Brazil, Chile, and Peru). It gives a central role to government deficits financed through money creation, but also to destabilizing expectations that can, under certain conditions, divorce inflation from fundamentals. The baseline framework consists of a non-linear hidden Markov model with the following key components: (i) a standard demand function for real balances, an adaptive scheme for the expected rate of inflation,² (iii) a government budget constraint that relates fiscal deficits to monetary

¹ Fischer et al. (2002), Catao and Terrones (2005), and Lin and Chu (2013), among others, document international evidence regarding the relationship between inflation rates, fiscal deficits, and money supply. Rogers and Wang (1994) estimate that between 1977 and 1990, fiscal and monetary shocks accounted for 60 percent of the variance of inflation in Mexico.

² Agents have adaptive expectations or backward-looking expectations when these are formed by extrapolating past values of the variable being predicted.
supply, and (iv) a stochastic fiscal deficit that follows a hidden Markov process. With these components, the model is able to distinguish between the causes and remedies of hyperinflations, such as persistent or transitory shocks to seigniorage-financed fiscal deficits, de-anchoring of inflation expectations from fiscal fundamentals, and cosmetic (non-fundamental) monetary reforms. Sargent et al. (2009) conclude that the behavior of monetized deficits determined most hyperinflations and stabilizations for the set of countries they studied.

We first use the baseline model to account for the evolution of inflation in Mexico between 1969 and 2016. The methodology uses a series for inflation, interpreting the density of the inflation series as a likelihood function in order to estimate the history of fiscal deficits and the process of the formation of inflation expectations that better account for the evolution of inflation. This approach is convenient given numerous methodological modifications in the construction of public accounts, the sometimes less-than-ideal transparency in historical series, and the fluctuations in the perception of economic agents of what constitutes fiscal responsibility for the government (e.g., bailouts of the financial system or sub-national governments). These problems plague historical accounts of events in developing economies. The estimated sequence of fiscal deficits is then compared to available data for government deficits and a historic narrative of the events associated with episodes of high inflation and stabilizations. In line with the results for other countries, the model suggests that the evolution of fiscal deficits is central in explaining the behavior of inflation in Mexico. Furthermore, it provides a description of the formation of inflation expectations. For example, the parameters of the model suggest that inflation must be high for several consecutive periods in order to de-anchor inflation expectations and generate an inflation spiral.

For the period of decreasing inflation that started in the second half of the 1990s, the baseline model suggests that the level of fiscal deficits financed through monetary expansion is modest. This interpretation, however, is not fully satisfactory as the Central Bank became independent in 1994. Thus, a theory that contemporaneously links inflation to fiscal deficits through the monetary channel seems lacking if we aim to understand inflation after 1994. This motivates the following question; can we find evidence that fiscal policy affects
inflation and inflation expectations even in the context of Central Bank independence? A strand of the macroeconomic literature proposes that fiscal policy is relevant to achieving price stability even in an environment where monetary policy is conducted by an independent Central Bank.\footnote{There exists a vast literature studying the relevance of fiscal policy and its interaction with monetary policy for the determination of inflation, a seminal paper is Sargent and Wallace (1981). Though we will not attempt to provide an exhaustive set of references, some additional examples are provided by Sims (2016), Leeper (1991), Davig \textit{et al.} (2011), Sargent and Zeira (2011), Woodford (2001), and Bianchi and Ilut (2017). For an introductory treatment of the fiscal theory of the price level, see Christiano and Fitzgerald (2000). Central Banks frequently express concern related to how fiscal imbalances may affect the effectiveness of monetary policy (e.g., Carstens and Jácome (2005) and Ramos-Francia and Torres-Garcia (2005)).} We extend the baseline model along several dimensions with the objective of documenting evidence, perhaps indirect, or rebutting the possibility that fiscal policy is relevant in determining inflation and inflation expectations in a context of Central Bank independence. A variable of interest we consider is the spread in the sovereign interest rate EMBI. This variable, which can be considered forward-looking, reflects the fiscal situation of the government. To the extent that economic agents perceive potential risks in terms of the ability of the government to make debt payments, it may also affect the credibility of the Central Bank. The perception of this type of risk is incorporated in the prices of sovereign debt. The state of public finances is often considered to affect the exchange rate; this is the second variable we assess in the model. The results indicate that both variables are relevant in determining inflation expectations and inflation.\footnote{There are different mechanisms through which these variables could potentially be relevant; we explore the impact through expectations and the demand for real money balances. We discuss the evidence of the extent to which these variables are influenced by international and exogenous factors, with a focus on the case of Mexico, such as prices of commodities in global markets.}

We proceed as follows: Section 2 presents the baseline model and describes the mechanisms that drive the behavior of the different variables. Section 3 presents the main results for the baseline model: (1) the parameter values of the model and their implications in terms
of the behavior of the main variables, (2) a comparison of the inflation series generated by the model and those observed in the data, with a historical account of the events associated with the different inflation and stabilization episodes, and (3) a comparison of the series for fiscal deficits generated by the model with the historical series. Section 4 presents the extensions of the model and the main results. Section 5 provides our concluding remarks.

2. THE BASELINE MODEL

The baseline model is the one featured in Sargent et al. (2009), constructed to study the relationship between inflation, fiscal deficits, and inflation expectations. An advantage of this model is its simple structure, which allows for the estimation of its parameters using only the historic series of one of the main variables, in our case the monthly inflation series (the estimation algorithm is described briefly in the next section and in the Appendix). With these parameters, the model accounts for an observed sequence of inflation as a result of fiscal deficits and a particular process for the formation of inflation expectations. The framework consists of three main components: a money demand function, the budget constraint of the government, a process that models the formation of expectations, and the (exogenous and stochastic) evolution of deficits. We now describe each of these components.

2.1 The Money Demand and the Government Budget Constraint

A standard money demand equation (e.g. Cagan (1956)) establishes a relationship between the nominal balances as a percentage of output Mt at time t, the price level Pt at time t, and the expectations of agents of the price level $P_{t+1}^e$ for period $t+1$: 5

$$\frac{M_t}{P_t} = \frac{1}{\gamma} \frac{\lambda}{\gamma} \frac{P_{t+1}^e}{P_t},$$

5 In a seminal paper, Cagan (1956) specifies a demand for real balances and backward-looking expectations to explain several European hyper-inflation episodes.
where $\lambda \in (0,1)$ represents the weight that the expected price level $P_{t+1}^e$ has on the current price level $P_t$, and $\gamma > 0$ is the weight that the nominal balances relative to output have on the price level at time $t$. Thus, if the public expects a higher price level in $t+1$, their real balances demand $M_t/P_t$ will fall.

The next equation represents the budget constraint of the government, where $d_t$ (a stochastic variable) is the part of the real deficit of the government that is monetized (net of debt emissions, so it must be covered by printing money). Thus, the growth of nominal balances per unit of output is determined according to the following equation:

\[ M_t = \theta M_{t-1} + d_t P_t, \]

where parameter $\theta \in (0,1)$ adjusts for growth in real output and taxes on cash balances. This equation implies that larger fiscal deficits are associated with increases in the level of nominal balances as a percentage of GDP.

We let $\beta_t = P_{t+1}^e/P_t$ denote the gross expected inflation rate. Using (1) and (2) it can be shown that the gross inflation rate at time $t$ is:

---

6 Equation (1) can be written as $P_t = \gamma M_t + \lambda P_{t+1}^e$. Hence, $\{\lambda, \gamma\}$ represent the weights that $P_{t+1}^e$ and $M_t$ have on $P_t$, respectively.

7 Parameter $\theta$ is related to output growth in the model. Let $\dot{M}_t = \frac{\dot{M}_t}{Y_t}$ where $\dot{M}_t$ are the nominal balances at time $t$ and $Y_t$ is output. If $D_t$ represents the level of real fiscal deficit at time $t$, then the government budget constraint is $\dot{M}_t = \dot{M}_{t-1} + P_t D_t$. Dividing this equation by $Y_t$ then: $\dot{M}_t = \frac{Y_{t-1}}{Y_t} M_{t-1} + P_t d_t$. Therefore, $\theta$ can be interpreted as the inverse of the output growth factor. Consequently, this model is assuming a constant output growth rate. Quantitatively, this parameter is not relevant for our results.

8 We are defining the fiscal deficit as $d_t = g_t - \tau_t + (1 + r_t) b_t - b_{t+1}$, where $g_t$ and $\tau_t$ represent government expenditures and revenues relative to output, $b_t$ is the level of sovereign debt relative to output and $r_t$ is the interest rate on sovereign debt.
This equation suggests that inflation is a function of two variables: the expected gross inflation rate and the real fiscal deficit. According to (3), if the expected gross inflation rate $\beta_t$ or fiscal deficit $d_t$ rise, current inflation $\pi_t$ will also increase. It is worth mentioning that, equation (3) does not depend on the particular process through which inflation expectations are formed, or the stochastic process assumed for fiscal deficits. Nevertheless, these assumptions are crucial to determine a sequence of inflation rates $\{\pi_t, \pi_{t+1},\ldots\}$ according to the model. The next two sections will explain the specification for the evolution of expectations and the dynamics followed by the real fiscal deficit.

### 2.2 Inflation Expectations

The baseline specification follows, for example, Marcet and Nicolini (2003), assuming that the public updates their beliefs on future inflation $\beta_t$ using adaptive expectations. According to Sargent and Wallace (1973), agents have adaptive expectations when they take into account past information to extrapolate it to form their expectations. Specifically in this model, the gross expected inflation rate is a weighted average between the gross inflation rate and the gross expected inflation lagged one period:

$$\beta_{t+1} = (1 - \nu) \beta_t + \nu \pi_t,$$

where $0 < \nu < 1$ is the weight that expectations give to past observed inflation. In related literature, this particular type of adaptive expectations is known as constant-gain expectations, given the constant weight in the process that determines the formation of expectations.\(^9\)

---

\(^9\) This is obtained with $\lambda \in (0,1)$, $\theta \in (0,1)$, and $\gamma > 0$.

\(^{10}\) For example, Branch (2004) develops a micro-founded model where agents optimally choose not to update their beliefs according to a rational expectations algorithm because the information it requires is too costly (rational expectations algorithms usually require a lot of information). In the type of models we are considering, adaptive
Assuming constant-gain expectations (cge) is key in determining the dynamics of the model. Panel (a) of Figure 1 shows the change in gross inflation $\pi_{t+1} - \pi_t$, as a function of expectations $\beta_t$, with a constant real fiscal deficit. As shown in the Figure, there are two values of $\beta$ that imply a constant inflation equilibrium: $\beta_1$ and $\beta_2$. In the adaptive expectations literature, $\beta_1$ and $\beta_2$ are known as self-confirming equilibria. As implied by the Figure, $\beta_1$ is a locally stable equilibrium, thus, if the beliefs of the public regarding future inflation are not sufficiently high then $\pi_{t+1} - \pi_t$ will converge to zero and $\beta_{t+1}$ to $\beta_1$. Additionally, equation (4) implies that $\pi_t$ will also converge to $\beta_1$. However, if $\beta_t > \beta_2$, then $\pi_{t+1} - \pi_t$ will increase, with unbounded dynamics. Therefore, $\beta_t > \beta_2$ implies that the model will eventually generate a hyperinflation episode. This phenomenon is called escape dynamics by Sargent et al. (2009).

Panel (b) of Figure 1 presents another result of cge: assuming $\beta_t$ induces escape dynamics, a hyperinflation episode can be prevented if the deficit is reduced. This Panel shows two dynamic paths for $\pi_{t+1} - \pi_t$ as a function of $\beta_t$. The only difference between these paths is the level of fiscal deficit. The dynamics shown in blue correspond to a high fiscal deficit, while the dynamics in green correspond to a low fiscal deficit. Assuming a high deficit and $\beta_t = \bar{\beta}$, if the deficit is not reduced then it will provoke an escape dynamics of inflation and expectations as shown with blue arrows in Panel (b) of Figure 1. However, if the government reduces its fiscal deficit to a sufficiently low level then, even when $\beta_t = \bar{\beta}$, it will be able to prevent an escape dynamics. Furthermore, $\pi_{t+1} - \pi_t$ will converge to a low and stable inflation equilibrium as shown by the green arrows in the Figure.

Finally, cge implies a non-trivial computational advantage; given the complexity of the function that will be used to estimate all the parameters involved in the model, assuming this type of expectations

---

expectations or other deviations from rational expectations, can be necessary to generate hyperinflation episodes (e.g. Sallum et al. (2005)). See Sargent et al. (2009) for a list of references in a growing literature using calibration or econometric techniques to compare time-series data with models in which agents use this type of algorithm to form their beliefs.

---

11 Williams (2016) characterizes how adaptive expectations can lead to escape dynamics and explains how the likelihood, frequency and direction of the variables during an escape dynamics can be characterized by a deterministic control problem.
Figure 1

DYNAMICS INDUCED BY ADAPTIVE EXPECTATIONS

A. INFLATION AND EXPECTATIONS

B. FISCAL DEFICIT AND EXPECTATIONS

Note: these figures considers $\beta_{t-1} = 1.02$ and the estimated parameters shown in Table 1.
allows us to reduce the computational burden.\textsuperscript{12} We discuss the implications of using rational expectations in the Appendix.

2.3 The Process for Fiscal Deficits

The last key variable that determines inflation rates is the level of real fiscal deficit relative to output $d_t$. The fact that $d_t$ is assumed to be a random variable is motivated by, among other factors according to our interpretation, exogenous conditions in global financial markets, the international price of commodities that are crucial in determining the fiscal situation of many governments in developing economies, and political processes. With these considerations, in an admittedly reduced form, it is assumed that $d_t$ is a random variable with the following conditional distribution:

$$
\log\left(d_t \mid \tilde{d}_t, v_t \right) \sim N\left(\log\left(\tilde{d}_t\right), v_t\right).
$$

Thus, $d_t$ is a random variable with a log-normal distribution that has a median of $\tilde{d}_t$ and a variance parameter $v_t$. A restriction of assuming a log-normal distribution for fiscal deficits relative to output is that $d_t$ cannot be negative (a fiscal surplus is not feasible). Sargent \textit{et al.} (2009) explain that even when they allow the distribution of $d_t$ to have negative values, there is not a significant improvement in the fit of the model. Furthermore, a log-normal distribution captures the skewness of inflation shown in the data. In the case of Mexico, we will see that three values for $\tilde{d}_t$ are sufficient to adequately capture the evolution of deficits during the period we analyze.

Each period, $\tilde{d}_t$ is determined by a discrete Markov process with $D$ possible states.\textsuperscript{13} In the same manner, $v_t$ follows another Markov process with $V$ states that is independent of the process that determines $\tilde{d}_t$. In related literature, the stochastic process followed by $d_t$

\textsuperscript{12} The next section explains some of the details involved in estimating the parameters of model.

\textsuperscript{13} A stochastic process $x_t$ is said to be a discrete Markov process if $x_t$ takes values in a set $I$ with $|I| \in \mathbb{N}$ and for all $t = 1, 2, \ldots$ the Markov property is satisfied: $P[x_{t+1} = i | x_0, x_1, \ldots, x_t] = P[x_{t+1} = i | x_t]$. This property states that past realizations of the process $\{x_0, x_1, \ldots, x_{t-1}\}$ do not affect future values, only the present state $x_t$ affects $x_{t+1}$. 

474 B. López Martín, A. Ramírez de Aguilar, D. Sámano
is called a Hidden Markov Process. Each Markov process involved in the model is related to a matrix where the elements represent the transition probabilities from one state of the process to another. We let $Q_d \in \mathbb{R}^{D \times D}, Q_v \in \mathbb{R}^{V \times V}$ be the transition matrix associated to the $\{d_t, v_t\}$ processes, respectively.

Another important property of the model is that it generates a non-linear relationship between inflation, its expectations, and fiscal deficits. The impact that current inflationary expectations $\beta_t$ have on inflation $\pi_t$ and future expectations $\beta_{t+1}$ is a function of the hidden Markov state that governs the median fiscal deficit $\bar{d}_t$. An example of the non-linearity generated by the hidden Markov process of the model can be seen in Panels (a) and (b) of Figure II. Panel (a) shows that, for the same level of $\beta_t$, the effect of the fiscal deficit on inflation is magnified as the median level of fiscal deficit $\bar{d}_t$ rises (this Figure considers $\bar{d}_1 > \bar{d}_2 > \bar{d}_3$). Panel (b) displays a similar effect of fiscal deficit on the evolution of inflation expectations. This non-linearity between the inflation rate, its expectations, and fiscal deficits in the model is consistent with empirical studies. For example, Catao and Terrones (2005) and Lin and Chu (2013) provide evidence, utilizing data for more than 100 countries, that fiscal deficits have a strong and weak impact on the inflation rate in high and low inflation episodes, respectively. Thus, the data and the model suggest that there is a non-linear impact of fiscal deficits on inflation and expectations of inflation.

---

14 Formally, a hidden Markov process is a pair $\{x_t, y_t\}$ such that $x_t$ is a (standard) Markov process and there exists a function $f$ such that for all $t = 1, 2, ..., y_t = f(x_t)$ and:

$$P[y_{t+1} = y|x_0, x_1, ..., x_{t+1}, y_0, y_1, ..., y_t] = P[y_{t+1} = y|x_{t+1}].$$

In these type of processes, $y_t$ is known as the observable part of the process and $x_t$ is the hidden component. In the model presented in this section, $y_t$ is the real fiscal deficit relative to output while $x_t$ is a vector that contains the median $\bar{d}_t$ and variance $v_t$ of fiscal deficit at each $t$.

15 This means, in the case of $Q_{d}$, its $(i, j)$ component contains the probability of being in a state $j$ in $t+1$ conditional on $d_t = i$:

$$Q_{d}(i, j) = P[\bar{d}_{t+1} = j|\bar{d}_t = i].$$

---
Figure 2

NON-LINEAR EFFECT OF FISCAL DEFICITS

A. EFFECT ON INFLATION

B. EFFECT ON EXPECTATIONS

Note: these figures consider $\beta_{t-1} = 1.02$ and the estimated parameters as described in the next section.
2.4 Model Restrictions on Expectations

Equation (3) implies that inflation in the model is well defined only if at each $t$:

$1-\lambda \beta_{t-1} > 0$ and $1-\lambda \beta_t - \gamma d_t > 0$ (otherwise the real balances demand could become negative). However, there is no restriction within the model preventing these constraints from being violated. Furthermore, (3) implies that the gross inflation rate is not bounded. Given the numerical problems that this can generate when estimating the parameters, it is assumed that there exists a constant $\delta > 0$ such that $\pi_t < \delta$ for every $t$.

The two restrictions that need to be considered such that $\pi_t$ is well defined and bounded are:

6 $1 - \lambda \beta_{t-1} > 0$ and $\delta(1-\lambda \beta_t - \gamma d_t) > \theta(1-\lambda \beta_{t-1})$.

If any of these constraints is violated, then it is assumed that the gross inflation rate is not determined following (3). Instead, $\pi_t$ will be determined randomly according to the following log-normal distribution:

7 $\log(\pi_t) \sim N(\log(\bar{\pi}(d_t)), v_\pi)$,

where $\bar{\pi}(d_t)$ is the inflation equilibrium determined by (3) in the model without uncertainty and conditional to a certain fiscal deficit $d_t$, whereas $v_\pi$ represents the variance of inflation when it is determined following (7). Additionally, if $\delta(1-\lambda \beta_t - \gamma d_t) \leq \theta(1-\lambda \beta_{t-1})$,

Sargent et al. (2009) suggest resetting expected inflation to $\beta_{t+1} = \pi_t$, otherwise the dynamics between $\beta_{t+1}$ and inflation will provoke $\pi_{t+1} \geq \delta$ and eventually $\beta, \pi \rightarrow \infty$.

Whenever the current hidden Markov state $\{\bar{d}_t, v_t\}$ provokes dynamics that will eventually make $\{\pi, \beta\}$ violate (6) or that will

---

16 If $1 - \lambda \beta_t - \gamma d_t \rightarrow 0$, then $\pi_t \rightarrow \infty$.

17 Certainty in the model implies $\pi_t = \beta_t$. In equilibrium, $\pi_t = \pi_{t-1}$. Using (3) it can be shown that:

$\bar{\pi}(d_t) = \left(1 + \theta \lambda - d_t - \sqrt{(1+\theta \lambda - d_t)^2 - 4\theta \lambda} \right) / 2\lambda$. 

generate an escape dynamics, the government can implement a reform to prevent this from happening. Sargent et al. (2009) define two types of reforms: a reform is said to be cosmetic if the government is able to (temporarily) control inflation but the median level of fiscal deficit is not altered. Following Panel (a) of Figure 1, a cosmetic reform can fail if the expected inflation rate associated with inflation \( \beta_{t+1} \) is such that \( \beta_{t+1} > \beta_2 \). However, a cosmetic reform can be successful if \( \beta_{t+1} \leq \beta_2 \). A structural reform, on the other hand, occurs when the government is able to control the inflation rate by reducing the median level of fiscal deficit, \( \tilde{d}_t \). Panel (b) of Figure 1 is an example of a structural reform where the government succeeded in controlling an escape dynamics.

An important contribution of the model is its ability to identify whether a reform is cosmetic or structural. Previous literature had only studied structural reforms, even though the notion of a cosmetic reform was part of academic and economic policy discussions. The inclusion of cosmetic reforms in the model represents a reduced form approach to consider different episodes in Latin America, when governments attempted to control inflation without tackling fiscal deficits. Discussions of economic events often point to the role of the exchange rate, which is not explicitly included in the baseline model, and we explore below through different extensions of the baseline model.

3. BASELINE MODEL RESULTS

In this section, we present the main results of the baseline model. We present the fit of the model for real fiscal deficits, inflation, and its expectations between 1969 and 2016. Then, as a validation procedure, we compare these model-fitted series with data available for different variables.

3.1 Baseline Model Estimation

Heuristically, the estimated parameters are obtained as the vector of values that maximize the likelihood function, which consists of the

\[ Sargent \ et \ al. \ (2009) \ argue \ that \ in \ Peru \ a \ cosmetic \ reform \ was \ enough \ to \ control \ the \ inflationary \ crisis \ this \ country \ experienced \ in \ 1985. \]
marginal density of the sequence of inflation.¹⁹ The inflation data corresponds to the Índice Nacional de Precios al Consumidor (INPC) between 1969 and 2016, at a monthly frequency. The INPC is the Consumer Price Index (CPI) computed by the National Institute of Statistics and Geography, Instituto Nacional de Estadística y Geografía (INEGI) since 2011, and by Banco de México before that year.

We consider a monthly frequency for the model estimation, consistent with the data. Before estimating the parameters, one must choose the number of states of nature for \( \{ \tilde{d}, v \} \): denoted \( D \) and \( V \), respectively. As \( D \) or \( V \) become larger, the fit of the model in terms of approximating the data tends to improve at the expense of increasing the computational burden. Sargent et al. (2009) estimate two models for each country they study: a model with \( D=3 \), \( V=2 \) and a model with \( D=2 \), \( V=3 \). Then, using the Schwarz information criterion (SIC), we select the model that provides a better fit to the data.²⁰ Table 1 shows the estimation results for a model with three possible states for \( \tilde{d} \) (\( D=3 \)) and two states for \( v \) (\( V=2 \)). We choose this model because, after estimating the two models with data for Mexico, the SIC suggests that \( D=3 \), \( V=2 \) provides a better approximation to the data.

The estimated parameters suggest interesting facts about the price formation process in Mexico: \( \lambda = 0.7556 \) implies that the price level reflects agents’ expectations on the future price level. Hence, if inflation expectations are volatile, then the observed inflation will also have a high variance. This result implies that a necessary condition to have stable inflation is to anchor expectations. Mexico’s \( \lambda \) is similar to the estimation by Sargent et al. (2009) for Argentina (\( \lambda = 0.730 \)) and Peru (\( \lambda = 0.740 \)).

The estimated value of \( \nu = 0.1147 \) for Mexico implies that to anchor expectations, observed inflation must remain stable for several months.²¹ On the other hand, this also implies that the expected

---

¹⁹ In the Appendix we provide further details regarding the estimation of the model. Ramirez de Aguilar (2017) describes the computational procedure.

²⁰ The SIC is a Bayesian selection criterion between two models, \( A \) and \( B \). Let \( L_x, P_x, n_x \) be the log-likelihood, the number of parameters, and the sample size in model \( x \in \{ A, B \} \), respectively. Then, the Schwarz criterion for model \( x \) is computed as \( SIC_x = \log(n_x)P_x - 2L_x \). If \( SIC_A < SIC_B \), then model \( A \) is preferred.

²¹ The estimation of \( \nu = 0.1147 \) implies that the weight agents give to their past expectations is 0.8853. Hence, if inflation is stable for only
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda$</td>
<td>0.7556 (0.0022)</td>
<td>weight of expectations on the price level</td>
</tr>
<tr>
<td>$v$</td>
<td>0.1147 (0.0081)</td>
<td>weight of past inflation on expectations</td>
</tr>
<tr>
<td>$\bar{d}_1$</td>
<td>0.0075 (0.0001)</td>
<td>monthly high median level of fiscal deficits</td>
</tr>
<tr>
<td>$\bar{d}_2$</td>
<td>0.0039 (0.0004)</td>
<td>monthly moderate median level of fiscal deficits</td>
</tr>
<tr>
<td>$\bar{d}_3$</td>
<td>0.0023 (0.0002)</td>
<td>monthly low median level of fiscal deficits</td>
</tr>
<tr>
<td>$v_1$</td>
<td>0.0671 (0.0087)</td>
<td>high variance of monthly fiscal deficits</td>
</tr>
<tr>
<td>$v_2$</td>
<td>0.0295 (0.0012)</td>
<td>low variance of monthly fiscal deficits</td>
</tr>
<tr>
<td>$v_\pi$</td>
<td>0.0753 (0.0010)</td>
<td>variance of inflation when it is determined randomly</td>
</tr>
<tr>
<td>$p_{11}^d$</td>
<td>0.9731 (0.0361)</td>
<td>probability of $\bar{d}_{t+1} = \bar{d}_1$ conditional on $\bar{d}_t = \bar{d}_1$</td>
</tr>
<tr>
<td>$p_{22}^d$</td>
<td>0.9787 (0.0390)</td>
<td>probability of $\bar{d}_{t+1} = \bar{d}_2$ conditional on $\bar{d}_t = \bar{d}_2$</td>
</tr>
<tr>
<td>$p_{33}^d$</td>
<td>0.9924 (0.0056)</td>
<td>probability of $\bar{d}_{t+1} = \bar{d}_3$ conditional on $\bar{d}_t = \bar{d}_3$</td>
</tr>
<tr>
<td>$p_{11}^v$</td>
<td>0.7493 (0.1072)</td>
<td>probability of $v_{t+1} = v_1$ conditional on $v_t = v_1$</td>
</tr>
<tr>
<td>$p_{22}^v$</td>
<td>0.7789 (0.0879)</td>
<td>probability of $v_{t+1} = v_2$ conditional on $v_t = v_2$</td>
</tr>
</tbody>
</table>

Note: the numbers shown in parentheses represent the standard deviation of each parameter, computed using the Hessian matrix of the maximum likelihood problem (see MacDonald and Zucchini (2009)).
inflation rate de-anchors only if the observed inflation is high for an extended period. Sargent et al. (2009)’s estimations for Argentina (v=0.023), Chile (v=0.025), and Peru (v=0.069) indicate that, in these countries, observed inflation has a relatively limited effect on inflation expectations, while the estimates for Bolivia (v=0.232) and Brazil (v=0.189), suggest that observed inflation has a stronger impact on expectations.

Regarding fiscal deficits, according to the estimation, when the government generates a high fiscal deficit for one year ( $\bar{d} = \bar{d}_1$ for twelve consecutive months), fiscal deficit represents approximately 9.12% of GDP. If the government generates a moderate deficit for one year, this will amount to approximately 4.76% of GDP. Finally, if fiscal deficits are low for one year, then it represents 2.78% of the GDP. These levels of deficit are associated, in steady state, with average annual inflation rates of 69.41%, 17.53% and 3.54%, respectively. As it will be shown, these estimates are consistent with fiscal deficit data between 1977 and 2016.

### 3.2 Fiscal Deficits, Inflation, and Expectations

Once the parameters are estimated, fiscal deficits relative to output can be computed in each period exploiting the assumptions made for $\{d_t | \bar{d}_t, v_t\}$ and considering that $\{\bar{d}_t, v_t\}$ follow a discrete Markov process. We estimate the conditional density of fiscal deficits given the sequence of inflation observed in the data $\pi^T$ and the parameter estimation, $p\left( d_t | \pi^T, \phi \right)$. Then, we use the median of each density to construct a sequence $\{d_t\}_{t=1}^T$ that is used to compute $\{\pi_t, \beta_t\}_{t=1}^T$ according to the model. Finally, we compare the model implied sequence of inflation $\{\pi_t\}_{t=1}^T$ with the empirical series.

Figure 3 presents the model simulation for fiscal deficits, inflation expectations, observed inflation, and the probability of a regime change in $\bar{d}$.

- Between 1969 and 1972, marked as Region (1) in Figure 3, a low rate of inflation is associated with the lowest hidden state
of median deficit $\bar{d}_3$. This is consistent with the economic history of Mexico; during the decade of the 1960s, the inflation rate in Mexico achieved its lowest value during the second half of the twentieth century: an average of 2.8%, which is replicated by the model.\textsuperscript{22}

- Between 1973 and 1982, marked as Region (2) of the Figure, the model suggests that fiscal deficits increased from a low to a moderate median level, accompanied by an increase of the inflation rate. Since this level of deficit remained constant for several years, inflation expectations de-anchored. Consequently, the observed inflation rate also presented an increase between 1973-1982. At the end of 1971, a global recession reduced international credit. Fearing a period of stagnation, the government responded by increasing public expenditures financed with monetary emission, foreign credit, and reserves of private financial institutions at the Central Bank. The fiscal deficit relative to output increased from 2.5% of GDP in 1971 to 4.9% in 1972, while the monetary base grew 14.8% during 1972, the rate of inflation registered an average of 14% during 1973-1976. Meanwhile, government expenditures increased from 30.9% relative to output to 40.6% in 1981; the fiscal deficit relative to output rose from 6.7% in 1977 to 14.1% in 1982.

- In 1981, the world economy was going through another recession that once again reduced international credit. In Mexico, there was not a significant reduction in expenditures and by 1982 the lack of foreign credit led the government to finance most of its expenditures with monetary emission: between 1981 and 1983, the monetary base was growing at an average rate of approximately 90% and the inflation rate was 63.1% on average. During 1983, the model generates an inflation rate above 80% as a result of an increase in fiscal deficits, which reached their highest median level. During 1983-1986, the government raised taxes and renegotiated its foreign debt.

\textsuperscript{22} In this section we draw from Cardenas (2015), who provides an exhaustive narrative of the economic history of Mexico during the period of our analysis. Historical series for output and the inflation rate data presented in this section were obtained in the Historic Statistics of Mexico published by INEGI.
However, there was not a significant adjustment of expenditures; by 1986 the fiscal deficit reached the same level it registered in 1982, equal to 14.1% of GDP. In 1985 world oil prices fell and by 1986 the price of the Mexican oil mix suffered a drop of 65%, generating a loss equivalent to 6.5% of GDP and a reduction of 26% in federal income. By 1987, the annual inflation rate was 159%.\footnote{Cardenas (2015) argues that the crisis presented during 1987 is a direct consequence of the unwillingness of the government to reduce its deficit during 1982-1987.}

- **Region (3) of Figure 3** presents evidence of a cosmetic reform, to control inflation: during 1984 the government was able to reduce inflation from 85% to 56%, according to the model, due to a temporal reduction of its fiscal deficit. However, as shown by Panels (a) and (d) the median fiscal deficit between 1985-1987 remained at the highest possible (estimated) value. As a consequence, inflation began to grow once again in 1985.

- **After the 1987 crisis**, in 1988 the Mexican government reached an agreement with representatives of the private sector called the Economic Solidarity Plan (in Spanish: Pacto de Solidaridad Económica) in which the government committed to reducing expenditures and inflation. The fiscal deficit came to historic lows and even achieved surpluses, and the government was able to restructure its debt. By 1989 the annual inflation rate was lowered to 20.3%. The model is consistent with this episode of economic history in Mexico; through the lens of the model, the government conducted a structural reform: between 1988 and 1993 (Region (4) of the Figure), fiscal deficits were reduced from the highest possible median $\tilde{d}_1$ to a moderate level $\tilde{d}_2$ in 1989 and then in 1993 to a lower median $\tilde{d}_4$. This reduction of the fiscal deficit had an immediate impact on inflation and its expectations.

- **Several factors** induced another crisis at the end of 1994 and during 1995. The re-privatization of the banks was financed with foreign debt, which left the financial sector exposed to sudden exchange rate movements and increments in interest rates. Additionally, the government issued bonds that were paid in pesos but with dollar nominal values (the
Tesobonos), which required a stable exchange rate in order to keep this debt sustainable. However, political events led to a significant depreciation of the domestic currency in 1994 accompanied by capital outflows (Calvo and Mendoza (1996), Cole and Kehoe (1996) analyze these events). The government faced a debt crisis, the private financial sector found itself in bankruptcy, and the inflation rate reached 51% in 1995. The government negotiated loans with the International Monetary Fund (IMF) and with the United States in order to finance its debt.

- The model attributes, in Region (5), the escalation in inflation during 1995 to an increase in fiscal deficit between 1994 and 1995. However, this escalation was a consequence, to a significant extent, of the nominal exchange rate depreciation at the end of 1994 and the collapse of the financial sector in 1995. In this case, there is a discrepancy between the in-sample predictions of the model concerning fiscal deficit and what is observed in the data. This discrepancy between the model and the data motivates the introduction of the nominal exchange rate in the model. It will be shown that by introducing this variable we can better account for the behavior of inflation during 1995 and in general.

- After a constitutional reform in 1993, Banco de México became independent in 1994. The reform established as its primary mandate to preserve the purchasing power of the national currency. The average annual inflation rate fell from 10.95% between 1996-2002 to 3.98% between 2003-2016, achieving historic minimums during 2015 and 2016.25

24 Some of the policies adopted by the Central Bank after 1994 were: (i) restoration of the level of international reserves to gain credibility, (ii) the use of an objective of cumulative current account balances that private banks held at the Central Bank as the primary monetary policy instrument, (iii) adoption of an inflation-targeting policy, and (iv) to improve transparency, the Central Bank began to publish reports communicating monetary policy decisions as well as quarterly reports of the economy. For a more detailed description of these policies see Ramos-Francia and Torres-García (2005).

25 Furthermore, as documented by Chiquiar et al. (2010), the inflation rate after 2000-2001 became a stationary process and initiated its convergence towards the inflation target.
Meanwhile, fiscal deficits remained relatively low and stable during 1997-2016.²⁶

- During the last sub-period (Region (6) of Figure 3), the model predicts that fiscal deficits were at the lowest median and variance hidden states. The model also shows that the expected inflation rate has fluctuated within the range of the target of Banco de México: an inflation rate of 3% that can vary between 2% and 4%. The model proposes that a necessary condition to anchor inflation and its expectations is a low monetization of fiscal deficit. The only year in which the fiscal deficit had a slight probability of being at a higher median state was in 2009, in the course of the global financial crisis. However, since the inflation rate remained low after 2009, the baseline model predicts that Mexico has remained in a low fiscal deficit regime.

Considering the inflation history previously described, we observe that the model predicts a deficit distribution with an elevated mean and variance during those years in which the inflation rate was elevated, as in 1987 (a year characterized by the highest inflation rate presented in Mexico during the second half of the twentieth century). In those years in which the inflation rate was moderately high, as in 1975, the model predicts a fiscal deficit with a moderate mean and lower variance than in 1987. Finally, in those years where the inflation rate is low, the fiscal deficit density is characterized by a low mean and variance.

3.3 Fiscal Deficits: Data and Model Simulation

The Ministry of Public Finance of Mexico, Secretaría de Hacienda y Crédito Público (SHCP), computes a measure of the fiscal deficit called Balance Público Tradicional (BPT) since 1977. This measure represents the difference between current and capital expenditures and revenue of almost all of the public sector.²⁷ Since 1990, the SHCP

²⁶ In 2008 there was a methodological modification in BPT, it became a wider measure of fiscal deficits: after 2008 the BPT considers part of the investments made by two important state-owned firms (Pemex and CFE) that before were considered as long-term debt (this type of investments are called PIDIREGAS).

²⁷ The BPT does not consider the revenue and expenditures of Banco de México or the public financial sector. The financial sector of the
Notes: Panel (a) plots the median real fiscal deficit relative to output together with the 10th and 90th percentile of the annual deficit distribution. Panel (b) shows the annual inflation rate predicted by the model given the real fiscal deficit, and the data. Panel (c) shows the expected inflation rate according to the GGE algorithm (4). Panel (d) plots $P[\hat{d}_{j}, \hat{\pi}_{t}, \hat{\phi}] + P[\hat{d}_{j}, \hat{\pi}_{t}, \hat{\phi}]$ where $\hat{d}_{j}$ are the moderate and low levels of mean fiscal deficit.

Source: INEGI and model results.
Notes: Panel (a) plots the median real fiscal deficit relative to output together with the 10th and 90th percentile of the annual deficit distribution. Panel (b) shows the annual inflation rate predicted by the model given the real fiscal deficit, and the data. Panel (c) shows the expected inflation rate according to the CGE algorithm (4). Panel (d) plots $P[\hat{d}_t = \hat{d}_2|\pi^t, \hat{\phi}] + P[\hat{d}_t = \hat{d}_3|\pi^t, \hat{\phi}]$ where $\hat{d}_2$ and $\hat{d}_3$ are the moderate and low levels of mean fiscal deficit.

Source: INEGI and model results.
computes an alternative fiscal deficit measure called Requerimientos Financieros del Sector Público (RFSP), which incorporates the financial requirements of the government at the federal level. This is a broader measure of fiscal deficit since it includes the BPT in addition to all revenues and expenditures of the public financial sector that provide funds for public policy.\textsuperscript{28}

Panel (a) of Figure 4 displays the estimated sequence of fiscal deficits from the model, as well as the BPT and the RFSP relative to GDP between 1977 and 2016. As shown in the Figure, there is an adequate approximation of the model to the BPT data before 1991 and to the RFSP after 1993. During 1991 and 1992, both series show a fiscal surplus. The model cannot match this feature of the data given the assumption of a log-normal distribution, and deficits cannot be negative. Additionally, the model predicts a higher deficit during 1994-1996 relative to those observed in the data; in 1995 the model predicts a fiscal deficit relative to output of 6.1\% of GDP, while the RFSP exhibits a fiscal deficit of 2.5\% of GDP. The baseline model can only attribute the spike in inflation of that year to fiscal deficits. We will see that the extensions of this model can better account for the rates of inflation during this episode. During 1977-2016, the model’s median deficit variance is 53.7\% of the variance presented in the fiscal deficit data.\textsuperscript{29}

Panel (b) of Figure 4 displays the model’s implied monetary base growth rate compared with Banco de México’s data between 1969 and 1970.\textsuperscript{30} The Figure shows that the model approximates the data’s government includes, among others, trust funds and banks administered by the federal government.

\textsuperscript{28} For example, during 1990-1998 the government managed a trust fund called FOBAPROA, its objective was to insure private banks against overdue accounts in case of a financial crisis. If the fund provided resources to a private bank to cover its overdue accounts, this would be considered in the RFSP but not in the BPT. The RFSP are a better approximation of the concept of deficits considered in the model. However, before 1990 the only official deficit measure available is the BPT. We are grateful to Nicolas Amoroso, Oscar Budar, and Juan Sherwell for their invaluable guidance in understanding historical accounts and providing these series.

\textsuperscript{29} For these results, we considered the BPT before 1991 and the RFSP after this year.

\textsuperscript{30} To compute the monetary base growth according to the model, we considered equation (1) to show that: $$\frac{M_t}{M_{t-12}} = \frac{P_t}{P_{t-12}} \left( \frac{1 - \lambda \beta_t}{1 - \lambda \beta_{t-12}} \right).$$ Ramirez de Aguilar (2017) presents further details.
sequence reasonably well, although there are differences in 1990-1992. The model’s monetary base growth rate variance accounts for 82% of the variance presented in the data.

4. BEYOND THE BASELINE MODEL

Considering that, since 1994, Banco de México has been an independent Central Bank and no longer finances the federal government through money creation, in this section we present modifications to the baseline model. Before we discuss these extensions, we should be explicit about the fact that the model by itself does not distinguish between periods of monetary or fiscal dominance. Formally, the estimation of the model will propose a series of deficits that are financed with monetary emission, while the classification of different periods in terms of the regime rests on the interpretation of the historical narrative we previously presented. In a similar manner, Meza (2017) concludes that the change in legislation that granted independence to Banco de México in 1993 represented a credible change from fiscal to monetary dominance, and that the transition to an independent Central Bank has been successful. Furthermore, Central Bank independence does not imply $d=0$ if the target for inflation is, for example, 3%. Through the lens of the model, the Central Bank would target a long-run level of money growth such that inflation fluctuates around the target of this institution.

The extensions we present will allow us to illustrate some of the channels through which fiscal policy may potentially influence inflation even in a context of autonomy of the Central Bank. These

---

31 As explained by Meza (2017), the Central Bank transfers resources to the Ministry of Finance (equivalent to the Treasury in the U.S.), after determining its earnings and following legally specified rules. This is called the Remanente de Operación de Banco de México. In the United States, the Federal Reserve transfers to the Treasury most of its interest earnings from government debt. As further discussed below, this can be perfectly consistent with a regime of monetary dominance.

32 In this sense, the approach is complementary to models that consider regime-switching environments, e.g. Chung et al. (2007), Cadavid-Sanchez et al. (2017), and Bianchi and Ilut (2017).

33 For the period, Meza (2017) estimates seigniorage at an average of 0.66 p.p. of GDP for the period 1995-2016.
Figure 4

DATA AND MODEL COMPARISON

A. REAL FISCAL DEFICITS RELATIVE TO OUTPUT 1977-2016

Panel (a): in blue the estimated scalar deficit with the 10th/90th percentiles of the estimated deficit distribution. In red/orange the BPT or the RFSP relative to GDP. Panel (b): in blue/red the model/data monetary base annual growth rate, respectively.

Source: Banco de México and SHCP.

B. MONETARY BASE GROWTH 1969-2016

Notes: the series presented are - Panel (a): in blue the estimated scalar deficit with the 10th/90th percentiles of the estimated deficit distribution. In red/orange the BPT or the RFSP relative to GDP. Panel (b): in blue/red the model/data monetary base annual growth rate, respectively.

Source: Banco de México and SHCP.
modifications are inspired by the literature that studies the interactions between fiscal and monetary policy, which suggests that, even with an independent Central Bank, fiscal policy can still affect inflation. For example, if agents observe an increasing deficit that translates into higher debt, they may anticipate a regime change to make the fiscal path sustainable, hence, they may increase their current inflationary expectations and inflation itself.

First, we present an extension where we consider that the expected inflation rate may be influenced by fluctuations in the nominal exchange rate (\textit{NER}) between the Mexican peso and the U.S. dollar. An important result of this model is that the effect that the NER has on inflation (known in the literature as Exchange Rate Pass-Through, \textit{ERPT}) is a function of the fiscal deficit. According to our estimation, in a situation with elevated fiscal deficits that generate high inflation rates, the \textit{ERPT} is considerable. After 1995, the year in which the NER changed from a fixed to a flexible regime and after Banco de México became an independent institution, the \textit{ERPT} to inflation and its expectations has become rather limited.

The second extension considers the sovereign interest rate spread \textit{EMBI} of J.P. Morgan as a variable that reflects the fiscal situation of governments. We estimate that the \textit{EMBI} has a moderate impact on inflation and its expectations, although its effect is positive and statistically significant. An increase in the \textit{EMBI} spread is associated with the perception that the government is not in a solid fiscal situation. Hence, following the example illustrated by Kocherlakota (2012), agents may incorporate in their inflation expectations the possibility that the Central Bank may lose independence to the fiscal authority, and consequently raise their inflation expectations. This, according to the model, generates an increase in observed inflation as well.

In the third extension we specify a real-balances demand function that incorporates the exchange rate, as an alternative channel through which this variable may influence inflation.\textsuperscript{34}

\textsuperscript{34} We have explored additional extensions of the model. For example, incorporating the \textit{CEtes} interest rate, and another specification that includes the target for the inflation rate of Banco de México. However, the fit of these alternative specifications is less favorable (results available upon request). Further exploration of alternative specifications would certainly be an interesting topic for future research.
Empirical evidence shows that sovereign interest rate spreads are, to a large extent, driven by international factors such as risk appetite, market volatility, terms of trade, global liquidity, contagion from events such as the Russian crisis or the LTCM collapse in 1998, and even U.S. macroeconomic news. In the same fashion, exchange rate fluctuations are linked to global financial factors (to give some recent examples, Gabaix and Maggiori (2015) and Itskhoki and Mukhin (2017)), and the Mexican peso is sometimes considered a commodity currency (see Kohlscheen (2010)). The state of public accounts can make the economy vulnerable to these external shocks.

Our model allows us to explore empirically the possibility that fiscal policy can make the evolution of inflation sensitive to events in international financial markets. The results motivate the need for further theoretical developments in this area, in particular for developing economies, where sovereign interest rate spreads and exchange rates seem to be of primary relevance. The historical narrative of events in Mexico for the period 1969-1994 supports this interpretation; events such as significant drops in the price of oil or sudden-stops make the economy vulnerable when fiscal accounts are in a dire situation and the government may be forced to turn to the Central Bank to cover its financial needs. Even in a context of de jure monetary dominance, economic agents may consider that these risks are still present, and thus we aim to capture this possibility in the estimation of our model.

---

35 There is an extensive literature that documents these facts, including Longstaff et al. (2011), González-Rozada and Levy-Yeyati (2008), Bunda et al. (2009), Ciarlone et al. (2009), Hilscher and Nosbusch (2010), and Ozatay et al. (2009).

36 The issue of endogeneity is addressed by exploiting alternative methodologies in Cortés-Espada (2013) and Lopez-Villavicencio and Mignon (2016).

37 These channels have been considered by Zoli (2005) in the case of Brazil, by assessing the impact of news concerning fiscal variables and fiscal policy on sovereign interest rate spreads and the exchange rate and discussing the potential implications for monetary policy. Cerisola and Gelos (2005) find that the stance of fiscal policy (proxied by the ratio of the consolidated primary surplus to GDP) is important to determine inflation expectations in the case of Brazil and argue that fiscal policy is instrumental in anchoring inflation expectations.
4.1 The Role of the Exchange Rate

As documented by Rogers and Wang (1994) and Carrasco and Ferreiro (2013), an important variable in determining inflation expectations is the nominal exchange rate ($\text{NER}$). Figure 5 presents, as a motivation for this extension, the annual inflation rate and the annual variation of the NER between 1977 and 2016. This Figure shows a significant correlation between these variables, particularly during episodes of high inflation. An important fact to consider is that before 1995 Mexico had a fixed exchange rate with bounded depreciations.\footnote{In the Appendix, we describe the different exchange rate regimes in Mexico.} After 1994, the peso-dollar NER entered a floating regime.

In this extension, we consider that the exchange rate variation $\Delta \text{NER}$ is a variable that can affect inflation expectations. We assume...
that this variation has a weight $\xi$ on expectations. Hence, for each period $t$, the expected inflation rate is determined as follows:

$$\beta_t = (1 - v - \xi) \beta_{t-1} + v \pi_{t-1} + \xi \Delta \text{NER}_t.$$  

Given that Mexico had a fixed $\text{NER}$ during 1969-1994 and after 1995 the $\text{NER}$ is in a floating regime, we estimate the model allowing $\xi$ to change during 1969-1994 and 1995-2016. Hence, the model allows agents to give a weight $\xi_1$ to the $\text{NER}$ variation during a fixed exchange rate regime and a weight $\xi_2$ when the $\text{NER}$ is in a floating regime. To estimate this model, again we consider the monthly inflation sequence according to the INPC between January of 1969 and December of 2016, and the sequence of the monthly variation in the peso-dollar $\text{NER}$ documented by Banco de México for that period. Table 2 presents the estimated parameters of this version compared with the baseline model estimation. Considering the exchange rate as a variable that can influence inflation expectations (and hence, inflation), the model can account for 75.8% of the variance observed in the inflation data, while the baseline model can explain 61.6% of this variance. Also, as suggested by the Diebold-Mariano test, during 2000-2016 the $\text{NER}$ and baseline models produce different in-sample forecasts of observed inflation (at a 1% significance level) and the modified model has a higher correlation with the inflation data. This result emphasizes the relevance of the exchange rate for the determination of the inflation rate in Mexico.

39 The hypothesis test proposed in Diebold and Mariano (1995) allows to assess if two forecasts $\{y_{it}, y_{jt}\}_{t=1}^T$ related to a series $\{y_t\}_{t=1}^T$ are statistically different. Defining $e_{it} = y_{it} - y_i$ for $k \in \{i, j\}$ and considering a loss-function $g(e)$, the null hypothesis in the Diebold-Mariano test is that $E\{g(e_i) - g(e_j)\} = 0$. These authors construct a statistic function that involves the autocorrelations of the forecasts and show that, if the time series considered are covariance stationary and short memory, it has a t-Student distribution. Then, they construct a statistic that, under the same assumptions, is asymptotically $N(0, 1)$.

40 More formally, according to the $\text{sic}$ comparison, the ordering of the models is the following: the model with the $\text{EMBI}$ spread and the $\text{NER}$ in the for-
The parameters \(\{\xi_1, \xi_2\}\) are statistically different, a result that can be interpreted as follows: between 1969 and 1994 the expected inflation was 0.0215 p.p. given 1% depreciation of the NER. After 1995 the expected inflation shows a considerable reduction: a 1% exchange rate depreciation translates to an increase in the expected inflation rate of 0.0047 p.p. To assess the expected inflation into the observed inflation, we must consider not only the expected inflation to expectations, but also the fiscal deficit level relative to GDP. This is because, within the model, both variables jointly determine the inflation rate. As we detailed in the previous

mation of expectations, the model with the NER in the real balances demand function (presented in the following section), the model with only the NER in the formation of expectations and, finally, the baseline model.
section, a higher fiscal deficit magnifies the effect that $\beta_t$ has on inflation (in fact this effect is nonlinear). Hence, if fiscal deficit increases, the effect that the \text{NER} variation has on $\pi_t$ will grow because this variation affects $\beta_t$. It can be shown that:

$$\frac{\partial \pi_t}{\partial \Delta NER} = \frac{\partial \pi_t}{\partial \beta_t} \frac{\partial \beta_t}{\partial \Delta NER} = \frac{\lambda \xi}{1 - \lambda \beta_t - d_t} \pi_t.$$  

This equation highlights two important results: (i) the ERPT is increasing in $d_t$; (ii) a higher inflation rate implies a higher ERPT. Figure 6 shows the impulse-response function of inflation given a 1% depreciation in the \text{NER}. As this Figure suggests, when fiscal deficit is high (e.g., during 1982-1987) the ERPT to inflation is 0.821 p.p. However, if fiscal deficit is low the ERPT of a 1% depreciation is 0.026 p.p. Hence, a low fiscal deficit financed by the Central Bank not only translates into low inflation, but also into a limited ERPT. A low pass-through
contributes to a steady and anchored expected and observed inflation rate.\footnote{The low level of pass-through is consistent with estimates in the literature for Mexico, see Albagli et al. (2015), Capistrán et al. (2011), Cortés-Espada (2013), and Kochen and Samano (2016). Furthermore, there is evidence of a declining ERPT in environments with more stable inflation and with the adoption of inflation targets (see Baqueiro et al. (2005), Choudhri and Hakura (2006) and Lopez-Villavicencio and Mignon (2016)). Capistrán et al. (2011) and Cortés-Espada (2013) document a lower ERPT for Mexico under the inflation targeting regime.}

Figure 7 shows that the model that considers the NER as a variable that influences inflation expectations is able to provide a better account of the behavior of inflation dynamics in general, but especially during 1982 and 1994-1995, relative to the model that does not consider the NER, given the depreciation of the NER observed during those years.

4.2 The Role of the EMBI Spread

In this section we analyze an extension of the baseline model that considers the sovereign interest rate spread EMBI, a variable that captures the perception of the fiscal situation in Mexico and may influence inflation expectations. To the extent that this variable is relevant according to the estimation then this would suggest that, even though Mexico has an independent Central Bank, fiscal policy must be relevant for monetary policy through its influence on the inflation rate and its expectations.\footnote{The perception of economic agents of the fiscal responsibility of the government may depend on the particular historical context. For example, Sargent and Zeira (2011) describe how the anticipation of a future government bailout of banks caused a jump in inflation in Israel in 1983. They argue that the public anticipated that this bailout would eventually be financed by monetary expansion. Alternatively, Chung et al. (2007) explore an environment where monetary and fiscal regimes evolve according to a Markov process, this possibility can change the impact of policy shocks. These authors argue that, to the extent that there has been a history of changes in policy regimes, private agents can ascribe a probability distribution over the different regimes.}

As a motivation for this extension, Figure 8 displays, in Panel (a), the interest rate spread EMBI and the NER between 1998 and 2016. This Figure shows that these variables are weakly correlated. Hence, if we consider the EMBI and the NER, we will be able to identify the effect that each variable has on inflation and its expectations. Panel (b)
Figure 7
INFLATION AND EXPECTATIONS IN THE NER MODEL

A. ANNUAL INFLATION RATE

![Inflation Data and Baseline Model vs. NER Model over the years]

- Average Inflation 2006-2016:
  - Data: 3.91%
  - NER Model: 3.56%
  - Baseline Model: 3.15%

B. EXPECTED INFLATION

![Expected Inflation and Baseline Model vs. NER Model over the years]

- Average Expected Inflation 2006-2016:
  - NER Model: 3.37%
  - Baseline Model: 3.15%

Source: INEGI.
of this Figure shows the relationship between the annual inflation rate and the variation (in basis points) of the EMBI spread.

In this extension, we consider two regimes: a fiscal dominance regime where the fiscal authority can use money creation to finance its deficit, and Central Bank autonomy, where it cannot. The interpretation we propose is that Mexico had a fiscal dominance regime between 1969 and 1994. Under fiscal dominance, Mexico had a fixed NER and under monetary dominance, the peso-dollar NER is under a floating regime (see the Appendix for a more detailed description of the exchange rate regimes). We assume that under fiscal dominance, agents determine their expectations according to:

\[
\beta_t = (1 - v_1 - \xi_1) \beta_{t-1} + v_1 \pi_{t-1} + \xi_1 \Delta \text{NER}_t.
\]

After 1994 we allow agents to give some weight \(\sigma\) to the current fiscal situation (which is reflected in the sovereign EMBI spread). Hence, agents determine their inflation expectations according to:

\[
\beta_t = (1 - v_2 - \xi_2 - \sigma) \beta_{t-1} + v_2 \pi_{t-1} + \xi_2 \Delta \text{NER}_t + \sigma \Delta \text{EMBI}_t.
\]

We allow the parameters \(\{v, \xi\}\) to vary because the NER had a change in its regime.

If parameters \(\xi\) and \(\sigma\) are positive and statistically significant, it would imply that the EMBI spread and the NER influence inflation. In fact, these variables can generate the escape dynamics that in the baseline model could only be ignited by the behavior of fiscal deficits.\(^{43}\) Figure 9 exemplifies how an escape dynamics, that leads to high or hyperinflation, can occur in this scenario: suppose that initially \(\beta_t = \beta^*\) and that \(\Delta \text{NER}_t, \Delta \text{EMBI}_t\) are limited. This implies that inflation and its expectations will converge to a low inflation equilibrium as the blue arrows show. However, if the fiscal authority starts to considerably increase its deficit (which is no longer financed with money creation and is therefore translated into debt) this would be reflected

\(^{43}\) In the baseline model, an escape dynamics can only occur if fiscal deficit increases for a considerable period, because it is the only way to raise inflation expectations.
Figure 8

EMBI, NER AND INFLATION

A. EMBI AND NER

EMBI

Source: Banco de México, Bloomberg and INEGI.

B. EMBI VARIATION AND INFLATION

EMBI Variation (Base Points)

Inflation

EMBI Variation

Annual Inflation (%)

Year
in the EMBI spread and influence the NER. In our model, the increment in these variables will affect inflation expectations. Furthermore, if this effect is large enough, as shown with an orange arrow in the Figure, it will cause that $\beta_1 > \beta_2$, which will lead to high inflation (as shown with red arrows). Consequently, if $\sigma$ and $\xi$ are significant and positive then, even in a context of monetary dominance, our model suggests the possibility of high inflation caused by the fiscal authority via expectations.

To estimate this model, once again we consider the inflation sequence according to the INPC during 1969-2016, the NER variation registered by Banco de México, and the EMBI spread reported by Bloomberg after 1994. The main results of this extension are:
• La estimación para σ sugiere que, todo lo demás constante, si la EMBI spread aumenta 100 puntos básicos, la tasa de inflación aumenta en 0.24 p.p.\textsuperscript{44}

• Por otro lado, la estimación de ξ\textsubscript{2} implica que bajo dominio monetario la tasa de inflación aumenta 0.011 p.p. dado un 1% depreciación del NER.

• Finalmente, con esta especificación para las expectativas de inflación, el modelo estima que \(\tilde{d}(\mathbf{3})\) es casi cero, que es la situación de déficit para el periodo de independencia del Banco de México.

Figura 10 muestra que, si consideramos la tasa de interés de interés de la EMBI y el NER, entonces la inflación generada por este modelo es más cercana a la secuencia de inflación presentada en los datos. En efecto, la incorporación de estas variables permite que el modelo explique 0.65 p.p. más de la tasa de inflación durante 2006-2016 en comparación con el modelo de base. El test Diebold-Mariano también sugiere que la secuencia de inflación entre estos años es estadísticamente diferente (a un 1% de confianza) entre la extensión EMBI y el modelo de base. Por lo tanto, estas extensiones sugieren que, en cierta medida, los escenarios fiscales han causado que la tasa de inflación sea superior al objetivo de inflación del Banco de México de 3%.

4.3 El Tasa de Cambio: Un Canale Alternativo

Un variable como la tasa de cambio puede afectar la inflación a través de varios canales y no solo a través de las expectativas de inflación. Ahora discutimos una extensión en donde el NER tiene un efecto en la inflación a través de su influencia directa en el nivel de precios \(P_t\). Suponemos que \(P_t = \gamma M_t + \lambda P_t^c + \psi NER_t\).\textsuperscript{45} Por lo tanto, el NER tiene un peso \(\psi\) en el nivel de precios, un parámetro que puede interpretarse como la passthrough del NER al nivel de precios. Esta modificación implica que la tasa de inflación ahora está dada por la siguiente expresión:

\[
\pi_t = \frac{\theta(1 - \lambda \beta_{t-1} - \psi NER_{t-1})}{1 - \lambda \beta_t - \psi NER_t - \gamma d_t}.
\]

\textsuperscript{44} Para encontrar el impacto que la EMBI spread tiene en la inflación, nuevamente debemos considerar una función de respuesta impulsiva como en la Figura 6.

\textsuperscript{45} Alternativamente, esta expresión se puede reescribir como una demanda de balanzas reales que depende del tipo de cambio.
Expectations are given by the cge algorithm $\beta_{t+1}=(1-\nu)\beta_t+\nu\pi_t$, when there is fiscal dominance (i.e. before 1994) and by $\beta_{t+1}=(1-\nu-\sigma)\beta_t+\nu\pi_t+\sigma\Delta EMBI_t$ under Central Bank independence. The main difference between assuming that the $\text{ner}$ affects expectations or $P_t$ is that, in this extension, inflation is a function of the $\text{ner}$ dynamics in two consecutive periods: $(\text{NER}_{t-1}, \text{NER}_t)$. Hence, if the $\text{ner}$ depreciates considerably between $t-1$ and $t$, this will have a higher impact on inflation and on future inflationary expectations.

Figure 11 presents the main results of this extension. As this Figure shows, the extended model better accounts for the inflation rate during 1970-2016 than the baseline model. This model performs particularly better in those periods in which the $\text{ner}$ registers a considerable depreciation. For example, during 1982, the peso-dollar $\text{ner}$ suffered a depreciation of over 200% and the model predicts that inflation at the end of that year was 118.1%. Additionally, during 1995 the $\text{ner}$ had a depreciation that surpassed 100%, which implied, according to the model, an inflation of 49.1% by the end of this year.
Figure 11

INFLATION IN THE EXTENDED MODEL

a. 1970-2016

b. 2006-2016

Source: Banco de México and INEGI.

504  B. López Martín, A. Ramírez de Aguilar, D. Sámano
5. CONCLUDING REMARKS

The baseline model and the extensions that we have presented allow us to assess the role of fiscal policy in the determination of inflation and its expectations. Even in a context of Central Bank independence, a large literature has explored the role of fiscal policy in determining inflation. We exploit a simple model and provide evidence of the relevance of fiscal policy in determining the behavior of aggregate prices in Mexico as well as the importance of expectations. Admittedly, the theoretical framework we utilize is relatively simple and models with more structure, perhaps in the inter-temporal dimension, would increase our understanding of the relationship between fiscal policy and inflation in emerging economies. Furthermore, it is sometimes argued that Central Bank independence acts as a mechanism that increases fiscal responsibility of the government in developing countries (Bodea and Higashijima (2015), Minea and Tapsoba (2014)). We believe that further research is necessary to understand the institutional arrangements that govern the relationship between a central bank and the fiscal authority in the presence of competing objectives and constraints.

6. APPENDIX

6.1 Parameter Estimation

The following equations, together with transition matrices \{Q_d, Q_v\} define inflation, expected inflation, and fiscal deficits at each \( t \) according to the baseline model:

\[
\pi_t = \chi_t \frac{\theta(1 - \lambda \beta_{t-1})}{1 - \lambda \beta_t - \gamma d_t} + (1 - \chi_t) \pi^*_t(d_t),
\]

\[
\beta_{t+1} = (1 - v) \beta_t + \pi_t, \quad \log(d_t | \bar{d}_t, \nu_t) \sim N\left(\log(\bar{d}_t), \nu_t\right),
\]
where $X_t$ is a constant equal to 1 if $\{\pi_t, \beta_t, dt\}$ satisfy $1 - \lambda \beta_{t-1} > 0$ and $\delta(1 - \lambda \beta_t - \gamma d_t) > 0(1 - \lambda \beta_{t-1})$. Assuming $\beta_0 = \pi_0$ and given a sequence of fiscal deficits $\{d_t\}_{t=0}^T$, the model can generate a sequence for the expected inflation rate $\{\beta_t\}_{t=0}^T$ and for the actual inflation rate $\{\pi_t\}_{t=0}^T$. However, the hidden Markov states $\{\bar{d}, \nu\}$, among other parameters, must be estimated to generate a sequence of fiscal deficits. Table 3 shows the parameters that need to be estimated.

### Table 3

**MODEL PARAMETERS**

<table>
<thead>
<tr>
<th>parameter</th>
<th>restrictions</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda$</td>
<td>$0 &lt; \lambda &lt; 1$</td>
<td>weight of expectations on the price level</td>
</tr>
<tr>
<td>$\nu$</td>
<td>$0 &lt; \nu &lt; 1$</td>
<td>weight of past inflation on expectations</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>$\gamma &gt; 0$</td>
<td>weight of monetary base on the price level</td>
</tr>
<tr>
<td>$\theta$</td>
<td>$0 &lt; \theta &lt; 1$</td>
<td>persistence of the monetary base</td>
</tr>
<tr>
<td>$\delta$</td>
<td>$\delta &gt; 0$</td>
<td>constant that bounds inflation</td>
</tr>
<tr>
<td>$\bar{d}_1, \bar{d}_2, ..., \bar{d}_D$</td>
<td>$\bar{d}_1 &gt; \bar{d}_2 &gt; ... &gt; \bar{d}_D &gt; 0$</td>
<td>median values of fiscal deficits</td>
</tr>
<tr>
<td>$v_1, v_2, ..., v_\nu$</td>
<td>$v_1 &gt; v_2 &gt; ... &gt; v_\nu &gt; 0$</td>
<td>variance values of fiscal deficits</td>
</tr>
<tr>
<td>$v_\pi$</td>
<td>$v_\pi &gt; 0$</td>
<td>inflation variance when determined randomly</td>
</tr>
<tr>
<td>$p_{ij}^d$</td>
<td>$0 \leq p_{ij}^d \leq 1, \sum_j p_{ij}^d = 1$</td>
<td>$i, j$-component of the transition matrix $Q_d$</td>
</tr>
<tr>
<td>$p_{ij}^v$</td>
<td>$0 \leq p_{ij}^v \leq 1, \sum_j p_{ij}^v = 1$</td>
<td>$i, j$-component of the transition matrix $Q_v$</td>
</tr>
</tbody>
</table>

46 These constraints guarantee that the model’s inflation rate is bounded and that the real balances demand is positive.
Let $\phi$ be the vector of all the parameters in the model. Given that $d_t$ is a random variable and because $\{\pi_t, \beta_t\}$ are a function of fiscal deficits, we can construct a joint density function for a sequence of $T$ periods of inflation, its expectations and fiscal deficit: $p(\pi^T, \beta^T, d^T | \phi)$. If there was available data on inflation, its expectations and fiscal deficit for a large $T$, the estimated parameters $\hat{\phi}$ can be obtained using the maximum-likelihood method applied to the joint density $p(\pi^T, \beta^T, d^T | \phi)$. However, data on inflation expectations and fiscal deficit is hard to find for a large $T$, or may not be reliable. Furthermore, we find that historical series often go through methodological modifications. This is particularly true in the case of Mexico, as we have already discussed.

INPC (consumer price index) data is available since January 1969 at a monthly frequency. Therefore, to estimate the parameters we use the marginal density of a sequence of inflation $\pi^T$ between January of 1969 and December of 2016. This marginal density is denoted $p(\pi^T | \phi)$. The estimated parameters are obtained as the vector $\hat{\phi}$ that maximizes $p(\pi^T | \phi)$ given the gross inflation rate sequence $\pi^T$ (subject to constraints):

$$\hat{\phi} = \arg \max_{\phi \in \Omega} p(\pi^T | \phi),$$

where $\Omega$ is the set of all the vectors $\phi$ that satisfy the constraints relevant for each parameter. Because there is no analytical solution to this maximization problem, $\hat{\phi}$ has to be approximated numerically. To do this, we used a constrained optimization algorithm based on the BFGS (Broyden-Fletcher-Goldfarb-Shanno) method of Nocedal and Wright (2006) and the block-wise method of Sims et al. (2006).

Given the computational burden of the maximum-likelihood optimization problem, Sargent et al. (2009) fix three parameters to reduce the complexity on the estimation. These parameters are: $\theta = 0.99$, $\delta = 100$, and $\gamma = 1$. The value assigned to $\theta$ is consistent with the behavior of nominal balances in the five countries these authors studied. Fixing $\delta = 100$ implies that, in every period, inflation cannot surpass 10,000%. Finally, $\gamma$ was fixed because the maximum-likelihood algorithm cannot identify $\gamma$ and $d_t$ separately. Once $d_t$ is estimated for each period, $\gamma$ is re-normalized so that the mean of fiscal
deficits estimated by the model matches the mean observed in the data (in our case, for Mexico for the period 1977-2016).

6.2 Adaptive vs. Rational Expectations

In this part of the Appendix we discuss some of the implications that rational expectations have in the baseline model presented in this paper. Additionally, we compare the main differences induced in the dynamics of the model between these types of expectations and CGE. One way of modeling that agents are rational when forming their beliefs on future inflation is to assume:

\[
\beta_{t+1} = \mathbb{E}_t \left[ \pi_{t+1} | \bar{d}_t, f_t \right].
\]

Equation (14) points out one important difference between rational expectations and CGE in this model. If agents are rational, they condition their expectations on the median level \( \bar{d}_t \), and the variance \( v_t \) of current fiscal deficit since the evolution of the median and variance of fiscal deficit is known to agents when they are rational. Assuming CGE does not require agents to condition their expectations on \( \{ \bar{d}_{t+1}, v_{t+1} \} \) because they update their beliefs according to (4).

Assuming rational expectations also affects the dynamics between the gross inflation rate of two consecutive periods \( \{ \pi_t, \pi_{t+1} \} \) as a function of \( \beta_t \). Panel (a) of Figure 12 plots \( \pi_{t+1} - \pi_t \) as a function of \( \beta_t \), assuming \( \beta_{t+1} \) is determined according to (14) and using the same median and variance of fiscal deficit in \( t \) and \( t+1 \). As this Figure shows, there is only one value of \( \beta_t \) that induce a constant inflation (and expectations) over time (\( \beta_1 \)). As the Figure suggests, \( \beta_1 \) is a stable equilibrium. Thus, if fiscal deficit remains with the same median and variance level, \( \pi_{t+1} - \pi_t \) will converge to zero and \( \beta_t \) to \( \beta_1 \).

With rational expectations, contrary to CGE, if inflation is high (\( \beta_t > \beta_1 \)), agents will not allow their expectations to provoke the escape dynamics. Their expectations will adjust and converge to \( \beta_1 \). However, the government could prevent expectations from converging to a high inflation equilibrium by reducing its fiscal deficits as shown in Panel (b) of Figure 12. This Figure plots \( \pi_{t+1} - \pi_t \) as a function of \( \beta_t \) for two different \( \bar{d} \) values (low and high). Assuming \( \beta = \hat{\beta} \) and that the median fiscal deficit level is high, if the government continues with this deficit level, inflation will converge to a high equilibrium.
Figure 12
DYNAMICS INDUCED BY RATIONAL EXPECTATIONS

A. INFLATION AND EXPECTATIONS

\[ \pi_{t+1} - \pi_t \]

\[ \beta_t \]

B. FISCAL DEFICIT, INFLATION AND EXPECTATIONS

\[ \pi_{t+1} - \pi_t \]

\[ \beta_t \]

Note: These figures considers $\beta_{t-1} = 1.02$ and the estimated parameters shown in Table 1.
and its expectations to $\beta_2$. However, if the government reduces its fiscal deficits, it will change the dynamics on inflation and its expectations inducing a convergence to $\beta_1$.

Figure 12 points out an important difference between rational expectations and CGE: when agents use the CGE algorithm, if the inflation rate induces a high $\beta$, then this could provoke an escape dynamics and eventually a hyperinflation episode, where the dynamics between inflation and its expectations are unbounded. However, with rational expectations, even with an extremely high fiscal deficit, agents always adapt their expectations to prevent a hyperinflation spiral. If fiscal deficit is high, rational expectations imply a stable equilibrium with a high inflation rate and no escapes.

Even though CGE and rational expectations induce different dynamics on the variables involved in the model, the inflation equilibria they predict are similar. Sargent et al. (2009) argue that, in the context of hyperinflation models, “an adaptive expectations version of the model shares steady states with the rational expectations version, but has more plausible out-of-steady state dynamics.” Besides, rational expectations may induce multiple equilibria that are hard to compute. Given the computational problem rational expectations may induce and the fact that some Latin American countries have experienced hyperinflation episodes with escape dynamics which a strictly rational expectations model cannot account for, CGE are necessary for the purposes of this study.

6.3 Exchange Rate Regimes

The table in this Annex presents the different regimes that the peso-dollar NER has had between 1954 and 2016. Before 1994, this NER had several regimes that can be considered slight variations of a fixed NER rule. For example: (i) controlled variation, in which the Banco de México established an interval in which the NER was allowed to vary; (ii) generalized controlled system, in which all credit institutions needed an authorization from the Central Bank to sell or buy currencies; and (iii) controlled flotation, in which Banco de México established an interval, changed daily, within which the NER was allowed to fluctuate.
Table 4

EXCHANGE RATE REGIMES IN MEXICO DURING 1954-2016

<table>
<thead>
<tr>
<th>Date</th>
<th>Regime</th>
<th>Beginning</th>
<th>End</th>
<th>Beginning</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 1954</td>
<td>Fixed</td>
<td>12.50</td>
<td>12.50</td>
<td>12.50</td>
<td>12.50</td>
</tr>
<tr>
<td>September 1976</td>
<td>August 1982</td>
<td>20.50</td>
<td>48.80</td>
<td>20.50</td>
<td>48.80</td>
</tr>
<tr>
<td>September 1982</td>
<td>December 1982</td>
<td>50.00</td>
<td>70.00</td>
<td>50.00</td>
<td>70.00</td>
</tr>
<tr>
<td>December 1982</td>
<td>August 1985</td>
<td>95.00</td>
<td>281.00</td>
<td>95.00</td>
<td>281.00</td>
</tr>
<tr>
<td>August 1985</td>
<td>November 1991</td>
<td>282.30</td>
<td>3,073.00</td>
<td>282.30</td>
<td>3,073.00</td>
</tr>
</tbody>
</table>

Notes: N denotes New Mexican Pesos.
Source: Banco de México.

References


