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Inflation Dynamics under Fiscal Deficit Regime Switching in Mexico*

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Abstract: We explore the dynamics of inflation, inflation expectations, and seigniorage-financed fiscal deficits in Mexico. To do so, we estimate the model in Sargent, Williams, and Zha (2009) using Mexican CPI inflation data. This model features dual expected inflation equilibriums and regime switching in the mean and variance of the fiscal deficit probability density function. We examine the dynamics of inflation and mean fiscal deficit regimes. In addition, we comment on the extent to which our results match to key economic events. Mexico has successfully stabilized inflation expectations for the past decades, an achievement for which fiscal policy has been fundamental. Nevertheless, this does not preclude the possibility of an increase in the expected price level or a switch to a regime in which inflation and its expectations become unstable.
Keywords: Inflation, Inflation Expectations, Public Deficit, Fiscal Deficit, Regime-Switching, Monetary Policy, Fiscal Policy.
JEL Classification: E31, D84, H62, E52, E62, C01

Resumen: Exploramos la dinámica de la inflación, expectativas de inflación y déficits financiados por señoreaje en México. Para ello, estimamos el modelo de Sargent, Williams y Zha (2009) usando datos de la inflación del IPC de México. Este modelo se caracteriza por equilibrios de inflación esperada duales y cambios en régimen para la media y la varianza de la densidad de probabilidad del déficit fiscal. Examinamos la dinámica de la inflación y de los regímenes de la media del déficit fiscal. Adicionalmente, comentamos hasta qué punto nuestros resultados corresponden a eventos económicos claves. México ha estabilizado exitosamente sus expectativas de inflación en las décadas pasadas, un logro para el cual la política fiscal ha sido fundamental. Sin embargo, esto no excluye la posibilidad de un incremento en el nivel de precios esperado o un cambio a un régimen en donde la inflación y sus expectativas se vuelvan inestables.
Palabras Clave: Inflación, Expectativas de Inflación, Déficit Público, Déficit Fiscal, Cambio de Régimen, Política Monetaria, Política Fiscal.

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"Inflation is always and everywhere a monetary phenomenon".
Milton Friedman (1970)

"In Latin America, inflation is always and everywhere a fiscal phenomenon".
Thomas J. Sargent (2018)

1. Introduction

Understanding the relationship between monetary and fiscal policies is paramount to their successful implementation. A plausible way of exploring such a relationship is to consider the intertemporal aggregate government budget constraint.[1] Essentially, it implies that the nominal government debt, standardized by the price level, is equal to the expected real tax revenues minus government expenditures plus seigniorage. Such an equation has in general two interpretations.

Under Ricardian equivalence, it is a constraint. Thus, for instance, a tax increase must eventually accompany a rise in government expenditures. If it is perceived that the expected present value of net tax revenues is insufficient to back the government's nominal debt, the government would need to increase its seigniorage, having no other source of income. Such an increase would put pressure on the price level, a situation known as fiscal dominance (Sargent and Wallace, 1981).

A related strand of the literature entertains the possibility of non-Ricardian policies. Under this assumption, it is an equilibrium condition, in which the price level adjusts so the equation is satisfied. Consequently, for example, increments in government expenditures do not necessarily lead to tax adjustments. Instead, such increments can directly lead to raises in the price level. This interpretation is central to the fiscal theory of the price level (Leeper, 1991).[2] In any case, both interpretations underscore the interdependence between monetary and fiscal policies.

[1] It is aggregate in the sense that it includes the fiscal and central bank's budget constraints.
[2] This theory has been subject to criticisms (e.g., see Buiter, 2001).

Against this backdrop, our main goal is to explore the relationship between three key macroeconomic variables of Mexico: inflation, inflation expectations (i.e., beliefs), and seigniorage-financed deficits. To that end, we estimate the model posited in Sargent, Williams, and Zha (2009), using Mexican monthly CPI inflation data from February 1969 to September 2018. In their model, the fiscal deficit follows a probability distribution with mean and variance that, in turn, follow Markov-switching regimes. This allows us to obtain the model-implied inflation expectations, seigniorage-financed deficits, and the regime dynamics determining such deficits.

We have a keen interest in exploring the relationship between inflation dynamics and the referred regimes. In addition, we consider the stability of inflation expectations. As we will see, if they pass some threshold, they become unstable. If such is the case, a reform would need to take place.

Anticipating our main results, we make the following remarks. First, the 1982 and 1994 crises were closely associated with periods during which the high-mean deficit regime predominated. It was only in the aftermath of such crises that the medium-mean deficit regime took hold. We interpret regime switches towards the medium- and low-mean deficit regimes as the product of reforms, which had varying degrees of success.[3]

Second, inflation expectations became unstable during the 1980s. However, they regained their stability in the aftermath of the 1994 crisis, also referred to as the Tequila Crisis. After the last switch to a low-mean deficit regime, the probability of being in such a regime has generally stayed close to one. This is a favourable result for the stability of inflation and its expectations in Mexico.

[3] More generally, in most economic crises, regardless of where the difficulties originate, public finances eventually absorb a large part of, if not all, the cost, leading to significant increments in deficits, as well as public debt levels.

Third, we explore the extent to which the model-implied variables relate to key economic events. In several episodes, fiscal adjustments proved insufficient to lower and stabilize inflation and its expectations. Further measures, such as incomes policies and external debt renegotiation, were crucial to attain their stability.

The consolidation of low and stable inflation and of the low-mean deficit regime are important achievements, although they should not be taken for granted. In effect, as time leaves crises episodes behind, a growing young society can gradually forget them.

2. An Abridged Literature Review

We divide our literature review into two parts. In the first one, we discuss general papers on the subject. In the second part, we briefly review some papers on the subject that focus on the Mexican economy.

Cagan (1956), in his classic paper, studies dual inflation equilibriums. He is interested in maximizing seigniorage given a semi-logarithmic money demand and an inflation expectations formation mechanism.[4] He shows that for any feasible level of seigniorage, there are two inflation equilibriums, a consequence of the shape of the demand for money. One equilibrium is associated with low and the other with high inflation.[5] This result is akin to the renowned Laffer curve, in which, for the same level of tax revenue (seigniorage), there are a low tax rate (inflation) and a high tax rate (inflation) equilibriums.

Sargent and Wallace's (1981) seminal article provides a framework to assess several features of the relationship between monetary and fiscal policies. They examine the implications of the intertemporal aggregate government budget constraint.[6] In particular, they characterize a situation in which agents deem that the expected net tax revenues are insufficient to back the

[4] Note that Cagan (1956) does not consider a budget constraint.
[5] The exception is the point at which seigniorage is at its maximum, which is associated with a unique inflation equilibrium.
[6] Again, it is aggregate in the sense that it includes the fiscal and central bank's budget constraints.

nominal government debt. Under such circumstances, the government might have to obtain further seigniorage to back its debt and use monetary policy to do so, thereby submitting it to its fiscal needs. This framework, although quite simple, has led to powerful insights like fiscal dominance.

Bruno and Fischer (1990) study dual inflation equilibriums concerning their stability under seigniorage-financed deficits. The authors highlight that, in general, under adaptive (rational) inflation expectations, the high inflation equilibrium is unstable (stable) and the low inflation equilibrium is stable (unstable).[7] Similar to Cagan (1956), they use a semi-logarithmic money demand and use adaptative expectations, but include a government budget constraint.

In their model, the economy might find itself trapped in a high inflation equilibrium, although a low inflation equilibrium is feasible with the same public financing needs. Furthermore, the authors show that when allowing for bond financing of deficits, one of the equilibriums disappears if, for example, the government fixes the nominal growth rate of money. Intuitively, allowing for bond financing, the government gains flexibility; by fixing the nominal growth rate of money, it gains credibility. They underscore that dual equilibriums are avoidable, because they are the product of the operating rules set in place.

Bruno (1989) is concerned about the design of economic reforms.[8] He conceives a reform as a planned transition from the economy being in a high-inflation equilibrium to a low-inflation one, which is Pareto superior. He applies this rationale to an inflation stabilization program implemented in Israel. Such a program entailed budget and external accounts corrections, and incomes policies (i.e., wage and price controls). Beyond the fiscal adjustment necessary to bring inflation to a low and stable level, these actions play a central role in coordinating inflation expectations towards a low-inflation equilibrium.

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[7] The stability of the two inflation equilibriums depends on the product of the semi-elasticity of money (λ) demand times the adaptative expectations parameter (ν). See Bruno (1989) and Bruno and Fischer (1990) for further details.

[8] He uses Bruno and Fischer's (1990) model. Although Bruno and Fischer (1990) published their paper after Bruno (1989), a working paper was available a few years prior.

Sargent et al. (2009) explore the relationship between inflation, inflation expectations, and seigniorage-financed deficits in the five South American economies of Argentina, Bolivia, Brazil, Chile, and Peru. Their framework also consists of a demand for money, an intertemporal public budget constraint, and an inflation expectations formation mechanism.[9] In addition, they consider a regime-switching process that affects the distribution of the seigniorage-financed deficit. In particular, they examine the stability of inflation expectations when these are formed under certain learning mechanisms, considering the economy's intertemporal budget constraint and money demand and where the economy's deficit can find itself in one of these regimes (e.g., high, medium, and low).

More specifically, they explore the extent to which changes in inflation and inflation expectations relate to the fiscal deficit probability distribution that follows a regime. They document that regime state transitions typically come about when economies confront the possibility or realization of unstable inflation expectations. As we describe in more detail, these authors distinguish between two types of reforms. First, reforms that take inflation expectations to a level at which they are stable but no regime switching takes place, referred as *cosmetic reforms*. Second, reforms that lead to stable inflation expectations due to a regime switch, called *fundamental reforms*. In this paper, we implement their model for Mexico.

In the literature related to Mexico, we mention the following papers. Ortiz (1991) discusses the stabilization program following the 1982 crisis. He argues that such a program brought inflation down and avoided a recession. It distinctly involved structural reforms besides fiscal and incomes policies, entailing trade liberalization, deregulation, and the privatization of some government-owned firms. Two elements were central to the program: the accord that included incomes policies and external debt negotiation. We will discuss these events later.

[9] One can think of their demand as an approximation to a semilogarithmic demand.

Gil-Díaz and Carstens (1996a) explore how the fiscal and trade reforms in Mexico could have led its economy into the crisis related to the December 1994 exchange rate devaluation. They contend that researchers time and again mention the political events in 1994 in passing or as a trigger, and not as a source. After having explored some of the hypotheses advanced, the authors claim that the crisis had a political origin. They argue that certain factors contributed to the crisis; including the fixed nominal exchange rate regime and an upsurge in international transactions (see also Gil-Díaz and Carstens, 1996b).[10]

Ramos-Francia and Torres (2005) assess the role of monetary policy in the disinflation process during the 1994–2003 period in the Mexican economy. They argue that, once an economy establishes a sustainable fiscal position, an inflation-targeting framework functions as a disciplinary mechanism for monetary policy. In addition, they describe the key measures taken to stabilize the economy after the 1994 crisis and argue that such measures prevented fiscal dominance. They contend that the central bank's policy responses have been consistent with inflation targeting principles.

Meza (2018) analyses the monetary and fiscal history of Mexico using as a framework the model of Sargent and Wallace (1981). He studies the 1960–2007 period, assessing the ability of the model to explain the 1982 and 1994 crises. He claims that it explains the 1982 crisis, but fails to explain the 1994 crisis. In addition, he argues that the constitutional changes—regarding the relationship between the government and central bank— and the policy choices made in the aftermath of the 1994 crisis were in line with a transition from fiscal dominance to an operationally independent central bank.[11]

[10] Musacchio (2012) argues that the excessive eagerness of foreign investors and weak regulation of the banking system led to a buildup of vulnerabilities that left Mexico exposed to variations in investors' sentiment. The political events in Mexico along with changes in U.S. monetary policy led to significant changes in investors' perception of the future of Mexico.

[11] While our paper was being reviewed in the Banco de México's Working Papers editorial process, Lopez-Martin et al. (2018) was published as a working paper. As both papers use the model in Sargent et al. (2009), their main differences are worth highlighting. The estimation samples used are different. We used a more recent one. Lopez-Martin et al. (2018) seem to be using year-to-year growth of the price level, while we use seasonally adjusted month-to-month growth of the price level. More

3. Model

The model has three building blocks. The first block entails a money demand and the government's budget constraint:

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

$$M_t = \theta M_{t-1} + d_t(m_t, \varsigma_t)P_t, \tag{2}$$

where M_t is the nominal money demand as a percentage of output at period t, P_t is the price level, P_{t+1}^e is the expectation of the price level in the next period, and d_t is the portion of the government's real deficit financed through seigniorage. Such a deficit follows a probability distribution, which depends on m_t and ς_t, its mean and variance.

Furthermore, the parameter θ adjusts the money supply for growth in real output and for direct taxes on cash balances, if any. We have the restrictions $0 < \lambda < 1$, $0 < \theta < 1$ and $\gamma > 0$. The parameter λ measures the sensitivity of money demand to changes in expected inflation and γ is a scale parameter. Thus, the demand for real money M_t / P_t depends negatively on the expected price level. In effect, a higher inflation implies a higher opportunity cost of holding money.

We assume that the deficit distribution's parameters (m_t and ς_t) follow two independent Markov chains, with the following transition probabilities:

$$\Pr(m_{t+1} = j \mid m_t = i) = p_{i,j}, \qquad i,j = 1, \dots, m_h, \tag{3}$$

$$\Pr(\varsigma_{t+1} = l \mid \varsigma_t = k) = q_{k,l}, \qquad k,l = 1, \dots, \varsigma_h. \tag{4}$$

importantly, we focus on the narrative on how the economic events match to the model estimations. On their part, they incorporate the nominal exchange rate and the sovereign debt premium in the inflation expectations formation mechanism.

There is then a total of $m_h \times \varsigma_h$ possible states for the deficit distribution parameters. As is common, we stack the probabilities defined in (3) and (4) in matrices denoted by Q_m and Q_ς, respectively, where $[Q_m]_{i,j} = p_{i,j}$ and $[Q_\varsigma]_{k,l} = q_{k,l}$. Additionally, we denote the transition probability matrix of the joint state $s_t \equiv (m_t, \varsigma_t)$ as Q_s. Because the Markov chains are independent, we have that $Q_s = Q_m \otimes Q_\varsigma$, where $\otimes$ denotes the Kronecker product between matrices.

For the second block of the model, the fiscal deficit d_t in equation (2) is modelled as $d_t(m_t, \varsigma_t) = \bar{d}(m_t) + \varepsilon_d(\varsigma_t)$, where $\bar{d}(m_t)$ is the mean deficit level for state m at period t and the shock $\varepsilon_d(\varsigma_t)$ has a lognormal density function $p_d(\varepsilon_d|s_t)$, where

$$p_d(\varepsilon_d|s_t) = \begin{cases} \dfrac{\exp\left\{\left[-\log\left[\bar{d}(m_t) + \varepsilon_d\right] - \log \bar{d}(m_t)\right]^2 / (2\sigma_d^2(\varsigma_t))\right\}}{\sqrt{2\pi}\sigma_d(\varsigma_t)\left[\bar{d}(m_t) + \varepsilon_d\right]}, & \varepsilon_d > -\bar{d}(m_t) \\ 0 & , \varepsilon_d \leq -\bar{d}(m_t). \end{cases} \tag{5}$$

This distribution, being lognormal, bounds the deficit to be positive. In other words, $\log d_t(m_t, \varsigma_t)$ follows a normal distribution with mean $\log \bar{d}(m_t)$ and variance $\sigma_d(\varsigma_t)^2$.

The third block of the model is the inflation expectations (i.e., beliefs) formation mechanism. Typically, under rational expectations, the expected level of prices P_{t+1}^e is set equal to its mathematical expectation $\mathbb{E}_t[P_{t+1}]$. Instead, the model assumes a mechanism, with constant-gain learning. We then have the following adaptative expectations mechanism:

$$\pi_{t+1}^e \equiv \frac{P_{t+1}^e}{P_t} = \beta_t, \tag{6}$$

with

$$\beta_t = \beta_{t-1} + \nu(\pi_{t-1} - \beta_{t-1}), \tag{7}$$

where $0 < \nu \ll 1$ and π_t denotes *gross inflation*, defined as P_{t+1}/P_t. [12] One could consider more general learning mechanisms. Yet, such a mechanism is relevant to the stability of inflation expectations and helps in the construction of the likelihood function. We use the terms inflation expectations, inflation beliefs and beliefs interchangeably.

Additional Restrictions on Inflation Expectations

Consider the demand for money, equation (1); the government budget constraint, equation (2); and the inflation expectation mechanism, equation (7). One can then obtain the following expression for the equilibrium inflation:

$$\pi_t = \frac{\theta(1-\lambda\beta_{t-1})}{1-\lambda\beta_t-\gamma d_t(s_t)}, \tag{8}$$

provided that the numerator and denominator are positive. In this context, β_t and β_{t-1} need to satisfy the following two inequalities:

$$1-\lambda\beta_{t-1} > 0, \tag{9}$$

$$1-\lambda\beta_t-\gamma d_t(s_t) > \delta\theta(1-\lambda\beta_{t-1}), \tag{10}$$

for a small positive constant δ. Restriction (9) implies that the price level and money stock are positive in period $t-1$.[13] Restrictions (9) and (10) ensure that the price level and money stock are positive in period t.[14] Restriction (10) makes δ^{-1} an upper bound for gross inflation.[15] Such a bound is a necessary condition for the existence of a self-confirming equilibrium (SCE), which we later define.

In sum, first, based on the three aforementioned blocks, it is possible to obtain the likelihood function of inflation, which we use to estimate the model. Sargent et al. (2009) present an

[12] Constant-gain learning means that ν is constant. There are, however, some rules that are more general. For example, there are some for which such a parameter might be a function of the state.

[13] Rewrite equation (8) as $\gamma M_{t-1}/P_{t-1} > 0$.

[14] Rewrite restriction (9) as $\gamma M_t/P_t > \delta\theta(\gamma M_{t-1}/P_{t-1}) + \gamma d_t(s_t)$.

[15] Rewrite restriction (9) as $(1-\lambda\beta_t-\gamma d_t(s_t))/(\theta(1-\lambda\beta_{t-1})) > \delta$, which leads to $\pi_t < \delta^{-1}$.

explicit derivation of such a likelihood. Second, the model has three central variables: inflation, inflation expectations, and seigniorage-financed deficits. Third, inflation is the only input variable with which we estimate the model. Fourth, the mean and variance regime states are unobservable to the econometrician. One can only estimate the probability of being in a certain regime state in a given period t. Accordingly, we interpret a probability close to one in a given period as indicative of the regime state in the economy in that period.

4. Preliminaries

In this section, we consider a deterministic version of the model. Thus, the mean deficit state m is fixed (i.e., known), and shocks ε_d are set equal to zero for all t. Next, consider the money demand, equation (1), the government budget constraint, equation (2), and the deficit degenerate distribution, equation (3), with which we obtain:

$$\pi_t(1-\lambda\pi_{t+1}) = \theta(1-\lambda\pi_t) + \pi_t\gamma\bar{d}(m).$$

$\pi(m)$ will have two solutions, the deterministic steady-state equilibriums (SSEs). Such solutions are:

$$\pi_1^*(m) = \frac{1+\theta\lambda-\gamma\bar{d}(m)-\sqrt{\left[1+\theta\lambda-\gamma\bar{d}(m)\right]^2-4\theta\lambda}}{2\lambda},$$

$$\pi_2^*(m) = \frac{1+\theta\lambda-\gamma\bar{d}(m)+\sqrt{\left[1+\theta\lambda-\gamma\bar{d}(m)\right]^2-4\theta\lambda}}{2\lambda}.$$

We note that $\pi_1^*(m) \leq \pi_2^*(m)$, hence, the first solution is the low-inflation SSE, and the second is the high-inflation SSE. On the one hand, when $\gamma\bar{d}(m)$ is equal to $1+\theta\lambda-2\sqrt{\theta\lambda}$, both SSEs are equal to $\sqrt{\theta/\lambda}$.[16] On the other hand, if $\bar{d}(m) = 0$, the high-inflation SSE has λ^{-1} as an upper bound.[17] To assure the existence of the SSEs, one needs to impose condition that $\gamma\bar{d}(m) < 1 + \theta\lambda - 2\sqrt{\theta\lambda}$ in the model. This inequality relates to the upper bound of seigniorage.

These equilibriums are akin to those of Bruno and Fischer (1990). Nonetheless, one is interested in equilibriums that are more general, particularly, those in which there are stochastic shocks pounding the deficit and Markov chains affecting the deficit distribution. To that end, we provide the following definition (Sargent et al., 2009).

Definition 1. *Self-confirming equilibrium* (*SCE*). For each m-state, a fixed-m SCE is a probability distribution over inflation histories $\pi^T \equiv \{\pi_1, \pi_2, \ldots, \pi_T\}$ and $\beta(m)$ such that:

$$\mathbb{E}[\pi_t | m_t = m \ \forall t] - \beta(m) = 0.$$

Although the mean deficit state m can change and agents have adaptative expectations, when the deficit regime process is highly persistent, a SCE represents a satisfactory approximation to the steady-state expectations.[18]

In the context of Sargent et al. (2009), when agents are confident about their previous beliefs, specifically meaning that they more closely rely on them to form their beliefs for the following period (i.e., when ν converges to 0), inflation beliefs converge to the solution of an ordinary differential equation of the following form:[19]

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[16] If $\gamma\bar{d}(m) = 1 + \theta\lambda - 2\sqrt{\theta\lambda}$, then $\left[1 + \theta\lambda - \gamma\bar{d}(m)\right]^2 = 4\theta\lambda$, which means $\pi_1^*(m) = \pi_2^*(m)$. It follows that $\pi_1^*(m) = \pi_2^*(m) = \frac{2\sqrt{\theta\lambda}}{2\lambda} = \frac{\sqrt{\theta}}{\sqrt{\lambda}}$.

[17] If $\bar{d}(m) = 0$, then $\pi_2^*(m) = \frac{1+\theta\lambda+\sqrt{[1+2\theta\lambda+\theta\lambda\theta\lambda]^2-4\theta\lambda}}{2\lambda} = \frac{1+\theta\lambda+\sqrt{[1-\theta\lambda]^2}}{2\lambda} = \frac{1}{\lambda}$.

[18] Intuitively, if the process is highly persistent, m_t will remain in the same regime state for a longer time. This will allow the adaptative expectations mechanism to get closer to π_t, hence improving $\mathbb{E}[\pi_t | m_t = m \ \forall t] - \beta(m) = 0$ as an approximation.

[19] The convergence is weak (Sargent et al., 2009), i.e., convergence in distribution.

$$\dot{\beta} = \hat{G}(\beta, m), \tag{11}$$

where a fixed-m SCE is a fixed point of the function $\hat{G}(\beta, m)$ for each m. Thus, inflation beliefs converge to a limit that only depends on m. Considering the adaptative expectations mechanism, demand for money, and budget constraint, one obtains the following expression:

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

which takes the form of equation (11) when ν and the time difference converge to zero. We refer the interested reader to Sargent et al. (2009) and Kushner and Yin (1997) for further details.

Specifically, for each m, based on equation (11), there exist two conditional SCEs: a low-inflation stable SCE denoted by $\beta_1^*(m)$ and a high-inflation unstable SCE denoted by $\beta_2^*(m)$. The dual equilibriums are partly due to the nonlinearity of the budget constraint.[20] We have that $\beta_1^*(m)$ is smaller than $\beta_2^*(m)$. Importantly, $\beta_1^*(m)$ is a stable SCE (i.e., $\hat{G}' < 0$) and $\beta_2^*(m)$ is an unstable one (i.e., $\hat{G}' > 0$). Furthermore, we point out that $\beta_2^*(m)$ is an upper bound of the domain of attraction of $\beta_1^*(m)$, the stable SCE. If inflation expectations are such that $\beta_t > \beta_2^*(m)$, then they become unstable, and restrictions (8) and (9) will no longer hold.

When the model switches, for instance, from a low- to medium-mean deficit regime, $\beta_2^*(m)$ decreases. Accordingly, the domain of attraction of $\beta_1^*(m)$ shrinks. Analytically, we have $\beta_2^*(m_{low}) \geq \beta_2^*(m_{medium})$. A higher mean-deficit regime not only leads to a greater level of inflation, but also to a smaller domain in which inflation expectations are stable.

As a side note, although SCEs are more general, they retain much of the logic of the SSEs in Bruno and Fischer (1990). For instance, their stability depends on the expectations formation

[20] In this model, the demand for money is linear with respect to gross inflation and inflation. The nonlinearity of the budget constraint leads to the dual inflation equilibriums or, more generally, the dual SCEs.

mechanism. Of course, their models have some key differences. Bruno and Fischer's (1990) model does not feature regimes in the deficit. Nonetheless, exogenous variations in its deficit affect the dual inflation equilibriums as a mean-deficit regime switch in Sargent et al. (2009).

As mentioned, the definition of SCE applies for each m-state and determines the stability regions of inflation expectations. Whereas the agent learns about its inflation beliefs following the rule in equation (6), the SCEs represent the average dynamics of such expectations as $\nu \rightarrow 0$. They will be close to the actual dynamics if the deficit state m is persistent.

In what follows, we review some key features of the model that are relevant when $\beta_t > \beta_2^*(m)$. If such were the case, inflation and inflation expectations become unstable, and the model generally breaks down. For instance, the equilibrium inflation would then be undefined. To that end, we provide the following definitions from Sargent et al. (2009).

Definition 2. An *escape* takes place if $\beta_t > \beta_2^*(m)$. This is when inflation beliefs are outside the domain of attraction of $\beta_1^*(m)$, the low and stable SCE.

Definition 3. A *reform* is called for when, without it, conditions (8) and (9) would be violated as long as the regime state m remains constant.

Definition 4. A *fundamental reform* takes place when, under its implementation, the mean-deficit state m switches for the initial β_{t-1} to satisfy conditions (8) and (9).

Definition 5. A *cosmetic reform* occurs when a reform is called for, the current regime state m remains the same, and inflation and inflation expectations are reset.[21] Such resets occur by setting inflation and its expectation to the inflation's low deterministic SSE value $\pi_1^*(m)$ plus some noise:

[21] Sargent at al. (2009) also consider cosmetic reforms in which only the inflation resets.

$$\pi_t^* = \pi_1^*(m_t) + \varepsilon_\pi,$$

where ε_π has the following probability density:

$$p_\pi(\varepsilon_\pi|m_t) = \frac{\exp\{-[\log[\pi_1^*(m_t)+\varepsilon_\pi] - \log \pi_1^*(m_t)]^2/2\sigma_\pi^2\}}{\sqrt{2\pi}\sigma_\pi[\pi_1^*(m_t)+\varepsilon_\pi]\Phi[(-\log\delta - \log[\pi_1^*(m_t)])/\sigma_\pi]}$$

if $-\pi_1^*(m_t) < \varepsilon_\pi < \frac{1}{\delta} - \pi_1^*(m_t)$, and $p_\pi(\varepsilon_\pi|m_t) = 0$ in all other cases. These last two inequalities ensure that inflation is always positive and less than its upper bound δ^{-1}.[22]

Given β_t and β_{t-1}, we consider shocks on the deficit that would *contribute* to an escape event. Consider, then, again that $d(m_t, \varsigma_t) = \bar{d}(m_t) + \varepsilon_d(\varsigma_t)$, where $\varepsilon_d(\varsigma_t)$ is as in equation (5). We then have $\underline{\omega}_t(m_t)$, defined as the value of $\varepsilon_d(\varsigma_t)$ such that $\pi_t = \beta_2^*(m)$, and $\bar{\omega}_t(m_t)$, defined as the value of $\varepsilon_d(\varsigma_t)$ such that $\pi_t = \delta^{-1}$ (i.e., its upper bound). Centrally, such inflation realizations would drive inflation expectations towards their unstable domain. One can prove that their values are as follows:[23]

$$\begin{aligned}
\underline{\omega}_t(m_t) &= 1 - \lambda\,\beta_t - \theta(1-\lambda\beta_{t-1})\beta_2^*(m_t)^{-1} - \bar{d}(m_t),\\
\bar{\omega}_t(m_t) &= 1 - \lambda\,\beta_t - \theta(1-\lambda\beta_{t-1})\delta - \bar{d}(m_t).
\end{aligned}$$

Conditional on the regime state the model is in during period t, the probability of an escape-provoking event is:

[22] Note that $\pi_t^* = \pi_1^*(m_t) + \varepsilon_\pi > 0$ if and only if $\varepsilon_\pi > -\pi_1^*(m_t)$. Moreover, if $\varepsilon_\pi < \frac{1}{\delta} - \pi_1^*(m_t)$, then $\pi_t^* = \varepsilon_\pi + \pi_1^*(m_t) < \delta^{-1}$.

[23] The problem is to find the value of $\varepsilon_d(\varsigma_t)$ such that $\pi_t = x$ for the given level of expectations β_t and β_{t-1}. Consider then $\gamma\bar{d}(m) < 1 + \theta\lambda - 2\sqrt{\theta\lambda}$ with $\gamma = 1$ and $d(s_t) = \bar{d}(m_t) + \varepsilon_d(\varsigma_t)$. This implies that $x = \theta(1-\lambda\beta_{t-1})/\big(1 - \lambda\beta_t - \bar{d}(m_t) - \varepsilon_d(\varsigma_t)\big)$, which in turn implies that $\varepsilon_d(\varsigma_t) = 1 - \lambda\,\beta_t - \theta(1-\lambda\beta_{t-1})x^{-1} - \bar{d}(m_t)$.

$$\Pr\{\underline{\omega}_t(m_t) < \varepsilon_d(\varsigma) < \bar{\omega}_t(m_t) | s_t = s\} = F_d(\bar{\omega}_t(m_t)|s_t = s) - F_d(\underline{\omega}_t(m_t)|s_t = s).$$

This is the probability of having a shock to the deficit that would lead inflation to be greater than $\beta_2^*(m)$ but smaller than δ^{-1}. More generally, given that the regime state the economy is in period t is unobserved, the escape-provoking event probability is:[24]

$$\iota\{\beta_{t-1} < 1/\lambda\} \sum_{s_0=1}^{h} \Pr(s_t = s_0 | \pi^{t-1}, \phi) \left[F_d(\bar{\omega}_t(m_0|s_0)) - F_d\left(\underline{\omega}_t(m_0|s_0)\right)\right],$$

where ι is an indicator function that is equal to one when the inequality $\beta_{t-1} < 1/\lambda$ is satisfied. We note that if $\beta_{t-1} \geq 1/\lambda$, a reform will occur with probability one.

Additionally, we must determine the parameters γ, δ and θ. The parameter γ is invariant to a renormalization of $\bar{d}_m$ and $1/\gamma$ by some constant.[25] Without loss of generality, we set $\gamma = 1$ and $\delta = 0.01$. Finally, we assume that $\theta = 0.99$. These values are in line with those used in Sargent et al. (2009).

One key aspect of the model is the number of deficit regime states, which is fixed before the estimation. To determine it, we use the Bayesian Information Criteria (BIC) for the inflation conditional likelihood function $p(\pi^T|\boldsymbol{\phi})$. Specifically, we compare the likelihood function values across three model specifications: three regimes for m and two for ς, two for m and two for ς, and one for each (i.e., there are no regimes).

The referred criterion favours the model with three regimes for m and two for ς specification, denoted by 3×2. In addition, we verify that the probability of being in a specific regime is strictly positive for at least some periods. If such a probability were equal to zero for all periods, the associated regime state would likely be unwarranted. In the case of the 3×2

[24] This follows from the law of total probability.
[25] It determines a standardization of the price level.

model, we impose the following restrictions on the transition matrices. Following Sims et al. (2008) and Sargent et al. (2009), such matrices have the following forms:

$$Q_m = \begin{pmatrix} p_{11} & 1-p_{11} & 0 \\ \frac{1-p_{22}}{2} & p_{22} & \frac{1-p_{22}}{2} \\ 0 & 1-p_{33} & p_{33} \end{pmatrix} \text{ and}$$

$$Q_\varsigma = \begin{pmatrix} q_{11} & 1-q_{11} \\ 1-q_{22} & q_{22} \end{pmatrix}.$$

These restrictions have two implications for the Markov chain associated with the mean. Any switch between the first and third or between the third and first deficit regimes, must go through the second regime state. If the Markov chain is at some point in the second regime state, it has an equal probability of switching to the first or third regime states. This simplifies the estimation of the model, instead of eight probabilities, we only estimate five. Of course, the restrictions for Q_ς are as usual. [26]

5. Data

We use the month-to-month inflation based on the seasonally adjusted consumer price index from the National Statistics Institute (*Instituto Nacional de Estadística y Geografía*, INEGI). In our estimation, such a series starts in February 1969 and ends in September 2018 (Fig. 1).

Our estimation provides an implied seigniorage-financed deficit series. A natural exercise, then, is to compare such series with several measures of the fiscal deficit. Hence, we use the economic balance series, a common measure of the fiscal deficit.[27] In addition, we use the

[26] We impose bounds on p_{ii} and q_{jj}. Being probabilities, they must be greater than zero and less than one, where $i = 1, 2,$ and 3, and $j = 1$ and 2.

[27] The economic balance (also known in Mexico as the traditional balance) equals the government's revenues minus its expenses. The revenues include tax collection, social security fees and rights, revenue from financing entailing the sale of goods and services, and financial products and recovery value from sales of fixed assets, among others. The expenses category includes those needed for

Public Sector Borrowing Requirements (PSBR) series, a much broader measure of the fiscal deficit. Yet, the economic balance series has a longer history than that of the PSBR.[28] We use this series with an annual frequency.

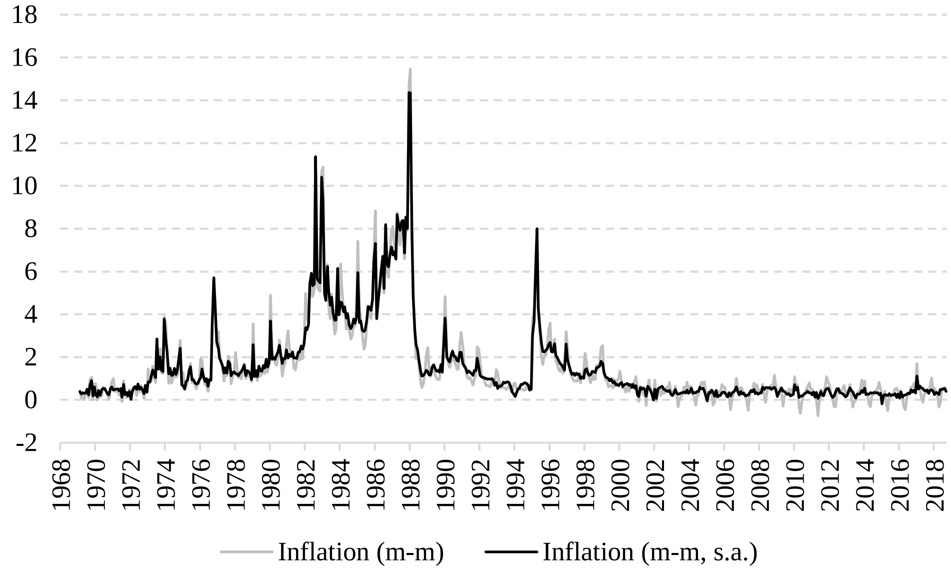

Figure 1. Mexican Inflation.
Notes: Month-to-month (m-m) percentage change of the CPI; s.a. stands for seasonally adjusted time series. The sample is February 1969–September 2018. Monthly frequency.
Source: Own estimations with data from INEGI.

More specifically, the economic balance series is available from 1977 to 2017. Because the estimation methodology for the PSBR was changed, we concatenate the growth rates of the two time series when available. The first, using the former methodology, is available for the 1990–2014 period, and the second, using the more recent one, is available for the 2000–2017 period. Such series are from the Mexican Ministry of Finance (*Secretaría de Hacienda y Crédito Público*, SHCP). It is worth reemphasizing that we use these series only for comparison purposes and not as part of the estimation.

public sector operation such as personnel services payments, materials, supplies and general services, capital accumulation, public debt service, subsidies, and transfers to the private and social sectors (SHCP, 2014).

[28] See Appendix A for a description of the PSBR (*RFSP*, in Spanish).

6. Model Estimation

We estimate the model by solving the following problem:

$$\max_{\boldsymbol{\phi}} p(\pi^T|\boldsymbol{\phi}),$$

where $p(\pi^T|\boldsymbol{\phi})$ is the inflation's likelihood function based on the model. Specifically, the parameter vector is $\boldsymbol{\phi} = (\nu, \lambda, \bar{d}_{\{1,2,3\}}, \sigma_{\{1,2\}}, p_{i,i}, q_{j,j}, \sigma_\pi)$, where $i = 1, 2, 3$ and $j = 1, 2$. As can be seen, $\boldsymbol{\phi}$ contains the inflation shocks' standard deviation σ_π, which we have introduced in Definition 5.

To estimate the model's parameters, we use a numerical optimization algorithm.[29] Our initial estimations suggest that the optimal estimate is sensitive to the initial values of $\boldsymbol{\phi}$, in particular to ν, λ and σ_π. Hence, we build a three-dimensional grid with 200 triplets to assess systematically diverse initial points. In turn, we consider the resulting estimated point and construct a new grid around its vicinity. The optimization program iterates on such a grid, searching for a final estimate. Of course, we corroborate that the final estimate is associated with a negative definite Hessian matrix of the likelihood function. In addition, we use it to calculate the standard errors, based on the Cramér-Rao bound, as is common.[30] Table 1 presents our estimates $\widehat{\boldsymbol{\phi}}$ and the corresponding standard errors.

A small ν implies that agents form their inflation expectations allocating more weight to their past inflation beliefs, relative to the past deviations between inflation and beliefs. In addition to this, note that the intervals built around the estimates of $\bar{d}_i$ do not overlap. We have centred

[29] We implement a hybrid optimization in Matlab, combining a quasi-Newton and the Nelder-Mead algorithms. Quasi-Newton methods derive from the classic Newton-Raphson method. They search for a local optimal point by solving the linearization of the first order conditions of the objective function. Their name derives from the fact that they use an approximation to the Hessian matrix or the Gradient vector, typically because they are unavailable or computationally expensive to calculate. The Nelder-Mead approximates the objective function with a simplex and then, searches for a local optimum point within the simplex.

[30] It is also known as Frechet-Darmois-Cramér-Rao inequality.

each interval in its corresponding estimate, each having a total length of four standard errors (i.e., two on each side). This result is indicative of differentiated regime states. In the case of σ_i, similar outcomes hold. Altogether, such results are in line with those of the BIC test. In short, given the number of regime states based on the BIC, the estimates associated with these regime are statistically different.

Parameter	**Estimate**	**Standard Errors**
ν	0.02	0.001
λ	0.94	0.001
$\bar{d}_1$	0.0013	0.00003
$\bar{d}_2$	0.0010	0.00002
$\bar{d}_3$	0.0008	0.00002
σ_1	0.59	0.056
σ_2	0.09	0.004
$p_{1,1}$	0.99	0.008
$p_{2,2}$	0.97	0.012
$p_{3,3}$	0.99	0.004
$q_{1,1}$	0.70	0.063
$q_{2,2}$	0.95	0.011
σ_π	0.07	0.051

Table 1. Parameter Estimates.

Notes: All parameters are significant at the usual confidence levels, with one exception. We have that σ_π is statistically significant at the 84% confidence level. Estimation sample February 1969–September 2018.
Source: Own estimations with data from INEGI.

The transition probability estimates ($p_{i,i}$) indicate persistent regimes for the mean deficit states. In the case of the regime for the variance deficit ($q_{j,j}$), both states are persistent as well. Nonetheless, the high variance regime state (σ_1) is not as persistent as the low variance one, as $q_{2,2} > q_{1,1}$. Taken together, the small value of ν and the regime states' persistence (i.e., estimates of $p_{i,i}$ and $q_{j,j}$ being close to one) make SCEs acceptable approximations to the steady-state equilibriums (SSEs), as previously explained.

We estimate the inflation implied by equation (8) using the inflation beliefs, the estimated parameters, and the median of the lognormal density function of the deficit process (equation 5). Relatedly, see Fig. B1 in Appendix B.

In the model, a fundamental reform is associated with a transition from a high- to a medium-mean regime state or from a medium- to a low-mean regime state. Thus, one can think of the regime states' persistence as reflecting a friction in switching regimes. In practice, implementing a reform is, in general, costly. Thus, one can also see their persistence as an advantage. If the economy were in a low-mean deficit regime state, it would be costly to switch out of it.

Table 2 presents the stationary or unconditional probabilities for all regime states. The high-mean regime state probability is equal to 0.22. In this regime, the probability that the inflation expectations become unstable is essentially 1, as we will explain below. The unconditional probability of the low variance regime is relatively high. Similarly, one can think of this feature as an advantage. Consider the joint state, in which the (low, low) regime has an estimated probability of 0.56.

Deficit Mean Regime (Marginal Probabilities)	
High	0.22
Medium	0.14
Low	0.64
Deficit Variance Regime (Marginal Probabilities)	
High	0.13
Low	0.87
Deficit Joint Regime (Variance, Mean)	
High, High	0.03
Low, High	0.19
High, Medium	0.02
Low, Medium	0.12
High, Low	0.08
Low, Low	0.56

Table 2. Stationary Markov Regimes Probability Estimates.

Notes: For the joint regime, we have assumed independence between the mean and variance regime states, as explained in the main text. Probabilities may not sum to 1 due to rounding.

Sources: Own estimations with data from INEGI.

We have used probabilities that are conditional on inflation history up to period $t-1$, i.e., one period before the current one, t (Fig. 3). This convention is in line with the escape-provoking probability. When reporting our estimations, we abstract from variance regimes by adding the probabilities across the same mean but different variance regime states. To be clear, when estimating the model, we consider mean and variance regimes. When reporting the estimations, we integrate the variance regimes out.

Inflation Expectations and SCEs

We have mentioned our interest in understanding events in which inflation expectations surpass a level after which they become unstable. Sargent et al. (2009) define such a situation as an escape event. As described, their model has generally two conditional SCEs for each state m: a low-inflation expectation equilibrium and a high one. While the low SCE is a stable fixed point, the high SCE is an unstable one. We present their estimations in Fig. 2 for our three m-states.

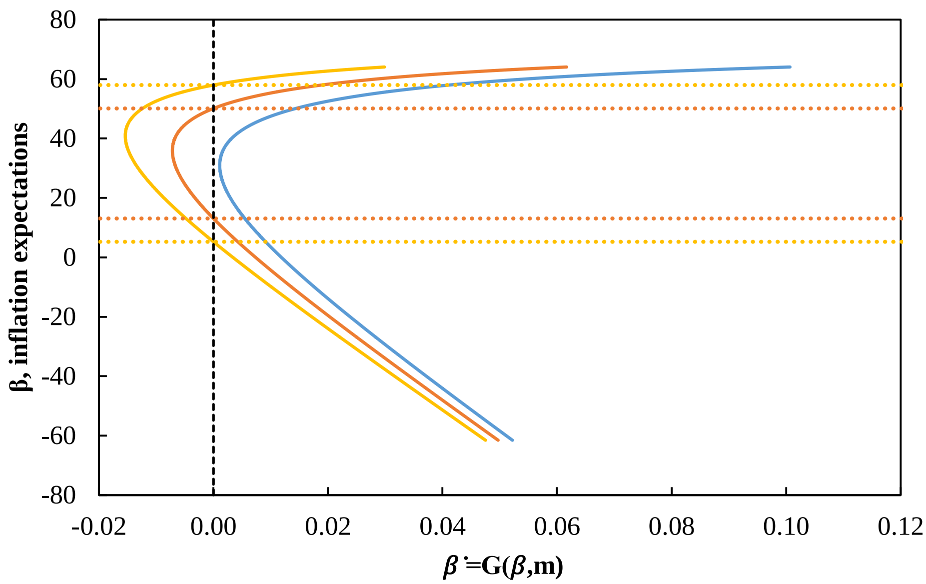

Figure 2. Conditional SCEs.
Notes: Each conditional SCE is determined when the contour lines cross the value of 0. Because the equation is in continuous time, SCEs are determined when $\dot{\beta} = 0$, i.e., $\beta_{t+1} = \beta_t$. Accordingly, each depends on the deficit mean state m. Low-, medium-, and high-mean deficit regimes are yellow, orange, and blue dotted lines ($\beta_2^*(m_{low})$, $\beta_2^*(m_{medium})$, and $\beta_2^*(m_{high})$), respectively. We have used annualized inflation expectations.
Source: Own estimations with data from INEGI.

Interestingly, the high-mean deficit state has no associated fixed-m SCEs (Fig. 2, blue contour lines). For that reason, if the mean-deficit regime switches to such a state, then the inflation expectations turn unstable, notwithstanding their level. Thus, unless a reform takes place, inflation expectations would amplify. The absence of SCEs is not unusual, for instance, this was the case for Brazil in Sargent et al. (2009).

7. General Discussion

We next consider the extent to which the model's dynamics match to key economic events. As we will demonstrate, the model's dynamics match quite well. We mainly base our economic narrative on Ortiz (1991), Ramos-Francia (1993), Sidaoui (2000), and Whitt (1996).[31] We consider the probability of being in a given mean-deficit regime and inflation (Fig. 3), inflation and inflation expectations (Fig. 4), the escape-provoking probability (Fig. 5), and deficits and model-implied deficits (Fig. 6).

Prior to 1970, the fiscal and monetary policies were successful in maintaining price stability for several years. Government expenses swiftly adjusted to unanticipated changes in public revenues. At the time, the monetary base growth was under control. Thus, inflation maintained a low and stable level. Commercial banks reserves were a noninflationary source of government finance (Ramos-Francia, 1993). In line with these events, the probability of being in the low-mean deficit regime was close to 1, and inflation expectations remained very near to their corresponding low SCE.

[31] We have two remarks. First, we base some of our claims on probabilistic statements. However, for simplicity, we are not always explicit about this. Thus, we might state that the regime transits to the low-mean deficit state, meaning that the probability of being in such a regime state is notably close to 1. Second, the model deficit levels are not directly comparable with the deficit data levels for the following reasons: i) the model deficits are invariant to a standardization of $1/\gamma$ and $\bar{d}(m_t)$, as mentioned; ii) in addition, given the deficit distribution, the model does not allow for negative deficit levels. In short, the data capture the general deficit and the model only accounts for the seigniorage-financed portion of the deficit.

Economic policy considerably changed after Luis Echeverría became president in 1970.[32] Government expenses, heavily financed through seigniorage, substantially increased. As a result, the monetary base growth rose. On their part, as bank reserves fell, their use as a source of public financing decreased. High fiscal deficits had as a counterpart high current account deficits, in line with the twin deficits hypothesis. In 1976, a balance of payments crisis took place, and the government devalued the peso, bringing a fixed exchange rate of more than two decades to an end, as the regime switched from the low- to the medium-mean deficit state. The latter state predominated during most of Echeverría's term.

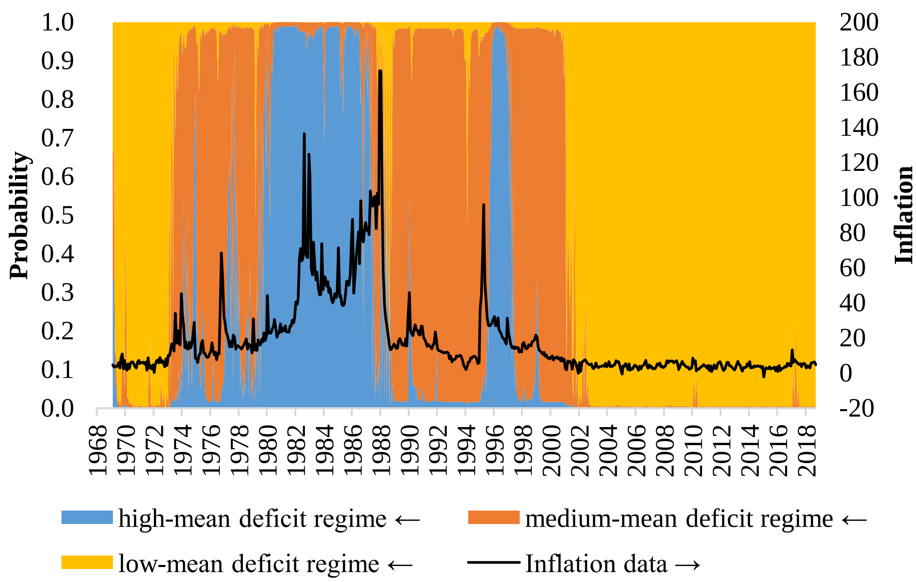

Figure 3. Probabilities of being in the high-, medium-, and low-mean deficit regime state, conditional on the information up to the previous period, and inflation.

Notes: We have stacked the probabilities of being in the high-, medium- and low-mean deficits, conditional on the information in period $t-1$. Thus, the left-hand scale has 0 and 1 as bounds. In addition, although we have estimated the 3×2 model, we add the regime probabilities across all regimes of v_t to focus on the regimes of m_t. As mentioned, these are the probabilities conditional on inflation in the previous period. Finally, the annualized monthly inflation uses the right-hand side scale.

Source: Own estimations with data from INEGI.

[32] Mexico's presidents for the 1970–2018 period were: Luis Echeverría Álvarez, 1970–1976; José Lopez Portillo, 1976–1982; Miguel de la Madrid Hurtado, 1982–1988; Carlos Salinas de Gortari, 1988–1994; Ernesto Zedillo Ponce de León, 1994–2000; Vicente Fox Quezada, 2000–2006; Felipe Calderón Hinojosa, 2006–2012; and Enrique Peña Nieto, 2012–2018.

At the beginning of the López-Portillo administration (1976–1982), an IMF-backed stabilization program was implemented. It was initially considered a success. In addition, pressures on the public finances wore off in light of a newly discovered supergiant oil field.[33] This was followed by a period during which the government kept a distance from the Fund (IMF, 2001). Government expenditures increased to unprecedented levels. The fiscal and current account deficits increased concomitantly. The Mexican external debt grew substantially. Consistent with these events, the model's inflation expectations increased and the probability of being in the high-mean deficit regime presented several discernible spikes.

In 1982, as financing sources withered due to higher global interest rates and falling oil prices, a deteriorating balance of payments led to capital outflows. The resulting peso devaluation impacted inflation and raised the external debt service. With no access to financing, the government entered a debt moratorium in August. In this context, it nationalized the commercial banks, which affected its credibility adversely. As a result, the probability of being in the high-mean regime state conspicuously increased in 1979 (Fig. 3), a possibly indication of the upcoming crisis.

The administrations of Echeverría and López-Portillo led to the 1982 balance of payments crisis. Our estimations show that the escape-provoking probability presented an increasing trend with marked and also increasing fluctuations. In 1980, it spiked considerably, although it marginally improved somewhat in the next two years. In 1982, it increased sharply again (Fig. 5).

De la Madrid's presidential term (1982–1988) started with a major stabilization plan. As its key element, it included substantial fiscal retrenchment. In spite of those adjustments, inflation kept escalating. Although the model-implied deficits decreased at the margin,

[33] Only a SDR 100 million drawing was made in February 1977 (out of SDR 618 million available). The government was able to meet its external financing requirements through commercial banks, partly due to the adjustment program and partly due to the new oil reserves (IMF, 2001).

unstable inflation expectations prevailed. Indeed, for most of the De la Madrid administration, the economy was stuck in a high-mean deficit regime, and high SCE (Fig. 4).

In all fairness, it must be said that in De la Madrid's term, the public finances faced several adverse economic shocks. Prominently, in 1985, an earthquake struck Mexico City, with catastrophic repercussions. Additionally, in 1986, there was an oil shock, with significant consequences for the terms of trade and the fiscal accounts (Fig. 6).

In 1987, the government implemented an Exchange Rate-Based (ERB) stabilization program, the Economic Solidarity Pact. One of its main objectives was to deal with the persistence of inflation. The program included not only a more restrictive fiscal stance (i.e., switching to a lower-mean deficit regime), but also a plan to coordinate inflation expectation at a low, stable equilibrium (i.e., to reach a low and stable SCE). Thus, the pact involved incomes policies (i.e., wage and price controls) and, most importantly, used the exchange rate to try to anchor the nominal system. Some other reforms took place, such as trade liberalization, deregulation, and some divestiture of government companies.

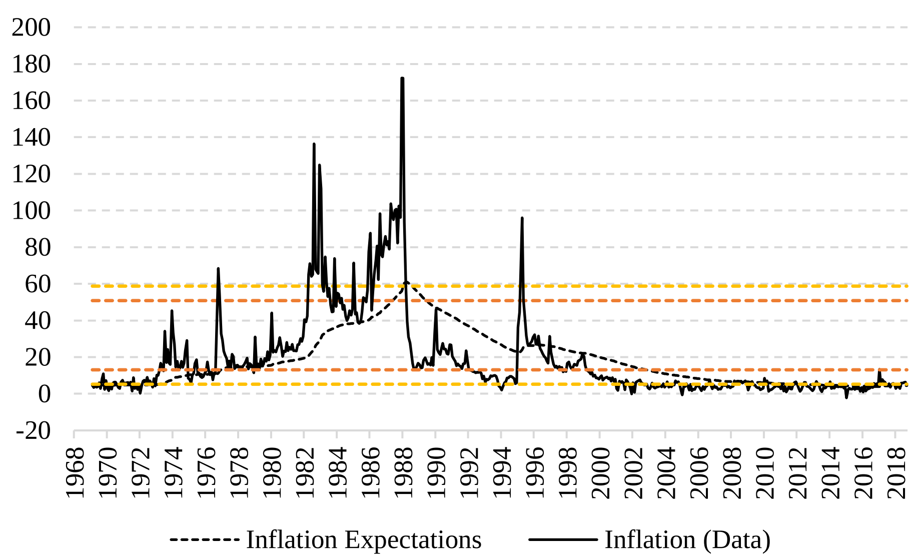

Figure 4. Inflation, Inflation Expectations, and SCEs.
Note: Annualized monthly inflation, inflation expectations, and SCEs. High SCEs are depicted by dotted lines—yellow for the low-mean deficit regime ($\beta_i^*(m_{low})$) and orange for the medium-mean deficit regime ($\beta_i^*(m_{medium})$), where $i = 1, 2$.
Source: Own estimations with data from INEGI.

For all the program's careful economic design and implementation, high and visible inflation and its expectations persisted. In fact, inflation reached its maximum in 1987. Indeed, as can be seen in Fig. 3, the probability of being in a high-mean deficit state stayed close to 1.

Although during the 1980s there were numerous episodes of fiscal retrenchment, there was a substantial dependence on seigniorage financing of the deficit, as servicing the very high stock of external public debt remained a key problem. Evidently, the economy had an external public debt overhang. There are, at least, two key issues when an economy faces a debt overhang predicament that are highly interlinked: understanding the role of inflation as a resource transfer (risk-sharing) mechanism, and the need to renegotiate the external debt. We next discuss both matters.[34]

First, a heavily indebted government needs resources. However, raising taxes or increasing controlled prices or cutting expenditures in the amount needed to confront a debt overhang problem is basically not possible on most occasions. This is even more so if, as is usually the case, the country with the debt overhang problem faces an acute roll-over risk. In this context, inflation acts as a catalyst to transfer resources. This is commonly brought about by exchange rate devaluations, which affect inflation directly and reduces real wages. This is feasible given the sluggishness with which nominal wages tend to adjust. The reduction in real wages decreases domestic consumption. On the other hand, exchange rate devaluations lead to a rise in export demand, improving the external accounts. In addition, and perhaps more importantly, inflation dilutes the real value of domestic currency denominated government nominal debt.[35] Therefore, inflation serves as a resource transfer mechanism, from local residents and nominal debt holders to external debt holders. The inflation tax is used as a resource transfer mechanism when a country tries to avoid defaulting on its external debt. Inflation results from the aggressive devaluations need to generate the foreign currency

[34] The existence of inflation as a risk-sharing mechanism could have been relevant for some economies individually in the Eurozone during the 2010 crisis.
[35] For its "effective" implementation, a government needs an element of surprise. Otherwise, if agents anticipate its actions, nominal variables adjust rapidly.

resources to service the country's external debt. The process is not a stable one, and might result in even higher inflation. It is therefore, almost inexorably, necessary to renegotiate the external debt.

Second, the Baker Plan (1985), in which Mexico participated in 1986 and 1987, was an attempt at external debt renegotiation. The main idea was that in return for economic reforms, highly indebted economies would obtain access to medium-term loans and to the possibility of rolling old loans over. In principle, with these reforms and fresh credit, high-debt economies would be able to grow their way out of debt. However, for several reasons, in general, this approach was not successful (van Wijnbergen et al., 1991).

Its successor was the Brady Plan, in which Mexico participated in 1989 and which had a better outcome.[36] We will have more to say about this below. The years 1986 and 1987 had the highest external debt over gross national income (GNI) levels. Thereafter, external debt levels decreased. Again, the inflation maximum was reached in December 1987, followed by that in January 1988. External debt renegotiations started taking place in 1989 under the Brady Plan. It is worth reemphasizing that inflation, the external debt, and the regime state dynamics are all consistent with the economy being stuck in a high unstable inflation equilibrium (SCE). In addition, the apparent escape event of 1988 made a fundamental reform unavoidable (Fig. 5).

During the term of Salinas (1988-1994), another ERB stabilization program was implemented, the Stability and Economic Growth pact (*PECE*, for its acronym in Spanish). This included another fiscal retrenchment, as well as wage and price controls, akin to those mentioned in Bruno (1989), and aimed at coordinating inflation expectations to a low stable equilibrium. Some structural reforms, including NAFTA, were also implemented. However, and most importantly, this time around, the external public debt was successfully renegotiated.

[36] It takes its name from James Baker, the U.S. Secretary of the Treasury at that time. Baker proposed it in the IMF/WB 1985 Meetings in South Korea. See Sachs (1989).

The government owed a substantial portion of its external debt to commercial banks. In turn, banks were unable to sell these loans and thus faced significant concentration risk. Under the plan, an indebted economy would issue Brady bonds and exchange them for such loans.[37] Thus, banks were generally willing to obtain such bonds at a discount and with longer maturities. They were then able to sell their Brady bonds to a third party. The IMF, the World Bank, and the Bank of Japan provided guarantees on their principal and initial coupon payments, leading to even lower costs. There was then the possibility for Pareto-improving renegotiations (Sanginés, 1989). Clearly, the external debt renegotiations were pivotal in regaining the stability of inflation expectations.

The Salinas administration implemented further reforms. In step with its trade liberalization, Mexico also removed most capital controls. The exchange rate policy was partially an exception. In November 1991, the authorities set a target zone for the exchange rate. After having nationalized the commercial banks in 1982, the government privatized them in 1991–1992. The privatization process raised substantial concerns, such as the newly owners' experience in the sector, the lacklustre implementation of international banking standards, and the moral hazard created by the presence of government guarantees for some of the banks' liabilities (Musacchio, 2012). The privatized banks also competed intensely for market share. These elements contributed towards an outright credit boom. Moreover, several commercial banks had funded their market expansions with USD denominated sources.

It is nontrivial to point to a specific cause for the 1994–1995 Mexican crisis. However, the following events played a role. The financial liberalization enabled an important surge in capital flows. In addition, a large portion of capital was allocated to short-term financial investments. For its part, the Federal Reserve maintained its policy rate at a low level for the initial part of the 1990s. As domestic inflation persisted, local short-term interest rates were relatively higher, leading to substantial portfolio investments from abroad. Most importantly, there was during the latter years of Salinas' term a considerable fiscal expansion and an

[37] Named after the U.S. Treasury Secretary at the time, Nicholas Brady.

important misalignment of the real exchange rate. The undervaluation of the latter led to a boom in construction and other non-tradable investments.

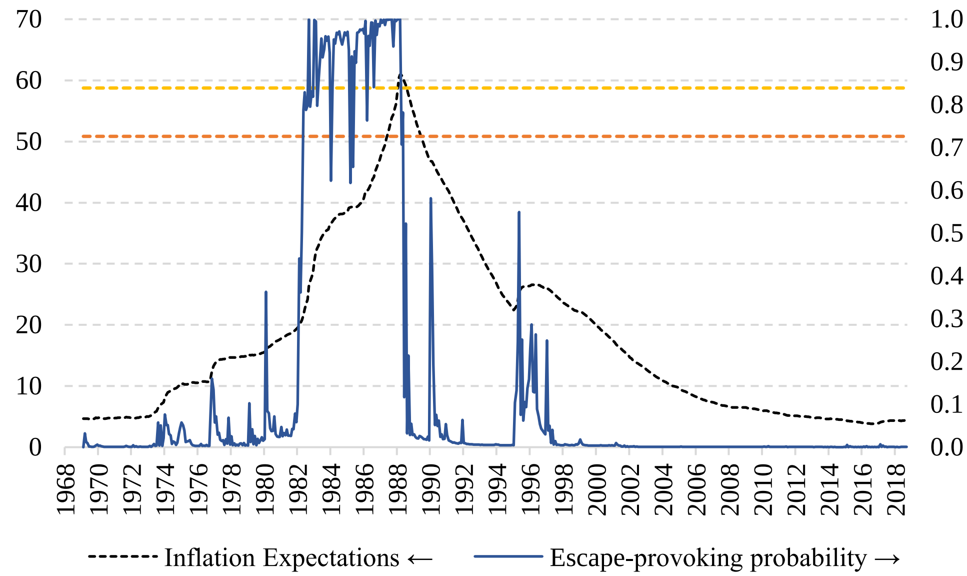

Figure 5. Escape-provoking Probability and Inflation Expectations.
Note: These are annualized monthly inflation expectations and SCEs. The dotted lines indicate each high SCE for each regime. We have yellow ($\beta_2^*(m_{low})$) for the low-mean deficit regime and orange ($\beta_2^*(m_{medium})$) for the medium-mean deficit regime.
Source: Own estimations with data from INEGI.

Three major political events occurred in 1994. A revolt erupted in January in the southernmost state of Chiapas, the leading presidential candidate was assassinated in March while campaigning, and a political leader was murdered in September. On top of this, the Federal Reserve began raising interest rates in early 1994. The combination of these events led to considerable outflows and the concomitant loss of international reserves by the central bank. In response, the government issued dollar-indexed short-term bonds (the so-called *Tesobonos*), i.e., borrowing to defend the exchange rate (Buiter, 1987). In November, whether the foreign reserves would be sufficient to back such bonds became a substantial concern to foreign investors.

The Zedillo administration (1994–2000) took office in December 1994. After considerable capital outflows, the Banco de México announced it would shift the upper bound of the exchange rate's target zone by 15%. Capital flows continued pouring out. On December 22, the exchange rate was left to float, and registered a considerable depreciation. The 1994 crisis' repercussions were dramatic. Inflation went all the way up to 52% in 1995 (December), interest rates averaged 51% (28-day interbank Interest Rate), and GDP fell by 6.3%. In spite of a considerable fiscal retrenchment effort, as the costs associated with the financial sector became more apparent, a switch to the high-mean deficit regime took place and lasted for most of 1995. Concomitantly, the escape-provoking probability increased considerably. By 1997, however, it returned to levels close to 0.

There were several elements to the crisis' policy response. We underscore the following ones. By the end of January, a financial support package was announced. It amounted to USD $50 billion and involved the participation of the U.S. Treasury, the IMF, the BIS, and private commercial banks. This action likely prevented an insolvency crisis (Sidaoui, 2000). As mentioned, there was a trend towards retrenching fiscally (e.g., see Whitt, 1996). The government also deployed several programs with the objective of preventing a banking crisis, which involved providing dollar liquidity to banks, recapitalizing banks that were not satisfying capital requirements, and the government absorbing bank loans, among others.

These events are consistent and are captured quite well by the dynamics of the estimated model. This is particularly so in the case of the transition from the high- to the medium-mean deficit regime in 1997–1998, and the associated stabilization of inflation expectations. Notably, in 1998, there was a sharp oil price drop. Nonetheless, a timely and credible fiscal adjustment avoided further economic deterioration.[38] Since 1999, the escape-provoking probability has kept close to 0, and inflation expectations have started closing their gap with

[38] The model captures the shock and corresponding adjustment by a small spike in the probability of being in the high-mean deficit regime.

their low SCE (Fig. 4).[39] These results are in line with Ramos-Francia and Torres (2005), who argue that the measures taken after the Tequila Crisis to stabilize the economy avoided a fiscal dominance situation.

Since 2000–2001, the regime has been mostly in the low-mean state (Fig. 3). The trend towards prudent fiscal management continued, and the central bank adopted an inflation-targeting regime. These elements laid the foundation for a low and stable inflation process. In this regard, Chiquiar et al. (2010) document that inflation transitioned from a $I(1)$ process to a $I(0)$ one around 2001. Interestingly, although the inflation process appeared to become stationary earlier than 2001, it was not until the regime switched to the low-mean deficit state that the inflation process (statistically) became so. The probability of being in the low-mean deficit state has remained, since then, near 1 (Fig. 3). It is worth noting that it stayed close to 1 before, during, and after the global financial crisis (GFC).

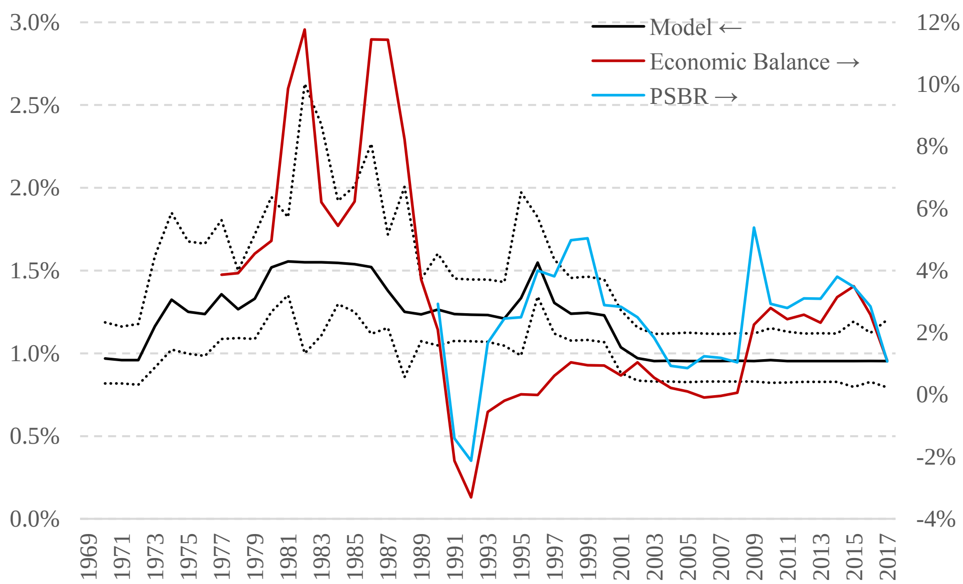

Figure 6. Deficits and Model-implied Deficits.
Notes: Correlation of the model-implied deficits with economic balances is 0.53, and with PSBR is 0.09. To obtain annual estimates, we have added the monthly data implied by the model as an approximation. The dotted lines are confidence intervals at the 90% significance level.
Source: Own estimations with data from INEGI and SCHP.

[39] Still, one can plausibly think of the government's actions as steps toward the mitigation of inflation expectation instability in the high-mean deficit regime.

8. Final Remarks

Historically, Latin American economies have partially financed their fiscal deficits through seigniorage. One common characteristic of economies in the region is that they have allowed the inflationary tax to have an active role. Mexico has not been the exception in this regard. In the past, it used several times the inflationary tax to finance its fiscal deficit; i.e., to close the gap in the government's intertemporal budget constraints.

As a consequence, the country had to bear eventually substantial costs in terms of inflation, fiscal imbalances, and indebtedness and, in some cases, economic crises. In response, the government confronted the associated challenges implementing several adjustment programs, many of which proved initially insufficient. Several factors were crucial for these programs to succeed eventually. For example, under the presence of debt overhang, the renegotiation of the external debt proved pivotal. In the context of the model, such factors made the transition from the high-mean fiscal deficit regime to the medium- and low-mean fiscal deficit regimes feasible, making fundamental reforms possible in the model.

The model captures the dynamics of inflation, inflation expectations, and seigniorage-financed fiscal deficits in a parsimonious way (e.g., see Sargent and Wallace, 1981). In effect, the interaction of the demand for money, the intertemporal government budget constraint, and the distribution of the fiscal deficits does a good job of characterizing the macroeconomic variables' dynamics. The regimes that are part of the distribution of fiscal deficits enable a better characterization of such dynamics.

It is worth reemphasizing that it has been several years since there was a favourable regime change in the stability of inflation and its expectations. From several perspectives, such a result is naturally quite important. Even so, we should not forget the hard-earned lessons. All in all, bearing the interdependence of monetary and fiscal policies in mind and sparing no efforts in maintaining discipline in both are key elements for the macroeconomic stability of the economy.

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Appendices

Appendix A. The Public Sector Borrowing Requirements

Based on (SHCP, 2014), we have the following descriptions. The Public Sector Borrowing Requirements (PSBR, or RFSP for its acronym in Spanish) is the broadest definition of the government deficit. It adds the following six elements to the economic balance. First, it includes the financial requirements of the Infrastructure Investment Projects with Deferred Public Expenses Registry (PIDIREGAS, in Spanish). PIDIREGAS commonly refers to public works projects financed by the private sector and executed by a private company. The government defers its registry, based on the General Public Debt Law. PSBR registers the resource requirements as the public work progresses, and the respective entity amortizes it. In contrast, the economic balance registers it once the contractor delivers the public work in question.

Second, it considers the financial requirements of the Bank Savings Protection Institute (IPAB, in Spanish). The total financial requirements of IPAB are not included in the economic balance based on the Bank Savings Protection Law (see Article 47). The economic balance only includes the fiscal support covering the real component of the financial cost that the referred institute faces.

Third, the included budget registry adjustments mainly refer to the following: a) the inflationary component of index-linked debt; b) the possible revenue due to debt buybacks; c) the income due to debt issuance above or below par (note that PSBR measures public debt based on its issuance value); and d) the Social Security actuarial reserves (i.e., Mexican Social Security Institute, and the Mexican Civil Service Social Security and Services Institute, IMSS and ISSTE, for their acronyms in Spanish).

Fourth, it encompasses the financial requirements of the National Infrastructure Fund (FONADIN, in Spanish) and those derived from the Road Rescue Program and new resources allocated to infrastructure development not financed by budget expenses. Fifth, it considers the debtors program, which includes the discounted payments and investments units (i.e., UDIs, in Spanish) restructuring programs.

Lastly, it adds the expected profits and losses of development banks and public funds regulated and supervised by the National Banking and Securities Commission (*CNBV*, for its name in Spanish), but does not consider their financial intermediation deficit. The PSBR does not include nonrecurring revenues, including revenues from privatizations, asset recovery from trusts and funds, and excess profits received from public entities. Its new methodology considers activities of the private sector when it is acting on behalf of the federal government or its entities, adjusted for the revenue obtained from the net sales of financial assets and the net acquisition of liabilities different from public debt.

Appendix B. Inflation

We present the inflation time series along with the model-implied inflation.

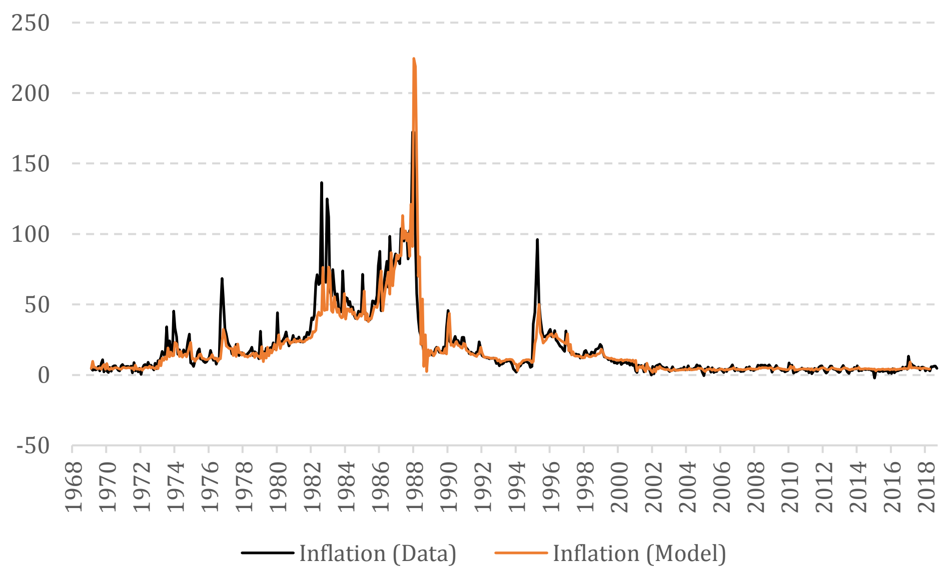

Figure B1. Inflation (Data) and Inflation (Model).
Notes: The correlation coefficient between the model inflation and the data is 0.87. Annualized monthly inflations.
Source: Own estimations with data from INEGI.