Monetary and Fiscal Policy Interactions in Mexico, 1981-2016*

March 2, 2018

Sebastián Cadavid Sánchez  André C. Martínez Fritscher  Alberto Ortiz Bolaños
CEMLA  BID  CEMLA and EGADE
scadavid@cemla.org  andrema@iadb.org  ortiz@cemla.org

Abstract

This paper analyzes the role of fiscal and monetary policies in the determination of inflation and government debt in Mexico during the 1981-2016 period. A Markov-switching DSGE model estimation allows us to identify five different periods of fiscal and monetary policy interactions, which are congruent with a historical account of the Mexican monetary and fiscal policy mix during the past 35 years. Counterfactual exercises show that the low-frequency evolution of inflation is mainly determined by the monetary policy stance, while the low-frequency evolution of debt is mainly determined by the fiscal policy stance. We show that if monetary dominance had prevailed throughout the whole period, average inflation would have been 13.2% rather than the 20.4% observed. On the other hand, complete fiscal dominance would have implied an average inflation of 42% and an average debt five times larger than the figure observed.


Keywords: Monetary policy, fiscal policy, inflation, debt sustainability, Markov-switching DSGE, Bayesian Maximum Likelihood methods.

*The authors thank Junior Mailh for making his RISE toolbox for the solution and estimation of Markov Switching Rational Expectations models available and for patiently answering all of our questions. The views expressed in this presentation are those of the author, and not necessarily those of BID, CEMLA or EGADE Business School of Tecnológico de Monterrey.
1 Introduction

While fiscal policy and monetary policy hold certain objectives in common – such as the stabilization of the economy – there are other areas in which their objectives do not necessarily align, and the implementation of the one may interfere with the achievements of the other. Fiscal policy is orientated towards promoting long-term growth, redistributing income and providing public services and goods through public expenditure financed by taxes or debt. The principal goal of monetary policy, meanwhile, is to foster economic conditions that achieve stable prices, by setting the money supply and interest rates. Both policies are key determinants of the aggregate levels of economic activity and prices. Moreover, the expected path of both affects the expectations and therefore decisions of both households and firms. Monetary policy may determine bounded inflation if fiscal policy is used complementarily, to guarantee fiscal sustainability. When the fiscal authority does not stabilize debt, the monetary authority may lose its ability to influence aggregate demand and control the price level. However, in order to control the path of the real value of debt, either the fiscal authority reduces expenditure and/or raises distortionary taxes that impact economic growth, or the central bank lets inflation increase to devalue real debt.

This paper constitutes an analysis of the role that monetary policy and fiscal policy have played in the determination of inflation and government debt in Mexico during the 1981-2016 period. The Mexican case is representative of the processes experienced in other emerging market countries that have been relatively successful in controlling inflation and stabilizing debt during the past three decades. As many other emerging market countries, after experiencing high levels of inflation and debt problems, Mexico granted autonomy to its central bank and established more accountable criteria to manage fiscal policy. Also, as other countries, Mexico faced internal and external shocks that created trade-offs for the policy authorities. Therefore, by identifying and carefully reviewing the evolution of the policies and the macroeconomic outcomes of Mexico, one can derive lessons that could be useful to understand other countries’ experiences.

To perform the analysis, we adapt to the case of Mexico, the model and methodology that Bianchi and Ilut (2017) employed to study the US economy. The quantitative results are accompanied with a historical narrative to analyze how the differing stances of the fiscal and monetary authorities in Mexico might have impacted inflation and public debt. In particular, the methodology allows us to identify periods in which fiscal and monetary policy have been, to adopt the terminology of Leeper (1991), active or passive, and how that stance has determined the evolution of relevant variables. An active policy is one that is free to pursue its objectives: minimize distortionary taxes for the fiscal authority and inflation control for the Banco de México (the Mexican central bank, referred to in this paper as Central Bank), regardless of the levels and dynamics of government debt. Meanwhile, a passive policy authority is constrained by the need to control debt dynamics, through higher taxes, in the case of the Treasury, or inflation to bring down the real value of debt, in the case of the Central Bank.

Monetary policy is classified as active when the interest rate response to inflation is larger than one, and passive otherwise, meaning that the Central Bank has a commitment to respond assertively to inflation pressures, regardless of fiscal policy behavior. On the other hand, fiscal policy is classified as active when the debt process is non-stationary, and passive otherwise. So active fiscal policy prevails when the public debt trajectory is increasing; in other words, when the current level of debt is insolvent to the extent that it

\footnote{The sample is constrained by the available data on fiscal accounts.}
is greater than the present discounted value of fiscal surpluses. A commitment to sustainability requires that the government be willing and able to cover current deficits with future reductions in expenditure, or higher tax and non-tax income streams. It is also important that economic agents believe that the government is capable of taking this action, as private sector expectations are very important in this process.

In practical terms, in this paper the relevant estimation to determine whether fiscal policy is active or not is centered on the evolution of debt, which in turn is a function of the distortionary response to indebtedness. The higher the response of taxation to debt, the more likely that fiscal policy will be passive. The policy space allows for the differentiation of four policy regimes: Passive Monetary and Passive Fiscal (PM/PF); Passive Monetary and Active Fiscal (PM/AF) or fiscal dominance; Active Monetary and Passive Fiscal (AM/PF) or monetary dominance; and Active Monetary and Active Fiscal (AM/AF).

Understanding the forces behind this evolution is particularly important, as Figure 1 shows. In Mexico, the last 35 years have seen large variations in the behavior of inflation, ex-post real interest rates, and government debt. We argue that part of the evolution of these variables is highly related to the stance of macroeconomic policies.

Figure 1: Inflation, ex-post real interest rate and debt-to-GDP in Mexico: 1981 - 2016

Note: Data from INEGI and Secretaría de Hacienda y Crédito público (SHCP). Inflation corresponds to consumer price index inflation. Ex-post real interest rate is calculated subtracting realized inflation from the observed nominal interest rate. Debt corresponds to net debt of the public sector. The interactions of policy regimes, identified as the intervals between the vertical lines, represent our own calculations as will be explained in subsection 3.2.

Two recent studies have analyzed how fiscal policy affects monetary policy. Meza (2017) uses the Sargent and Wallace (1984) model to analyze Mexican monetary and fiscal policies from 1960 to 2007, illustrating how the model can explain the 1982 debt crisis, which led to fiscal dominance, but cannot explain the 1994 Crisis. Additionally, the author presents the hypothesis that four forces contributed to the “Great Reduction” of inflation in Mexico: i) the sequence of primary surpluses that started in 1983; ii) the price controls agreed by the government, labor unions, farmers and business chambers in the Pacto de Solidaridad Económica in December 1987; iii) the 1994 constitutional law granting autonomy to the Central Bank which sets price stability as its primary mandate and states that no authority can force it to provide financing to the government; and iv) the implementation of an inflation targeting regime in 2002. López-Martín et al. (2017) extend the model proposed by Sargent et al. (2009) to estimate the relationship between fiscal deficits financed with monetary emission, the inflation rate, and its expectations in Mexico from 1969 to 2016. These
authors find that the benchmark Sargent et al. (2009) model provides a good account of inflation during the 1977-1994 period, and that the estimation suggests that after 1994 there was a structural change associated with the Central Bank’s limited ability to finance fiscal deficits.

The present paper studies how fiscal policy affects monetary policy, as in Meza (2017) and López-Martín et al. (2017), but also analyzes how monetary policy affects fiscal policy: a key consideration, given that both policies are interdependent. In addition, our structural, general equilibrium approach takes into account preferences, endowments and technology to study the joint determination of the relevant economic variables, among them inflation and debt, providing us with a unified framework to analyze transmission mechanisms and identify structural shocks. This framework also serves as a consistent method of performing counterfactual exercises. Our Markov-switching specification endogenously determines regime changes and provides us with clear criteria to guide the counterfactual exercises. The Bayesian maximum likelihood estimation, being a full information method, exploits the information content of the data to identify the structural parameters of the model. The estimation of the general equilibrium model eliminates the endogeneity bias that a non-structural framework is prone to. Finally, we can identify clearly-defined policy regimes with the macroeconomic evolution of the period and with historical description.

The identification of macroeconomic policy stances is highly relevant, as several crises in emerging countries during recent decades have lent support to the fiscal dominance hypothesis (Turner, 2011). Since the governments in these countries lack the capacity to finance fiscal deficits through long-term domestic debt, partly due to their macroeconomic policy’s lack of credibility, they had to rely on bank credit or external debt. These restrictions in some cases may have translated into a monetary policy that was over-expansive, as an attempt to compensate for fiscal deficits. The dominance of fiscal policy was diminished through the implementation of reforms increasing the autonomy of the central banks. And many emerging countries, among them Mexico, have recently implemented expansive fiscal policies, calling for an in-depth analysis of the interactive effects of fiscal and monetary policies.

Our study uses an estimated Markov-switching DSGE model, and the results are compared to a historical account of the mix of Mexican monetary and fiscal policy over the past 35 years, on a quarterly basis. The new-Keynesian Markov-switching model allows us to endogenously determine if there have been changes in: 1) the stances of the policies and 2) the volatility of the structural shocks that produce economic fluctuations. The DSGE framework recognizes that two policies mutually condition each other, and that the prices and quantities observed in the economy are a function of both policies, implemented while households and firms make their own decisions. The estimation exploits the information content of the data to pin down the parameters that indicate how variables are related. The estimation of the model provides the parameters in which the fiscal and monetary policies are active and passive for the whole period. Monetary policy is classified according to the interest rate’s response to inflation. Active monetary policy has an interest rate elasticity to inflation of 1.81, while the passive stance has an elasticity of 0.79. Fiscal policy is classified based on the autoregressive component of debt. Active fiscal policy has an autoregressive value of 1.0015, associated with a 0.0003 tax elasticity to debt, while passive fiscal policy has an autoregressive value of 0.9955 with a 0.0624 tax elasticity to debt. Moreover, for every quarter we find a probability for each policy regime, in order to detail the interactions that exist between fiscal and monetary policies in each period.

According to the probability estimates, we find very clear patterns of macroeconomic policy regimes in Mexico from 1980 to 2016. On the one hand, we identify that monetary policy was passive with high
probability in two periods: 1981Q1-1988Q2 and 1995Q2-1998Q4. On the other hand, fiscal policy was active with high probability in three well-defined periods: 1981Q1-1988Q2, 1995Q2-1998Q4 and 2008Q4-2016Q4. From those probabilities and results we identify the following five different periods of fiscal and monetary policy interaction configurations, which are congruent with the macroeconomic environment, as well as the institutional and macro policy changes that Mexico has seen over the last 35 years: 1) 1981Q1 - 1988Q2: fiscal dominance; 2) 1988Q3 - 1995Q1: monetary dominance; 3) 1995Q2 - 1998Q4: fiscal dominance; 4) 1999Q1 - 2008Q3: monetary dominance; and 5) 2008Q4-2016Q4: both policies active.

During most of the 1980’s, the combination of fiscal imbalances and lack of central bank independence led to fiscal dominance. The end of the 1980’s and beginning of the 1990’s saw a period of structural reform, of fiscal consolidation and policies aimed at combating inflation, which led to a phase of monetary dominance. The 1995 economic crisis provoked depreciation that impacted inflation and debt dynamics temporarily, but, as we show below, this did not mean a real change in the stance of the macroeconomic policies. The following decade was characterized by macroeconomic strength, and a regime focused on inflationary and fiscal equilibrium. The 2008-2009 crisis gave rise to the need to instrument an expansionary fiscal policy that has lasted until 2016, explaining the change to an active fiscal policy stance. Monetary policy remained active in this last period, favored by the independence of the Central Bank which allowed inflation expectations to be anchored and kept inflation under control. A particularly interesting result is that monetary policy has been active since 1989, except for a brief period after the 1995 crisis, allowing inflation to converge to single digits and remain stable and predictable.

In order to further analyze the role of policies and expectations, we use the estimated model to perform two sets of counterfactuals. First, we explore what the trajectory of the macroeconomic variables would have been if the monetary / fiscal policy mix had remained constant over the 35-year span we study. The results are congruent, as fiscal dominance, PM/AF, and AM/AF regimes would have led to considerably higher debt and inflation paths than those actually observed. Meanwhile, a regime of monetary dominance, AM/PF, would have resulted in lower inflation and negative debt in most of the quarters of the sample. Our estimations show that a monetary dominance regime in the last 35 years would have led to a yearly average inflation of 13.2% instead of the actual figure of 20.4%. On the other hand, if the fiscal dominance regime had prevailed since 1981, it would have implied an average debt of more than 150% of GDP, compared to the observed level of 31%, with an average inflation of 42%.

Second, we perform counterfactual exercises around each regime switch - 1988Q3, 1995Q2, 1999Q1 and 2008Q4 - comparing the actual evolution of different macroeconomic series (GDP growth, inflation, debt as a percentage of GDP, and interest rates) with what would have happened: i) without a regime switch (status quo, 95% probability of remaining in the previous regime); ii) if the observed regime switch had been fully credible (95% probability of remaining in the new regime); and iii) if the observed regime switch had been non-credible (5% probability of remaining in the new regime). When the trajectory of the variables in one of these three exercises closely resembles that observed, we consider that this is the relevant counterfactual in terms of the expectations described above. The analysis shows that the 1988Q3 regime switch from PM/AF to AM/PF was fairly credible and contributed to lowering inflation and stabilizing debt. The 1995Q2 regime switch from AM/PF to PM/AF was perceived as non-credible, or a short-term response to the Mexican financial crisis, and the evolution of inflation and debt is closer to the predicted behavior of the status quo, AM/PF. Debt and inflation were affected more by depreciation than by a change in policy.
stance. The 1999Q1 regime switch from PM/AF to AM/PF was perceived as credible in the context of the Central Bank’s independence, and seen as a fiscal consolidation effort that contributed to hurrying inflation towards its target while also containing debt dynamics. Finally, the 2008Q4 regime switch from AM/PF to AM/AF was initially perceived as non-credible, given the fiscal record of the two previous decades and the transitory need of a countercyclical impulse from the fiscal side in response to the Great Financial Crisis. However, since debt has been growing continuously during the last eight years of the sample, the behavior of debt has come closer to what would be observed following a credible regime switch to AM/AF.

The rest of the paper is organized as follows. Section 2 presents a monetary-fiscal DSGE model that provides the theoretical basis of our analysis. This section starts with a description of the model, as well as an analysis of the monetary and fiscal policy mix that yields the four possible regimes conditional on the active or passive stance of those policies, and a description of the tools used to solve and estimate the Markov-switching DSGE model. Section 3 describes the estimation strategy and presents the results, showing first the parameter estimates, then the regime probabilities and a historical account of the Mexican monetary and fiscal policy mix in the 1981-2016 period, and finally the counterfactual exercises we used to analyze the role of policies and expectations. Section 4 lays out our conclusions.

2 A monetary-fiscal policy DSGE model

The model in this section follows the one presented in Bianchi and Ilut (2017), which is a new-Keynesian model with fiscal and monetary blocks. The government sources of income are: tax collection from households, an exogenous stream of non-tax income, two-period government bonds, and long-term government bonds to allow for a maturity structure of government debt. Fiscal resources are used for transfers to households, for government expenditure that distinguishes between short-term and long-term expenditure, and for debt repayment of interests and principal. We assume a fiscal rule in which the fiscal authority can set taxes that respond to the level of indebtedness, the level of expenditure, and real activity. As in Bianchi and Ilut (2017), we specify a Markov-switching DSGE model and allow for changes in the policy-makers’ behavior and stochastic volatility. Potential policy regime changes are captured by changes in the parameters associated with the monetary and fiscal authorities’ reaction functions, where we use a state variable $\xi_{t}^{sp}$ to denote the structural parameters $sp$ regime at time $t$. Meanwhile, to allow for regime changes in the stochastic volatilities we model a second, independent, Markov-switching process and use a state variable $\xi_{t}^{vo}$ to distinguish the volatility $vo$ regime at time $t$.

2.1 Model description

Households

Each optimizing representative household chooses consumption, $C_t$, and working hours, $h_t$, to maximize lifetime utility given by:

---

2We augment the original Bianchi and Ilut (2017) set-up with government non-tax revenue which is an important source of income for the analyzed economy. For reference, the average level of non-tax revenue as a share of GDP was 12.41% for the 1981-2016 period, while tax revenue as a share of GDP averaged 8.78%. Meanwhile, during the same sample, central government debt excluding financial entities as a percentage of GDP averaged 31.09%, while total government expenditure, which encompass government purchases and transfers, as a share of GDP averaged 23.61%.
where $\beta \in (0,1)$ is the discount factor, $C_{t-1}^A$ represents the average level of consumption in the economy and $\Phi$ captures the degree of external habit in consumption. The preference shock $d_t$ follows an $AR(1)$ process $d_t = \rho_d d_{t-1} + \sigma_d \xi_{d,t} \varepsilon_{d,t}$, where $\sigma_d \xi_{d,t}$ is the standard deviation of the stochastic volatility of the preference innovation $\varepsilon_{d,t} \sim N(0,1)$, whose $\xi_{d,t}$ subscript denotes that it is allowed to change across regimes at time $t$.

The representative household faces the following budget constraint:

$$P_tC_t + P_t^m B_t^m + P_t^s B_t^s = P_t W_t h_t + B_{t-1}^s + (1 + \rho P_t^m) B_{t-1}^m + P_tD_t - T_t + TR_t \tag{2.2}$$

where $P_t$ is the aggregate price level on final consumption goods and $W_t$ is the real wage. Households own firms from which they receive real dividends, $D_t$. Households pay lump-sum taxes, $T_t$, and receive government transfers, $TR_t$. Households choose among two types of government bonds: a one-period discount bond denoted by $B_t^s$, priced at $P_t^s = R_{t-1}$, and a portfolio of long-term discount bonds with varying maturity denoted by $B_t^m$, priced at $P_t^m$, with an average maturity $\rho \in (0,1)$, a payment structure following $\rho^T - (t+1)$ for $T > t$ and a future value $P_{t+j}^m = \rho^j P_t^m$ for instruments issued in period $t$ at a future period $t+j$.

**Firms**

There is a continuum of domestic firms in monopolistic competition, each producing differentiated goods. The representative firm $j$ faces the following demand curve:

$$Y_t(j) = (P_t(j)/P_t)^{-\frac{1}{\eta}} Y_t \tag{2.3}$$

where $\frac{1}{\eta}$ is the elasticity of substitution between two differentiated goods, $P_t(j)$ represents firm’s $j$ price and $Y_t$ is the level of real activity. Shocks to the elasticity of substitution imply shocks to the firm’s mark-up, defined as $\kappa_t = \frac{1}{1-\eta}$. The rescaled mark-up, $\kappa_t = \frac{\kappa}{1-\eta} \log(\Pi_t)$ follows an $AR(1)$ process: $\kappa_t = \rho_{\kappa}\kappa_{t-1} + \sigma_{\kappa} \xi_{\kappa,t} \varepsilon_{\kappa,t}$, where $\varepsilon_{\kappa,t} \sim N(0,1)$. Meanwhile, $\kappa \equiv \frac{1}{1+\eta}$ is the slope of the Phillips curve.

The price adjustment cost is represented by an output loss:

$$AC_t(j) = \frac{1}{2} \varphi \left( \frac{P_t(j)}{P_{t-1}(j)} - \Pi_{t-1} \Pi^{1-\varsigma} \right)^2 Y_t(j) \frac{P_t(j)}{P_t} \tag{2.4}$$

where $\Pi_t = \frac{P_t}{P_{t-1}}$ is the gross inflation rate at $t$, $\Pi$ is the corresponding steady state, and $\varsigma$ is the parameter that controls the level of indexation to lagged inflation in the price determination. The firm’s objective is to maximize its profits by choosing $P_t(j)$:

$$E_0 \left[ \sum_{t=0}^\infty Q_t \left( \frac{P_t(j)}{P_t} Y_t(j) - W_t h_t(j) - AC_t(j) \right) \right] \tag{2.5}$$
where \( Q_t \) is the marginal value of a unit of consumption good. The monopolistic firm only uses labor as an input: \( Y_t (j) = A_t l_t^{1-\alpha} (j) \). Total factor productivity evolves according to an exogenous process: \( \ln(\frac{X_t}{X_{t-1}}) = \gamma + \alpha_t \), which is represented as an autoregressive process, \( \alpha_t = \rho_\alpha \alpha_{t-1} + \sigma_\alpha \varepsilon_{\alpha,t} \), where \( \varepsilon_{\alpha,t} \sim N (0,1) \).

### Government

In equilibrium, the one-period discount bond, \( B_t^m \), is in zero net supply. The government budget constraint is therefore given by:

\[
P^m_t B^m_t = (1 + \rho P^m_t) B^m_{t-1} - T^t \text{tax} - T^t \text{non-tax} + \text{Exp}_t + TP_t
\]

where \( P^m_t B^m_t \) is the market value of debt, \( \text{Exp}_t \) stands for total government federal expenditures,\(^3\) \( T^t \text{tax} \) and \( T^t \text{non-tax} \) represents tax and non-tax revenues, respectively\(^4\) and \( TP_t \) is a shock introduced to capture non-modeled features such as changes in the maturity structure and the premium.

Rewriting the federal government budget constraint in terms of the debt-to-GDP ratio, \( b^m_t = \frac{P^m_t B^m_t}{P_t Y_t} \), gives us:

\[
b^m_t = \frac{R^m_{t-1} Y_{t-1}}{\Pi_t Y_t} b^m_{t-1} - \tau^t \text{tax} - \tau^t \text{non-tax} + \text{exp}_t + tp_t
\]

where all the variables are expressed as a fraction of nominal GDP, \( P_t Y_t \), while \( R^m_{t-1} \) is the realized return of the maturity bond. The premium shock is assumed to be an \( AR(1) \) process:

\[
tp_t = \rho_t \varepsilon_{tp,t-1} + \sigma_{tp} \varepsilon_{tp,t} \varepsilon_{tp,t} \sim N (0,1) \).
\]

We rewrite this evolution of debt in log-linear deviations from the steady-state as:

\[
\hat{b}_t = \beta^{-1} \hat{b}_{t-1} + \beta^{-1} \left( R^m_{t-1} - \bar{y}_t + \bar{y}_{t-1} - \bar{a}_t - \bar{\pi} \right) - \frac{\tau^t \text{tax}}{b} \hat{t}^t + \frac{\tau^t \text{non-tax}}{b} \hat{t}^t_{\text{non-tax}} + \frac{\text{exp}_t}{b} \hat{e}_t + \frac{tp_t}{b} \hat{t}_p (2.8)
\]

The linearized federal government expenditure as a fraction of GDP, \( \text{exp}_t \), is divided between short- and long-term components, \( e^S_t \) and \( e^L_t \), respectively. The former is meant to capture the government expenditure response to the business cycle and is assumed to respond to the log-linearized output gap, \( y_t - y^*_t \). The latter represents federal expenditures in large programs that arise from political processes and it is modeled as an \( AR(1) \).

\[
e^S_t = \rho_e e^S_{t-1} + (1 - \rho_e) \ln(y_t - y^*_t) + \sigma_{e\text{S}} \varepsilon_{e\text{S},t}
\]

\[
e^L_t = \rho_e e^L_{t-1} + \sigma_{e\text{L}} \varepsilon_{e\text{L},t}
\]

where it is assumed that \( \varepsilon_{e\text{S},t} \sim N (0,1) \) and \( \varepsilon_{e\text{L}} \sim N (0,1) \).

\(^3\)Defined as the sum of federal transfers and good purchases from government: \( \text{Exp}_t = P_t G_t + TR_t \).

\(^4\)The non-tax revenues are modeled as an \( AR(1) \) process.
The total federal government expenditure is divided into transfers $TR_t$ and government purchases $G_t$. The ratio between the latter and federal expenditure is defined as: $\chi_t \equiv \frac{G_t}{EXP_t}$, and modeled as:

$$\chi_t = \rho \chi_{t-1} + (1 - \rho \chi) l_y(y_t - y^*_t) + \sigma_{\chi,\xi^{sp}} \varepsilon_{\chi,t}$$

(2.11)

where $\varepsilon_{\chi,t} \sim N(0, 1)$ and $l_y$ captures the sensitivity of government expenditure to the log-linearized output gap. Finally, the market clearing condition requires that $Y_t = C_t + G_t$.

**Policy rules**

**Monetary policy**

The monetary authority is assumed to have an interest rate reaction function in response to inflation and the output gap, according to:

$$R_t = \left( \frac{R_{t-1}}{R} \right)^{\rho_{R,\xi^{sp}}} \left[ \left( \frac{\Pi_t}{\Pi} \right)^{\psi_{\pi,\xi^{sp}}} \left( \frac{Y_t}{Y^*_t} \right)^{\psi_{y,\xi^{sp}}} \right]^{1 - \rho_{R,\xi^{sp}}} \sigma_{R,\xi^{sp}} \varepsilon_{R,t}$$

(2.12)

where $R$ is the steady-state nominal interest rate and $\varepsilon_{R,t}$ is the monetary policy shock, which is assumed to be independent and identically distributed (i.i.d.). The $\xi^{sp}$ subscript indicates that these policy parameters are allowed to change across regimes at time $t$. A key parameter in the classification of monetary policy regimes is $\psi_{\pi}$, which captures the Central Bank’s response to inflation. A value larger than one would imply that interest rates are adjusted more than proportionally to inflationary surges, and would correspond to an active monetary policy.

**Fiscal policy**

The fiscal authority is assumed to have a tax reaction function that responds to the level of indebtedness at time $t - 1$, current government expenditure, and the output gap, according to:

$$\tilde{t}^{tax}_t = \rho_{\tau^{tax},\xi^{tax}} \tilde{t}^{tax}_{t-1} + \left( 1 - \rho_{\tau^{tax},\xi^{tax}} \right) \left[ \delta_b \xi^{tax}_t \delta_{b-1} + \delta_e \left( \tilde{e}^S_t + \tilde{e}^L_t \right) + \delta_y \left( \tilde{y}_t - \tilde{y}^*_t \right) \right] + \sigma_{\tau,\xi^{tax}} \varepsilon_{\tau,t}$$

(2.13)

where $\tilde{t}^{tax}_t$ represents linear deviations of the tax-to-GDP ratio from its steady state and $\varepsilon_{\tau,t} \sim N(0, 1)$. A key parameter for the classification of fiscal policy regimes is $\delta_b$, which captures the fiscal authority’s response to indebtedness. Note that this tax reaction function enters the evolution of debt so the tax response to indebtedness is key to guaranteeing that debt is stationary. By doing so and rearranging terms we see that the condition that guarantees debt is not explosive, which is equivalent to requiring that debt is stationary, becomes: $\beta^{-1} - \frac{\tilde{t}^{tax}_t}{\beta} (1 - \rho_{\tau^{tax},\xi^{tax}} \delta_b \xi^{tax}_t) \delta_{b-1} < 1$. Fiscal policy will be considered passive when debt is stationary.
2.2 Monetary and fiscal policy mix

Our analysis of the blend of monetary and fiscal policy is centered on the inflation control and debt solvency. Following Leeper (2013), we classify an active policy authority as one that is free to pursue its objectives, unconstrained by the state of government debt, while a passive policy authority is constrained by the behavior of the active authority and the private sector.

Monetary policy is active when the interest rate response to inflation is larger than one, i.e., $\psi_{\pi,\xi_{sp}} > 1$, and passive otherwise. Fiscal policy is active when the debt process is non-stationary, which implies $\beta^{-1} - \frac{\tau_{tax}}{b} (1 - \rho_{\tau_{tax},\xi_{sp}}) \delta_{b,\xi_{sp}} > 1$, and passive otherwise. The policy space allows for the differentiation of four policy regimes: Passive Monetary and Passive Fiscal (PM/PF), Passive Monetary and Active Fiscal (PM/AF), Active Monetary and Passive Fiscal (AM/PF) and Active Monetary and Active Fiscal (AM/AF). We describe in detail below how policies interact in each region; and Table 1 summarizes this information.

It is important to note that the model has five forward-looking, or non-predetermined, variables, which are the expected values of: consumption, $C_t$; goods purchases from the government, $G_t$; inflation rate, $\Pi_t$; price of government debt, $P^m_t$; and return on the maturity bond, $R^m_{t,t+1}$. The existence and uniqueness of the equilibrium depend on the relationship between the number of forward looking variables and the number of eigenvalues outside the unit circle in the $\Omega^*$ ($\xi^{sp}$, $\theta^{sp}$, $H$) matrix of equation (2.20), where $\xi^{sp}$ is the Markov chain of the structural parameters, $\theta^{sp}$ are those structural parameters, and $H$ are the transition matrices.

The policy stance will affect the number of eigenvalues outside the unit circle, an active monetary policy, $\psi_{\pi,\xi_{sp}} > 1$, will add one explosive eigenvalue, and an active fiscal policy, $\beta^{-1} - \frac{\tau_{tax}}{b} (1 - \rho_{\tau_{tax},\xi_{sp}}) \delta_{b,\xi_{sp}} > 1$, will add another.

As shown in Blanchard and Kahn (1980), if the number of forward-looking variables is equal to the number of eigenvalues outside the unit circle, as in the AM/PF and PM/AF regimes, then the solution will be unique. If the number of forward-looking variables exceeds the number of eigenvalues outside the unit circle, as in the PM/AF regime, then there are multiple solutions, while in the opposite case, as in the AM/AF regime, no solution exists. As noted in Bianchi and Ilut (2017), the Markov-switching structure of the system allows us to arrive at a solution even when the Blanchard and Kahn conditions are not satisfied in a single period, as long as agents believe that the regime will eventually shift to one with a unique solution.

Passive Monetary and Passive Fiscal (PM/PF)

As both policies are passive we have more forward-looking variables than eigenvalues outside the unit circle, producing an indeterminate equilibrium with multiple solutions. It is possible that with identical fundamentals (preferences, endowments and technology) the economy ends up with different allocations, which are known as sunspot solutions. In this case both monetary policy and fiscal policy are stabilizing debt, while neither policy is controlling inflation. This is the policy regime in Sargent-Wallace’s result in Unpleasant Monetarist Arithmetic regarding indeterminacy under an interest rate peg.
Passive Monetary and Active Fiscal (PM/AF)

We refer to this regime as one of fiscal dominance. In this case, the active fiscal policy generates an eigenvalue larger than one in modulus and the number of eigenvalues is equal to the number of forward-looking variables producing a unique equilibrium. Leeper (2013) labels this region “Regime F”, which corresponds to the Fiscal Theory of the Price Level (FTPL), the fiscal theory in which “fiscal policy determines the price level”. Surprise inflation is a fiscal phenomenon. Monetary policy permits inflation to revalue and stabilize debt. Any shock that would raise debt also raises inflation because taxes do not respond to debt. For fiscal policy to determine inflation, agents’ expectations must be anchored by monetary policy adjusting to maintain the value of debt. Under active fiscal policy, a tax cut generates wealth effects. At pre-shock prices, lower taxes, with no increase in expected taxes, make households feel wealthier, inducing them to try to raise their consumption paths, increasing aggregate demand and generating inflationary pressures. If monetary policy tries to combat inflation with higher interest rates, it amplifies the inflationary effects of fiscal policy as it enlarges the wealth effect and hence increases aggregate demand.

Active Monetary and Passive Fiscal (AM/PF)

We refer to this regime as one of monetary dominance. In this case, the active monetary policy generates an eigenvalue larger than one in modulus, and the number of eigenvalues is equal to the number of forward-looking variables, producing a unique equilibrium. Leeper (2013) labels this region “Regime M”; it is characterized by being Monetarist and Ricardian. This is the usual regime in monetary models in which monetary policy determines the price level. Inflation is entirely a monetary phenomenon. Fiscal policy adjusts future surpluses to cover interest plus principal on debt. Any shock that changes debt must create the expectation that eventually future surpluses will adjust to stabilize debt’s value.

For monetary policy to target inflation, expectations must be anchored by fiscal policy adjusting to maintain the value of debt. Taxes and debt are irrelevant for inflation; in other words, equilibrium exhibits Ricardian equivalence. In expectation, debt converges back to the steady state. Higher debt induced by fiscal or monetary shocks is expected to bring forth higher taxes that retire debt back to a steady state. Tax policy provides essential support to monetary policy, allowing higher interest rates to reduce consumption and inflation.

Active Monetary and Active Fiscal (AM/AF)

In this case, as both policies are active, two additional eigenvalues larger than one in modulus are generated and there is therefore no equilibrium with bounded debt. Both monetary and fiscal policy are controlling inflation, without taking into account the government budget constraint. Thus, neither policy is stabilizing debt: this is an “unsustainable” policy mix.
Table 1: Characterizing the monetary and fiscal policy mix

<table>
<thead>
<tr>
<th>Monetary Policy</th>
<th>Fiscal Policy</th>
<th>Passive (PF): $\beta^{-1} - \frac{\tau_{tax}}{1 - \rho_{tax}} \delta_{b,\xi^{sp}} &lt; 1$</th>
<th>Active (AF): $\beta^{-1} - \frac{\tau_{tax}}{1 - \rho_{tax}} \delta_{b,\xi^{sp}} &gt; 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive (PM):</td>
<td>PM / PF: Equilibrium is indeterminate and admits bounded sunspot solutions. Both monetary policy and fiscal policy are stabilizing debt. Neither policy is controlling inflation.</td>
<td>PM / AF: Unique equilibrium. Non-Monetarist and Fiscal Theory of the Price Level (FTPL), the fiscal theory regime in which “fiscal policy determines the price level”. Monetary policy permits inflation to revalue and stabilize debt.</td>
<td></td>
</tr>
<tr>
<td>Active (AM):</td>
<td>AM / PF: Unique equilibrium. Monetarist and Ricardian. The usual regime in which monetary policy determines price level, i.e., inflation is entirely a monetary phenomenon. Fiscal policy adjusts future surpluses to cover interest plus principal on debt.</td>
<td>AM / AF: No equilibrium exists with bounded debt. Both monetary policy and fiscal policy are controlling inflation. Neither policy is stabilizing debt: an “unsustainable” policy mix.</td>
<td></td>
</tr>
</tbody>
</table>

Note: This table summarizes the key elements of each policy regime as explained in the text.

2.3 Solving and estimating the Markov-switching DSGE model

The DSGE system with constant parameters has the following matrix form:

$$\Gamma_{o} x_{t+1} = \Gamma_{1} x_{t} + \psi Z_{t} + \varphi \eta_{t}$$  \hspace{1cm} (2.14)

where $\Gamma_{o}$, $\Gamma_{1}$, $\psi$ and $\varphi$ matrices contains the model's parameters. $x_{t}$ stands for the $(n \times 1)$ vector of endogenous variables, $Z_{t}$ is the $(k \times 1)$ vector of exogenous processes and $\eta_{t}$ corresponds to the $(\ell \times 1)$ disturbances vector. The conditions for existence and uniqueness of the solution (2.14) depend on the generalized eigenvalues of the system’s matrices Farmer et al. (2008).

Using the solution algorithm proposed by Sims (2002) and Schmitt-Grohé and Uribe (2003) the unique solution to the system (2.15) is combined with the observation equation:

$$x_{t} = G (\Lambda) x_{t-1} + AZ_{t}$$ \hspace{1cm} (2.15)

$$Y_{t}^{obs} = M x_{t}$$ \hspace{1cm} (2.16)

where $\Lambda$ stands for the parameters of the model, $Y_{t}^{obs}$ are the observed variables, and $M$ provides the policy function for the observables. Following Bianchi and Ilut (2017), we introduce the possibility of

---

5GDP growth, inflation rate, interest rate, debt-to-GDP, government purchases (as described for $\eta_{t} = 1 / (1 - \zeta_{t})$ in Bianchi and Ilut (2017), where $\zeta_{t}$ is the government purchases-to-GDP ratio), tax-to-GDP and total expenditure-to-GDP.
regime change for the structural parameters and the volatilities through two Markov chains, $\xi^{sp}$ and $\xi^{vo}$. The former denotes the unobserved regime associated with the monetary and fiscal rules parameters subject to regime shifts and takes on discrete values $sp \in \{1, 2, 3, 4\}$, while the latter stands for the shock volatilities, taking discrete values, $vo \in \{1, 2\}$, and evolve independently of $sp$.

Both state variables $sp$ and $vo$ are assumed to follow a first-order Markov chain with the following transition matrices, respectively:

$$
H = \begin{pmatrix}
H_{11} & H_{21} & H_{31} & H_{41} \\
H_{12} & H_{22} & H_{32} & H_{42} \\
H_{13} & H_{23} & H_{33} & H_{43} \\
H_{14} & H_{24} & H_{34} & H_{44}
\end{pmatrix}
$$

and

$$
Q = \begin{pmatrix}
Q_{11} & Q_{21} \\
Q_{12} & Q_{22}
\end{pmatrix}
$$ (2.17)

where $H_{ij} = p(sp_t = j \mid sp_{t-1} = i)$, for $i, j = 1, 2, 3, 4$, and $Q_{ij} = p(vo_t = j \mid vo_{t-1} = i)$ for $i, j = 1, 2$.

Then $H_{ij}$ stands for the probability of being in regime $j$ at $t$ given that one was in regime $i$. The analysis is symmetric for $Q_{ij}$.

The Markov switching system can be cast in a state-space form by collecting all the endogenous variables in a vector $X$ and all the exogenous variables in a vector $Z$:

$$
B_1 (\xi^{sp}_t) X_t = E_t \{ A_1 (\xi^{sp}_t, \xi^{sp}_{t+1}) X_{t+1} \} + B_2 (\xi^{sp}_t) X_{t-1} + C_1 (\xi^{sp}_t) Z_t
$$ (2.18)

$$
Z_t = R (\xi^{sp}_t) Z_{t-1} + \epsilon_t \quad \text{with} \quad \epsilon_t \sim N (0, \Sigma^{vo})
$$ (2.19)

where the matrices $A_1 (\xi^{sp}_t), B_1 (\xi^{sp}_t), B_2 (\xi^{sp}_t), C_1 (\xi^{sp}_t)$ and $R (\xi^{sp}_t)$ are functions of the model parameters. Note that, in contrast with (2.14), in (2.18) there are unobserved variables and unobserved Markov states in the Markov chains.

There are several studies in the MS-DSGE that analyze the technical aspects involved in solving the state-space system (Farmer et al. (2008, 2011); Foerster et al. (2014); Maih (2015) and Cho (2016)), since the solution algorithms developed for solving DSGE models with fixed parameters (e.g. Sims (2002) and Schmitt-Grohé and Uribe (2003)) are unsuitable. To solve the system we used the Newton methods developed in Maih (2015), which extend that proposed by Farmer et al. (2011) and concentrate on minimum state variable solutions (MSV) of the form:

$$
X_t = \Omega^* (\xi^{sp}, \theta^{sp}, H) X_{t-1} + \Gamma^* (\xi^{sp}, \theta^{sp}, H) Z_t (\xi^{vo}, \theta^{vo})
$$ (2.20)

---

6 Where 1, 2, 3, 4 are the PM/PF, PM/AF, AM/PF and AM/AF regimes, respectively.

7 Where 1 and 2 are the high and low volatility regimes.

8 The routines used for the computations were implement using RISE, an object-orientated Matlab toolbox for solving and estimating Markov switching rational expectation models, developed by Maih (2015).

9 See McCallum [1983].
2.4 Stability

Various authors have focused on the concept of Mean Square Stability solutions (MSS)\textsuperscript{10} for \eqref{eq:2.20}. As Maih (2015) and Foerster (2016) emphasize, this condition implies finite first and second moments in expectations for the system:

\begin{align}
\lim_{j \to \infty} E_t [X_{t+j}] &= \bar{x} \\
\lim_{j \to \infty} E_t [X_{t+j}X'_{t+j}] &= \Sigma
\end{align}

Additionally, as pointed out by Costa et al. (2006), and Foerster (2016), the solution of the system \eqref{eq:2.20}, given that the matrix \( T(\xi^p, \theta^p, H) \) does not satisfy the standard stability condition, a necessary and sufficient condition of MSS stability, implies that all the eigenvalues of the matrix \( \Psi \) are in the unit circle (Alstadheim et al., 2013):

\begin{equation}
\Psi = (\mathbb{H} \otimes I_{n^2}) \begin{bmatrix} T_1 T_1 & \cdots & \cdots \\ & & \vdots \\ & & T_h T_h \end{bmatrix}
\end{equation}

2.5 Estimation

The presence of unobserved DSGE states \( X_t \) and unobserved parameters (corresponding to the Markov chains), implies that the standard Kalman filter cannot be used to compute the likelihood function. Following Bianchi and Ilut (2017), we use a modified version of the Kim et al. (1999) filter and follow a Bayesian approach.

1. We compute the solution of the system using an algorithm found in Maih (2015), and employing a modified version of the Kim et al. (1999)\textsuperscript{11} filter to compute the likelihood with the prior distribution of the parameters.

2. Construct the posterior kernel result from stochastic search optimization routines\textsuperscript{12}.

3. We used the posterior mode as the initial value for the Metropolis Hasting algorithm, with 200,000 iterations.

4. Utilizing the mean and variance of the last 100,000 iterations from (3) we run the main Markov Chain Monte Carlo (MCMC) algorithm.

\textsuperscript{10}See Costa et al. (2006); Cho (2014); Foerster et al. (2014); Maih (2015).

\textsuperscript{11}As in Bjørnland et al. (2018), we “collapse” the system right after the prediction step of the Kalman Filter, rather than right after the updating step as proposed by Kim et al. (1999). As noted by Alstadheim et al. (2013) and Bjørnland et al. (2018), this approach achieves numerically similar results with computational savings.

\textsuperscript{12}Provided in the RISE toolbox.
3 Results

We use quarterly data for the period 1981Q1-2016Q4. The following series were used to estimate the MS-DSGE model for the Mexican economy: gross domestic product (GDP) at market prices; real GDP at constant prices; broad consumer prices index (IPC); CETES (91 days) interest rates; taxes and non-tax fiscal revenues; government debt; purchases; and transfers.

The real GDP and the consumer prices index (CPI) are obtained from Mexican National Institute of Statistics and Geography (INEGI) databases. The interest rates and series for fiscal variables are obtained from the Central Bank and Mexican Secretariat of Finance and Public credit (SHCP). When treating the series, seasonality is removed using the X12-ARIMA technique, and all fiscal variables are expressed as a fraction of the nominal GDP.

3.1 Parameter estimates

Table 2 reports the prior and posterior parameter estimates. Priors follow the values used in Bianchi and Ilut (2017) and, as detailed in subsection (2.3) the Bayesian estimation uses the posterior mode as its initial value.

Starting with the monetary policy parameters, for periods when monetary policy is characterized as passive, the response of interest rates to inflation, $\psi_{\pi,PM}$, is estimated at 0.7862, while the response to output, $\psi_{y,PM}$, is 0.6604, and the persistence of inflation, $\rho_{R,PM}$, is 0.5794. Meanwhile, when monetary policy is active the response of interest rates to inflation, $\psi_{\pi,AM}$, is 1.8119, the output response, $\psi_{y,AM}$, is 0.9385, and the persistence of inflation, $\rho_{R,AM}$, is 0.5526.

In the case of the fiscal policy parameters, for periods when fiscal policy is passive there has been low persistence of tax income with an autoregressive coefficient, $\rho_{\tau,PF}$, of 0.7945, while the elasticity of taxation to government indebtedness, $\delta_{b,PF}$, is 0.0624. When fiscal policy is active, the estimated persistence of taxes, $\rho_{\tau,AF}$, is 0.7299, while the response to indebtedness, $\delta_{b,AF}$, is negligible at 0.0003. Taxation is higher when expenditure increases with an estimated coefficient, $\delta_{e}$, of 0.929 and an elasticity of taxation to output gap, $\delta_{y}$, of 0.1468, denoting procyclicality. Periods of active fiscal policy are also characterized by higher persistence of non-tax income as the autoregressive coefficient, $\rho_{\tau_{non-tax},AF}$, is estimated at 0.8937 compared to 0.7454 for $\rho_{\tau_{non-tax},PF}$, when fiscal policy is classified as passive.

Following Bianchi and Ilut (2017), we separate out short-term and long-term components of government expenditure. The persistence of the long-term component, $\rho_{eL}$, is restricted to 0.99, and the standard deviation of its innovations, $\sigma_{eL}$, to 0.1%. The estimated autoregressive coefficient of short-term expenditure, $\rho_{eS}$, is 0.3958, while elasticity with respect to the output gap, $\phi_{y}$, is -0.3017, a countercyclical behavior of short-term expenditure. Taken together, the pro-cyclical behavior of taxation and the counter-cyclical response of expenditure provide evidence that, on average, fiscal policy was counter-cyclical during the sample period. However, a full description of fiscal cyclical stance requires a historical decomposition of the contribution of tax and expenditure shocks.

Additionally, with respect to the IS curve parameters the estimated degree of households’ external habit, $\Phi$, is 0.8829, which represents a high level of consumption indexation in the model. On the other hand, the exogenous total factor productivity parameter, $\bar{\gamma}$, is estimated at 0.3906 for the steady state.
Finally, the estimated parameter for the Phillips curve slope, $\kappa$, which gives evidence of the frequency at which firms change prices, is 0.1278, while the estimate of the indexation degree, $\varsigma$, is 0.4168.

3.2 Regime probabilities and historical accounts

The estimation provides us with the responses of fiscal and monetary policy under passive and active regimes, as well as the probability of each of the four possible cases (PM/PF, PM/AF, AM/PF and AM/AF) inhering at any given time. Figure 2, below, shows the smoothed probabilities of each regime. According to these probability estimates, we find very clear patterns of different macroeconomic policy regimes in Mexico in the 1980-2016 period. We find that monetary policy was passive with a high probability in two periods: 1981Q1-1988Q2 and 1995Q2-1998Q4. For most of the remaining quarters, meanwhile, we estimate that there is a high probability that monetary policy was instrumented actively. Of note are two short periods - the years 2009 and 2016 - in which we identified that the probability of PM increased and even went beyond 50% in two quarters (in both years). As we discuss further below, in both cases we observed volatile episodes in some macroeconomic variables, but in particular in exchange rates, which are not explicitly modeled. These volatile episodes may have influenced the probabilities in our results. Meanwhile, fiscal policy has a high probability of being active in three well-defined periods: 1981Q1-1988Q2, 1995Q2-1998Q4 and 2008Q4-2016Q4.

From those probabilities and results we identify five different periods of fiscal and monetary policy interaction configurations which are congruent with the macroeconomic environment, as well as the institutional and macro policy changes that Mexico saw during the last 35 years: 1) 1981Q1 - 1988Q2: PM/AF; 2) 1988Q3 - 1995Q1: AM/PF; 3) 1995Q2 - 1998Q4: PM/AF; 4) 1999Q1 - 2008Q3: AM/PF; and 5) 2008Q4-2016Q4: AM/AF. Below we provide a detailed historical account of these periods.

---

13To make this exercise comparable to Bianchi and Hut (2017), the model was specified as a closed-economy which given the importance of the open-economy factors could bias the results. Cadavid Sánchez and Ortiz Bolaños (2017) specify a Markov switching DSGE open-economy model to analyze the monetary policy stance in Brazil, Chile, Colombia, Mexico and Peru. Their exercise identifies that monetary policy has been passive from 1981Q1 to 1988Q2 and from 1995Q1 to 2002Q2, which is relatively similar to our estimations. The difference from 1999Q1 to 2002Q2, which they classify as passive monetary policy and we identify as active monetary policy, could be due to the open-economy aspect of their exercise and/or their lack of a fiscal policy specification. A natural step is to add open-economy factors to our current model.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mode</th>
<th>Mean</th>
<th>Credible intervals</th>
<th>Prior</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\psi_{e,PM}$</td>
<td>0.7469</td>
<td>0.7862</td>
<td>0.4780 0.9710</td>
<td>Gamma 0.87 0.3</td>
</tr>
<tr>
<td>$\psi_{e,AM}$</td>
<td>1.9275</td>
<td>1.8119</td>
<td>1.1506 2.5185</td>
<td>Normal 1.89 0.5</td>
</tr>
<tr>
<td>$\psi_{y,PM}$</td>
<td>0.4755</td>
<td>0.6604</td>
<td>0.3281 0.9277</td>
<td>Gamma 0.88 0.1</td>
</tr>
<tr>
<td>$\psi_{y,AM}$</td>
<td>0.9111</td>
<td>0.9385</td>
<td>0.6569 1.2200</td>
<td>Gamma 0.60 0.2</td>
</tr>
<tr>
<td>$\rho_{R,PM}$</td>
<td>0.7243</td>
<td>0.5794</td>
<td>0.4056 0.7880</td>
<td>Beta 0.68 0.2</td>
</tr>
<tr>
<td>$\rho_{R,AM}$</td>
<td>0.7855</td>
<td>0.5526</td>
<td>0.3292 0.7460</td>
<td>Beta 0.76 0.2</td>
</tr>
<tr>
<td>$\delta_{b,PF}$</td>
<td>0.0625</td>
<td>0.0624</td>
<td>0.0156 0.0733</td>
<td>Gamma 0.08 0.02</td>
</tr>
<tr>
<td>$\delta_{b,AF}$</td>
<td>0.0004</td>
<td>0.0003</td>
<td>0.0002 0.0004</td>
<td>Gamma 0.001 0.01</td>
</tr>
<tr>
<td>$\rho_{\tau_{tax},AF}$</td>
<td>0.6998</td>
<td>0.7299</td>
<td>0.5109 0.9488</td>
<td>Beta 0.5 0.3</td>
</tr>
<tr>
<td>$\rho_{\tau_{tax},PF}$</td>
<td>0.7819</td>
<td>0.7945</td>
<td>0.4067 0.8489</td>
<td>Beta 0.6 0.3</td>
</tr>
<tr>
<td>$\rho_{\tau_{non-tax},AF}$</td>
<td>0.9714</td>
<td>0.8937</td>
<td>0.6256 0.9519</td>
<td>Beta 0.5 0.3</td>
</tr>
<tr>
<td>$\rho_{\tau_{non-tax},PF}$</td>
<td>0.9939</td>
<td>0.7454</td>
<td>0.5069 0.8911</td>
<td>Beta 0.5 0.3</td>
</tr>
</tbody>
</table>

Table 2: Estimated Parameters

Posterior modes, means, and 90% credible bands for the model parameters. The right side of the table reports the priors.
Before moving on to a period-by-period historical analysis, it will be useful to analyze the transition probabilities across regimes. Table 3 reports the estimated transition matrix, from which we can infer that the probabilities of staying in the previous regime are 0.7055, 0.6402, 0.7191 and 0.5746 for PM/PF, PM/AF, AM/PF and AM/AF, respectively.\footnote{These probabilities are calculated as the complement of the ones reported. For example, $H_{PM/PF-PM/AF} = 1 - H_{PM/PF-PM/AF} - H_{PM/PF-AM/PF} - H_{PM/PF-AM/AF}$.} The PM/PF regime is the least prevalent and it is most likely to gravitate to an AM/AF regime. Fiscal dominance regimes of PM/AF also tend to transition to an AM/AF regime. The Monetarist regime of AM/PF exhibits a relatively large probability of transitioning either to one of fiscal dominance or one where both policies are active. Finally, an AM/AF regime is equally likely to move to either of the other three regimes.

The last panel of figure 2 reports the smoothed probabilities for the high volatility periods, while the last two rows of table 3 report the transition probabilities across high and low volatility regimes. There have been several periods of high volatility (1983Q1 to 1983Q3, 1990Q2, 1994Q2, 1994Q4 to 1996Q2, 2001Q3}
to 2002Q1, and 2009Q1 to 2010Q2) that match periods of domestic crisis and/or international financial instability. When in a highly volatile environment, the probability of moving to a low volatility environment is 0.0737, while there is a 0.1131 probability of transitioning to a high volatility environment from a low volatility environment.

### Table 3: Estimated Transition Matrix

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mode</th>
<th>Mean</th>
<th>Credible intervals 5%</th>
<th>Credible intervals 95%</th>
<th>Type</th>
<th>Priors</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_{PM/AF-PM/AF}$</td>
<td>0.0428</td>
<td>0.0312</td>
<td>0.0187</td>
<td>0.0416</td>
<td>Dirichlet</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>$H_{PM/AF-AM/PF}$</td>
<td>0.0736</td>
<td>0.0830</td>
<td>0.0279</td>
<td>0.0889</td>
<td>Dirichlet</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>$H_{PM/AF-AM/AF}$</td>
<td>0.1703</td>
<td>0.1803</td>
<td>0.0715</td>
<td>0.2471</td>
<td>Dirichlet</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>$H_{AM/PF-PM/AF}$</td>
<td>0.0332</td>
<td>0.0235</td>
<td>0.0155</td>
<td>0.0320</td>
<td>Dirichlet</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>$H_{AM/PF-AM/PF}$</td>
<td>0.0883</td>
<td>0.0688</td>
<td>0.0447</td>
<td>0.0895</td>
<td>Dirichlet</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>$H_{AM/PF-AM/AF}$</td>
<td>0.3148</td>
<td>0.2675</td>
<td>0.1873</td>
<td>0.3558</td>
<td>Dirichlet</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>$Q_{Low-High}$</td>
<td>0.0741</td>
<td>0.1388</td>
<td>0.0888</td>
<td>0.1832</td>
<td>Dirichlet</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>$Q_{High-Low}$</td>
<td>0.0920</td>
<td>0.1012</td>
<td>0.0678</td>
<td>0.1406</td>
<td>Dirichlet</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

Posterior modes, means, and 90% credible bands for the model parameters. The right side of the table reports the priors.

### I. 1981Q1-1988Q2. PM and AF

This is a period in which the Mexican economy, and in particular public finance, was affected by several turbulence-producing shocks. The 1980s were characterized by low average growth, currency devaluations, a lack of balance in external accounts, and high inflation. The Mexican government responded to this challenging situation by implementing structural reforms, public expenditure adjustments, and some orthodox and heterodox measures to get to grips with inflation and volatility. The Central Bank was not autonomous, and the main aim of monetary policy was to sustain the fixed exchange rate regime.

The Mexican oil boom - triggered by substantial oil field discoveries at the end of 1970s, as well as high international oil prices - gave rise to significant growth in public expenditure, from 30.9% of GDP in 1978 to 40.6% of GDP in 1981. This spending expansion was mostly financed through deficit, which went from 6.7% to 14.6% of GDP over the same period, since revenue did not expand at the same pace as expenditure (Cárdenas, 2011; Suárez, 2015). The government based its growth strategy on an expansive fiscal policy, with a combination of the newly-discovered oil sources and expectations that oil prices would remain high leading them to expect debt to prove sustainable. Public deficits were financed in part by printing money and in part through external credit with foreign banks (Cárdenas, 2011). At the beginning of the 1980s, however, oil prices dropped and international interest rates increased. The government nevertheless kept to the same elevated level of public expenditure, causing the fiscal deficit and debt to surge.

That said, the fixed exchange rate regime worked for the Central Bank as the nominal anchor of the economy. The debt market in Mexico at the time was not profound, which implied that liquidity was regulated mainly
through reserve requirements (Carstens, 2015). In order to regulate and offset the impact of the increased supply of money used to finance public deficits, the Central Bank raised the minimum reserve requirements, which led to higher interest rates. By the early 1980s a decline in oil prices, higher foreign and domestic interest rates, and doubts regarding external sustainability and the peso-dollar parity all led to pressures on external accounts through capital flight forcing the government to in 1982 decree a devaluation of the peso (Carstens, 2015). The higher exchange rate, along with a lack of fiscal adjustments, provoked a rise in inflation. In this environment, capital outflows continued and international reserves diminished quickly, which prevented the Mexican government from servicing its external debt and in August of 1982 forced it to announce the suspension of payment for six months (Cárdenas, 2011). Due to an elevated deficit, a debt mainly denominated in foreign exchange, and the depreciation of the peso, public debt as a percentage of GDP was more than double the observed level of 1981 by the end of 1982. This inability to adjust public expenditures was aggravated by the devaluation that impacted interest payments on the public debt, putting even more pressure on public finances.

In response to the crisis, the government implemented an Immediate Economic Reordering Program (PIRE, to use its acronym in Spanish) to adjust public finances through public expenditure and subsidy cuts, higher taxes, and renegotiation of external debt. This would set the conditions for a healthier recovery in the medium term (Suárez, 2015). The measures allowed the government to halve the deficit observed in 1982 over the three following years. That the deficit reduction was not greater is due to the rise in financial costs caused by higher debt and foreign exchange. While in 1981 the payment of interest represented 13% of the federal budget, this percentage increased to 27% in 1982, reaching a maximum of 45% in 1987. But inflation could not be abated because of the periodic devaluations implemented to boost exports and the indexation of wages to inflation (Carstens, 2015). The dual shocks of the 1985 earthquake and the 1986 drop in oil prices impacted GDP growth and public revenues. This situation reinforced the need to implement structural reforms and keep on restructuring public finances to promote growth (Carstens, 2015; Suárez, 2015).

The main measures were the reduction of the public sector through privatization of public companies, increased economic and trade openness, and deregulation. These efforts proved ineffectual in the 1987 financial crisis, which considerably worsened the economic and inflationary outlook. The Mexican government responded with the implementation of a set of heterodox policies aimed at controlling inflation through the Economic Solidarity Pact (PSE, to use its acronym in Spanish), which was a national agreement subscribed to by the government, firms and workers. PSE included specific steps to reduce the size of the public sector, a more restrictive monetary policy to restrain credit, wage indexation in line with expected inflation and longer labor contracts, and input price fixing in leading sectors. Moreover, after an initial adjustment, the exchange rate was fixed during 1988 and was intended to continue working as the nominal anchor of the economy and PSE. PSE proved successful, as the public expenditure adjustments translated into a shrinking public deficit and inflation dropped considerably: from 159.2% in 1987, to 51.2% in 1988 (Cárdenas, 2011).

Parallel to this, starting in 1985 a series of legal changes took place which culminated in the Constitutional Reform granting the Central Bank autonomy in 1994. Among these changes were the establishment of credit limits by the Central Bank, and the substitution of reserve requirements for open market operations to control liquidity (Cárdenas, 2011).
In sum, this was a period of economic instability, characterized by high inflation and public debt, which is consistent with the results of the estimated probabilities for the policies regime. Central Bank instruments were based on reserve requirements and fixed exchange rates, so the response of interest rates to changes in inflation was weak \( (\hat{\psi}_\pi,\xi^p < 1) \) with a high probability. From the fiscal perspective, although this was a period in which various efforts were made to adjust expenditure, there were other forces that hindered the debt-to-GDP ratio following a sustainable path. High debt levels, mostly denominated in foreign currencies, were further burdened by an increase in interest payments. Moreover, both variables were affected by devaluations, as the amount in pesos required to service the interest payments increased along with public expenditures, as well as the valuation of external debt in pesos. Finally, low economic growth did not help to stabilize the debt ratio. The probability of an explosive debt path associated with an active fiscal policy \( \left( \beta^{-1} - \sum_{t=0}^{\infty} (1 - \rho_{\text{int},\xi^p}) \delta_{b\xi^p} > 1 \right) \) is thus almost 1 in all periods. The Central Bank’s lack of autonomy, combined with double and triple digit inflation and high public deficits partially financed with an increase in the money supply, could explain the result of our estimation which identifies this period as fiscal dominance (PM/AF).

II. 1988Q3-1995Q1. AM and PF

The macroeconomic stabilization efforts of the preceding years had by now started to take effect, and the process of structural economic reform was consolidated. Inflation diminished quickly, to 18% by 1989Q4 and to single digits by 1993Q1. Fiscal policy successfully adjusted public expenditures, causing public deficit and debt to decrease. Renegotiation of the external debt in 1989 (Brady Plan) was key to this process, as the agreement with the US consisted of interest rate reductions, partial capital cancellation, and longer periods of maturity. This led to a sharp reduction in debt and the associated financial cost. Financial cost represented only 10% of the budget in 1994 and this smaller burden contributed to the existence of fiscal surpluses from 1991 through 1994.

The North American Free Trade Agreement (NAFTA), financial liberalization, bank privatization, and the implementation of a deeper sale process for public enterprises were among the most important reforms. They generated a positive outlook on the Mexican economy, which in turn led to capital inflows, although most of this was short-term. Exchange policy remained the nominal anchor of the economy as well as the main instrument of monetary policy. In 1991, the exchange policy changed from a fixed exchange rate to a band system with a floor and a ceiling, both adjustable over time (Carstens, 2015). Both capital inflows and the new exchange regime reduced pressures on the peso. A more stable exchange rate, increased fiscal prudence, more confidence in the Mexican economy, structural reforms, and successes in the instrumentation of PSE all contributed to diminishing inflation and interest rates, and to increasing the correlation between them.

Towards the end of this period, in 1994 the Constitution was reformed to grant legal autonomy to the Central Bank and to establish that its main objective was to ensure the stability of the purchasing power of the currency. This reform also mandated that no authority could force the Central Bank to grant financing (Carstens, 2015). This was a remarkably far-reaching reform, and one that marked a new era of monetary policy.

As outlined above, this was a period of macroeconomic stability, with a sustainable path of public debt,
and lower inflation and interest rates. Our estimation suggested there was a high probability that fiscal policy was passive and monetary policy active. Although monetary policy did not yet explicitly operate through a Taylor rule, the macroeconomic environment was auspicious to low inflation and interest rates, so that the relationship between the two was captured by a high interest rate response to inflation. The diminishing path of debt is congruent with our estimation that shows a very high probability that the relevant parameter of debt motion is lower than one (current debt is lower than the previous period’s debt).

III. 1995Q2-1998Q4. PM and AF

By 1994, the Mexican economy was once again in turmoil. Domestic political events combined with an accumulation of imbalances in the private and external sectors to undermine credibility in the exchange regime. This, together with increasing international rates, produced capital outflows, and the Central Bank was no longer able to defend the exchange rate regime as international reserves dropped considerably. By the end of 1994, authorities were forced to let the peso float (Cárdenas, 2011; Carstens, 2015), which led to a sharp depreciation and caused knock-on inflationary pressures in 1995. The exchange rate thus ceased to be the nominal anchor of the economy and in 1995 the Central Bank set money aggregates targets instead (Banco de México, 2017). The main instrument was setting a limit in the growth rate of the monetary base. The new nominal anchor turned out to be the first step in a migration towards an inflation-targeting regime, which was finally completed in 2002 (Turrent and Díaz, 2007). To strengthen the money growth target, the authorities created the option of modifying interest rates through commercial bank balances held at the Central Bank, with an instrument called “corto” (Carstens, 2015). Interest rates had become an instrument of monetary policy, and could now be used to control inflation. This in turn led to an increased correlation between both variables. The implementation of these instruments allowed the Central Bank to push back against the increasing inflation observed after free flotation was implemented.

The fiscal response to the 1994 crisis was orthodox: adjustment in public expenditure and implementation of measures aimed at strengthening public revenues through a tax reform that included a rise in the Value Added Tax (VAT) rate from 10% to 15%. The public balance was in deficit, but only moderately. However, thanks to the weakness of the peso at the beginning of this period, the importance of foreign exchange-denominated debt, and a sharp decline in GDP, the public debt-to-GDP ratio surged. Nevertheless, subsequent healthy economic growth and a more balanced public budget were able to put debt on a sustainable path.

The 1995 crisis brought more turbulence to the Mexican economy, as an acute depreciation of the peso generated pressures on inflation and public debt. Our estimation is consistent with active fiscal policy and passive monetary policy, according to the estimated probabilities. Interestingly enough, the categorization of this regime during the post-crisis period seems to be driven, more than by different macroeconomic policies, by exogenous factors linked to a change in the valuation of peso, which impacted directly on inflation and debt valuation, and, furthermore, the regime’s probabilities.

Exchange rate exclusion may bias the relationship between interest rates and inflation. Depreciation causes inflation, but in response to any given event the Central Bank could decide not to change interest rates, as inflationary pressure may come from a transitory shock, or interest rates’ movement may be bounded. Therefore, if the estimation does not take into account the exchange rate, the sensibility of interest rates
to inflation decreases. On the fiscal side, depreciation increased debt valuation, but it did not necessarily mean that the sensitivity of tax rate to debt changed, as it was perceived that the cause of the increase in debt was unrelated to the fiscal position. The fiscal authority could have decided not to modify the tax rate, not because it is less sensitive to debt dynamics, but because of the exogenous nature of the rise in debt. In short, during this period fiscal and monetary policy did not change, as the Central Bank concerned itself only with inflation evolution; in addition, public deficit was moderate, as the government did not implement an aggressive expansionary fiscal policy. Adding exchange rate and policy rules into the model and estimations might perhaps lead to a different result. As adjustment policies were implemented, volatility disappeared and macroeconomic policy swung back to a monetary dominance regime.

IV. 1999Q1-2008Q3. AM and PF

This period was characterized by a sound macroeconomic environment: inflation remained consistently stable, low and predictable, and public deficit was moderate, while public debt as percentage of GDP reached a historical minimum.

Solid public finances were buoyed by high international oil prices, which boosted oil and overall public income despite levels of tax revenues being historically low, even when compared to other Latin American countries during the first eight years of the millennium (OECD, 2017). Oil revenues formed around one third of public revenues in this period, but reached 45% in 2008. They also helped boost international reserves. The abundance of oil income allowed the public sector to increase expenditures without ruining the fiscal equilibrium. In 2006, the Federal Budget and Fiscal Responsibility Law (LFPRH, to use its acronym in Spanish) was approved, which among other things set a zero fiscal deficit rule, forcing public expenditure to be constrained by revenue. Escape clauses were also guaranteed so deficits could be incurred in exceptional circumstances. LFPRH was an important step towards institutionalizing the management of public finances in a responsible and accountable manner.

Several factors explain this period’s declining path of debt and higher resilience to exchange market volatility: low deficits, reasonable GDP growth, and the development of a public debt market in Mexico, which allowed for the composition of public debt to change and come to rely more on domestic currency and longer maturities. Disciplined fiscal policy, the efficient implementation of an inflation targeting regime of 3% (with a margin of +/-1%) by the Central Bank, credibility in macroeconomic policy and fundamentals, change in the instruments used to implement monetary policy (from “corto” to one day inter-bank interest rate), transparency, more active communication from the Central Bank, and finally relative stability in the peso/dollar parity were the ingredients that allowed Mexico to converge to a low, less persistent (Chiquiar et al., 2007), stable and predictable level of inflation within the official target (Carstens, 2015). In addition, the anchoring of medium- and long-term inflation expectations (García-Verdú et al., 2012) and the reduction of the exchange rate pass-through to inflation were significant achievements from the perspective of monetary policy (Capistrán et al., 2011). The free exchange market functioned correctly, and capital inflows to domestic public and private financial markets were central to the stability of Mexican currency.

The results of our estimation are congruent with the developments outlined above. The Central Bank could now count interest rates among its instruments, adjusting them in function of inflation and its own expectations. We can therefore reasonably expect that the probability of interest rates having an
elevated sensibility to inflation ($\psi_{\pi, \xi, sp} > 1$) is almost one for each quarter of the period. The Central Bank objective of keeping inflation under control was eased by a serious and observable commitment by the fiscal authority, with a view to adjusting public finances in order to guarantee a sustainable debt path. The estimation parameter of the past debt is thus lower than one in the dynamic equation of the debt with a high probability. In sum, this is a period of monetary dominance, as fiscal policy is passive and monetary policy is active: the Central Bank was able to react efficiently to fluctuations in inflation and keep its level within the target range, a task which was eased by the implementation of a responsible fiscal policy.

V. 2008Q4-2016Q4. AM and AF

The Mexican government’s response to the 2008/09 international financial crisis gave rise to a new regime of monetary and fiscal interaction. A sharp drop in national GDP in 2009 prompted the government to implement a countercyclical fiscal policy, which was initially supposed to stay in place temporarily, but deviation of the public deficit from the equilibrium defined in the LFPRH has recurred on a yearly basis up to (at least) 2016. Deficits allowed for a significant expansion of public expenditure over these eight years, in a context of relatively stable public revenue.

In the meantime, public revenue saw a structural change in its composition. Until 2014, around one third of public income came from oil sources and around 40% from tax revenues: this changed to 16% and 56%, respectively, in 2016. While oil revenue was impacted by declining oil production and prices, tax-related income was boosted because of the 2014 Tax Reform. Deficits, along with exchange rate depreciation since 2014 and low growth since 2013, led to a sizable increase in the debt-to-GDP ratio: after reaching a historically low level in 2007, debt has grown continuously. At the end of 2016, the ratio of the broadest definition of debt-to-GDP was almost 100% higher than the ratio of 2007. The Ministry of Finance anticipated a reversion of the growing debt trend in 2017, thanks to the existence of a Central Bank surplus generated by a strong depreciation in the final part of 2016. In line with LFPRH, this had to be used to write off debt, reduce financial needs and strengthen public assets. The peso was anticipated to appreciate by the end of 2017, thus reducing the valuation in pesos of external debt.

The monetary response to the financial crisis was to reduce interest rates. However, in the years following 2009 Mexico went on attracting capital due to low international rates, mainly in the US, confidence in its macroeconomic policy, and access to the World Government Bond Index (WGBI). Although there were episodes of volatility in the exchange market during and after the crisis, the peso benefited from capital inflows and remained in a relatively stable range between 2010 and 2014. Weakness in aggregate demand allowed the Central Bank to stick to low rates without provoking inflationary pressures.

Inflation stayed within the target range. Then, in 2014, the peso went into a period of volatility and depreciation, the result of a concatenation of shocks. A range of factors contributed to an apparently permanent depreciation of peso (especially in comparison with the exchange rate observed in 2014): a decline in oil prices; uncertainty about the pace of monetary policy normalization in the US; the forecast of a downgrade to Mexico’s credit rating; concerns about the capacity of the government to execute fiscal consolidation; and uncertainty about the US election and potential policy implications to Mexico of the new US presidential administration. At the beginning of the period, in part due to the low exchange rate pass-through, inflation was not compromised, but it had started rising by the end of the period analyzed.
Anticipating this process of higher inflation, which went further than it expected, the Central Bank started hiking rates in December 2015.

According to the estimation of the model for the Mexican case, we find a high probability that both fiscal policy and monetary policy were active. The probability of a motion debt equation parameter being larger than one was high, causing debt-to-GDP to grow. A more tightly-bound relationship between interest rates and inflation was also significant. This is consistent with the narrative of evolution of the macroeconomic policy: an expansive fiscal policy, which incurred deficits positively impacting levels of debt, and a monetary policy using its available instruments to keep a handle on inflation. Credible monetary authority, low pass-through, relative stability in peso parity, and weak aggregate demand evolution favored the Central Bank objective of controlling inflation, despite an active fiscal policy. Unlike in other periods, the absence of government financing allowed the Central Bank to focus on keeping the price dynamic stable, low and predictable. As we saw above, this is an unsustainable policy mix, as neither policy is concerned with stabilizing debt. In the long run, debt will thus not be bounded, and we can therefore reasonably expect a regime change to take place in the fairly immediate future.

During 2016, the probabilities of being under one regime or another were more or less even in both monetary policy and fiscal policy. In particular, during the last two quarters of 2016 the most probable regime (higher than one half but lower than two thirds) was PM/AF. Depreciation of the peso led to a preventive hike in interest rates, even though inflation was still stable. As the exchange rate is not modeled, we observe a reaction in interest rates that is not explained by higher inflation, which in the estimation translates into a lower sensitivity of interest rates to variations in inflation. Furthermore, this by design leads to a more passive instrumentation of monetary policy, even if monetary policy was actually very active and forward-looking, in order to prevent future inflation pressures. Although we have not estimated the first quarters of 2017, the materialization of inflation and further interest rate hikes would presumably have led to a more active monetary policy stance. On the fiscal side, depreciation of the Mexican peso, increased public deficit, and low growth prevented public deficit from achieving a stable and sustainable path downward in 2016. Fiscal policy thus remained active with a high probability, although that probability has decreased as deficit has decreased relative to previous quarters’ results.

Although this is not a sustainable policy mix, it is interesting to note that a fiscal policy that has considerably increased debt did not impact on increases in inflation until 2016. To explain this unexpected result, certain factors need to be taken into account. Firstly, monetary policy implemented by an independent authority has been consistently focused on controlling inflation and expectations thereof. Secondly, the Mexican government had sufficient fiscal space to incur continuous fiscal deficits without worrying about the sustainability of the national debt, because of the historically low levels of debt enjoyed by public finances in 2007. However, this space has been reduced gradually as analysts and credit rating companies have raised concerns about the growing trajectory of debt (Moodys, 2016; Fitch, 2016; S&P, 2016). This highlighted the need for an effective fiscal consolidation plan in order to maintain macroeconomic strength, fiscal space and inflation control.
3.3 Impulse responses

Figure 3 shows the impulse response functions (IRF) for GDP growth, the inflation rate, interest rates, and debt-to-GDP, to the long-term expenditure, monetary policy, and preferences shocks. Each graph compares the responses of each variable under the four policy regimes controlling the effect of switching volatilities.\footnote{In order to analyze the differences between monetary and fiscal policy interactions we isolate the effects of high or low volatility taking the medium value for the volatilities of each shock.}

Figure 3: Impulse response functions

Note: The figure displays the regime-specific impulse responses of one standard deviation shock in long-term expenditure, monetary policy and preferences, respectively.

As shown in the first column, the first shock, constituted by an unexpected increase in long-term expenditures, increases the output gap, inflation rate, and the response of interest rates, while it lowers the debt-to-GDP ratio. Although the responses for GDP are almost identical for all the policy regimes, the combinations of either active or passive for the monetary policy determine the reaction of the other variables. Under the AM combinations, inflationary reactions are lower and the interest rate increments higher. Furthermore, the path of debt-to-GDP is mainly determined by the behavior of the fiscal authority. Under AF combinations, the government is not committed to a stable debt level, and after 12 periods the levels of this variable displays a downward trend. By contrast, when the economy is in a PF combination, the authority is committed to a reverting level of debt.
The second shock, an unexpected increase in the monetary policy rate, generates a recession and lower levels of inflation. In every case in which the Central Bank increases interest rates, the response differs between AM and PM regimes, as in the case of long-term expenditure. The response of debt-to-GDP is very different across different regimes. For the PM/PF and AM/PF regimes, the debt ratio increases quickly, but after 4 periods the trends have a downward reverting movement. The differences between both regimes are reflected in the levels of the variable, which are higher for the PM/PF case. In contrast, the PM/AF and AM/AF regimes present a rapid increase in the variable, but after 2 periods the trends begin to increase.

The third shock, related to a negative preferences innovation, produces a deep drop in the output gap and inflation for the PM/PF and PM/AF regimes, accompanied by a minor decrease in the interest rates of the monetary authority. In contrast, the recessions and drops in inflation are lower for the AM/PF and AM/AF regimes, which are accompanied by deep drops in interest rates. Even though in the AM/PF and AM/AF regimes the debt-to-GDP increases by a smaller margin, the inflation reduction is dampened by the larger drop in interest rates. The effect is contrary for the remaining regimes.

Finally, it is important to emphasize that among the different regimes, the differences in inflation paths are essentially driven by the behavior of the monetary authority, while the dynamic of the debt-to-GDP ratio is controlled by the behavior of the fiscal authority. In this light, the model mechanism is accommodated by a mix of these combinations.

3.4 Counterfactual analysis

To explore the characteristics of the MS-DSGE model with multiple regimes, in this exercise we generate counterfactual series based on conditional forecast simulations. In particular, this analysis allow us to have an idea of what would have happened if the fiscal and monetary policy regime had stayed within a single regime (for instance, AF/PM) during the whole sample period, given the smoothed shocks estimated by the model. Following Bianchi (2012), the model is re-solved introducing a law of motion consistent with the fact that no other regime would have been observed.

Once the model is estimated, we generate forecasts from the MS-DSGE model conditional on the realized path of all the shocks. The first quarter in every sample is used as the initial condition. The parameters utilized are the estimated posterior distribution of the coefficients for each regime. That means we use the estimated parameters for active and passive policies with no changes of regime throughout the whole period.

Counterfactual paths are traced out, generating a new data vector for $Z_t$ in (2.18), including the smoothed shocks. Given that for this regime-switching model different paths for the endogenous variables (one for each regime) are obtained, we utilized the “expected smoothed series” of the shocks that correspond to the weighted average paths of the exogenous variables. Once the system is integrated, the data is filtered and the counterfactual paths for the unobserved and observable variables are generated.

The results of the counterfactual exercises are shown in Figure 4 and Table 4, and they align with what we would expect from the explanation of the regimes in Section 2. On average, in a PM/PF regime inflation would have been higher, and debt lower. Although this is an undetermined equilibrium, which moreover has not been observed in the time span analyzed, none of the policies are concerned with inflation, or try
to restrain debt evolution. The second case is of fiscal dominance in which both inflation and debt would have been higher than their respective prevailing paths. This result is natural, as monetary policy has low sensibility to inflation and is readier to accept inflation in order to diminish nominal debt. On the other hand, fiscal policy is unresponsive to debt evolution, so this has a high path. The third case is monetary dominance which would have resulted in both lower inflation and debt trajectory, as monetary policy would have focused on containing inflation and fiscal policy on controlling debt. Finally, in an AM/AF situation, inflation would have been lower and debt higher because none of the policies would have focused on controlling the evolution of debt, as monetary policy interest rates are highly responsive to inflation and fiscal policy instruments are not sensitive to debt path. Consistent with what was already described in the IRFs, this figure also constitutes evidence that inflation is mainly driven by the monetary policy stance, while the evolution of debt is mainly dictated by the fiscal policy stance.

Figure 4: Counterfactual simulated series for the full sample

Note: The figure shows the data and regime-specific counterfactual scenarios for each given policy regime (PM/PF, PM/AF, AM/PF and AM/AF) in the full-sample.

To further analyze the effects of policies and credibility we generate other counterfactual exercises around the periods when regime switches were observed. In these exercises we compare the actual evolution of each variable relative to what would have been observed, if: i) the regime had not changed, preserving the status quo; ii) the regime switch had been fully credible; and, iii) the regime switch had had no credibility at all. For instance, in a switch from a fiscal dominance to a monetary dominance regime, we explore what would have been observed had monetary dominance been a fully credible regime and a non-credible regime. For this we modify the transition matrix. In the status quo case we assign a probability of 95% to remaining in the previous regime and equally distribute the remaining 5% probability among the other three regimes. In the case of full credibility we assign a probability of 95% to remaining in the switched referred
Table 4: Sample averages of data and counterfactuals for the full sample

<table>
<thead>
<tr>
<th></th>
<th>1981 – 2016</th>
<th>Inflation</th>
<th>Debt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td></td>
<td>20.4</td>
<td>31.2</td>
</tr>
<tr>
<td>Both passive (PM / PF)</td>
<td></td>
<td>49.4</td>
<td>-62.1</td>
</tr>
<tr>
<td>Fiscal dominance (PM / AF)</td>
<td></td>
<td>42.0</td>
<td>154.0</td>
</tr>
<tr>
<td>Monetary dominance (AM / PF)</td>
<td></td>
<td>13.2</td>
<td>-57.1</td>
</tr>
<tr>
<td>Both active (AM / AF)</td>
<td></td>
<td>15.4</td>
<td>201.7</td>
</tr>
</tbody>
</table>

Note: This table reports the sample averages of inflation and debt-to-GDP ratio for the data and the four counterfactuals series, based on the assumption that the specified regime was prevalent during the whole sample.

regime and equally distribute the remaining 5% probability among the other three regimes. Finally, for the case of no credibility, we assign a probability of 5% that the regime switch will prevail and, using as a basis the estimated probabilities, we distribute its probability equally among the other three regimes. This analysis allows us to explore in more detail the role of policies and agents’ expectations in the evolution of macroeconomic variables, and how the interaction between expectations and policy regimes has determined macroeconomic outcomes in Mexico.

Figures 5 to 8, below, present the counterfactual exercises around each regime switch: 1988Q3, 1995Q2, 1999Q1 and 2008Q4.

Table 5: Sample averages of data and counterfactuals around each regime switch

<table>
<thead>
<tr>
<th>Period</th>
<th>Regime</th>
<th>Inflation</th>
<th>Debt</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM / PF</td>
<td>1988Q1/2016Q4</td>
<td>13.0</td>
<td>42.5</td>
</tr>
<tr>
<td>PM / AF</td>
<td>1995Q2/2016Q4</td>
<td>19.2</td>
<td>6.4</td>
</tr>
<tr>
<td>AM / PF</td>
<td>1999Q1/2016Q4</td>
<td>4.9</td>
<td>12.9</td>
</tr>
<tr>
<td>AM / AF</td>
<td>2008Q4/2016Q4</td>
<td>4.8</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Note: This table reports the sub-sample averages of inflation and debt-to-GDP ratio for the data and the counterfactuals for each period in which there was a policy regime switch. The Fully-credible scenario assumes a 95% probability of remaining in the reported switched regime; the Non-credible scenario assumes a 5% probability of remaining in the reported switched regime; and the Status Quo scenario assumes a 95% probability of reverting to the previous regime.

Figure 5 illustrates the regime switch from fiscal dominance PM/AF to monetary dominance AM/PF in 1988Q3. If the switch had been fully credible, with monetary dominance, inflation would have been slightly lower and debt would have stabilized. If the status quo had prevailed, inflation and debt would have been higher than the observed level, but lower than in the non-credible case. Note that the actual evolution of these variables is closer to fully credible than to status quo and non-credible regimes. Based on this, we could argue that this regime switch towards monetary dominance was relatively credible and contributed to lower inflation and debt. Also noteworthy is the fact that interest rates are relatively similar, with fully credible monetary dominance resulting in lower interest rates with a close correlation to inflation. We must remember that after the traumatically high inflation of previous years, this is a period of profound economic structural transformation in Mexico, which came accompanied by changes in macroeconomic policy instrumentation. This later meant fiscal discipline, the end of Central Bank financing to government, and the implementation of gradual steps towards the implementation of the monetary authority’s independence.
Figure 5: Status quo of PM/AF regime and fully credible and non-credible AM/PF regime switch since 1988Q3

Note: The black lines show the full-sample observed series for the GDP growth, inflation rate, debt-to-GDP ratio and interest rate. For the simulated counterfactuals, the paths are reported since the first regime-switch reported in 1988Q3, from PM/AF regime to AM/PF regime. The blue lines show the Fully-credible scenario, conditioning the prevalence probability of AM/PF regime to be 95%. The red lines show the Non-Credible scenario, conditioning the prevalence probability of AM/PF regime to be 5%. The green lines show the Status Quo scenario, conditioning the probability of regime change from PM/AF to any different regime (either PM/PF, AM/PF or AM/AF) to be 1.6%.

Figure 6 shows the regime change from monetary dominance AM/PF to fiscal dominance PM/AF in 1995Q2. In this case, if the switch to fiscal dominance had been fully credible, inflation would have been much higher and debt would have exploded. Sticking with the status quo would have resulted in inflation and debt levels similar to those observed, while, in a non-credible scenario, inflation would have been lower, but debt higher than in the status quo and observed cases. Note that in this case the actual evolution of these variables is closer to the status quo, followed by the non-credible regime, while the fully credible regime generates series that are farther apart. We thus have grounds to argue that this regime switch towards fiscal dominance was non-credible, and allocations were closer to a situation in which monetary dominance prevailed. Perhaps agents understood that the singular situation originated by the crisis called for the temporary leadership of the fiscal authority. A significant aspect of the worsening outlook in public finance is explained by the peso’s depreciation, which impacted on both public expenditure (through interest payment) and debt (through revaluation of external debt). From the monetary policy side, these represent the first years of the Central Bank’s autonomy, the liberalization of the exchange rate, and the change of the monetary policy instrument of setting money aggregates. The crisis affected the exchange rate, which became a shock absorber in the Mexican economy and in turn gave rise to pressures on inflation. But in the new context interest rates did not rise as much as consumer prices, leading to a lower correlation between the two series. Stabilization policies proved immediately effective, however, leading to low credibility of lasting fiscal dominance. And fiscal dominance did indeed only last for a brief time.
Figure 6: Status quo of AM/PF regime and fully-credible and non-credible PM/AF regime switch since 1995Q2

![GDP growth](image1)
![Inflation rate](image2)
![Debt-to-GDP](image3)
![Interest rate](image4)

**Note:** The black lines show the full-sample observed series for the GDP growth, inflation rate, debt-to-GDP ratio and interest rate. For the simulated counterfactuals, the paths are reported since the second regime-switch reported in 1995Q2, from AM/PF regime to PM/AF regime. The blue lines show the *Fully-credible* scenario, conditioning the prevalence probability of PM/AF regime to be 95%. The red lines show the *Non-Credible* scenario, conditioning the prevalence probability of PM/AF regime to be 5%. The green lines show the *Status Quo* scenario, conditioning the probability of regime change from PM/AF to any different regime (either PM/PF, AM/PF or AM/AF) to be 1.6%.

Figure 7 illustrates the shift from fiscal dominance PM/AF to monetary dominance AM/PF in 1999Q1. As in 1988, if the switch had been fully credible, monetary dominance would have resulted in smaller inflation and debt. If the status quo had prevailed, debt would rapidly have exploded, with significant inflationary effects. The evolution of the variables is very close to the fully credible regime, which could be interpreted as a credible switch towards monetary dominance. As explained above, given that the previous regime had low credibility, and that the evolution of the variables between 1995 and 1998 behaved as if it were in AM/PF, it was natural that a return to monetary dominance would carry high credibility. Fiscal policy focused on low deficits, allowing debt to follow a sustainable path throughout this period. On the other hand, monetary policy was instrumented through an inflation target scheme with an independent Central Bank. Given the behavior of both policies, agents perceived a credible regime committed to low inflation. This naturally produced high interest rate correlation and healthy public finance.
Figure 7: Status quo PM/AF, fully-credible and non-credible AM/PF regime switch since 1999Q1

Note: The black lines show the full-sample observed series for the GDP growth, inflation rate, debt-to-GDP ratio and interest rate. For the simulated counterfactuals, the paths are reported since the third regime-switch reported in 1999Q1, from PM/AF regime to AM/PF regime. The blue lines show the Fully-credible scenario, conditioning the prevalence probability of AM/PF regime to be 95%. The red lines show the Non-Credible scenario, conditioning the prevalence probability of AM/PF regime to be 5%. The green lines show the Status Quo scenario, conditioning the probability of regime change from PM/AF to any different regime (either PM/PF, AM/PF or AM/AF) to be 1.6%.

Figure 8 shows the shift from a regime of monetary dominance AM/PF to a regime where both policies are active AM/AF in 2008Q4. If this switch had been fully credible debt would have exploded, while if the switch had had no credibility, debt would have been lower than the observed level. If fiscal policy had remained passive, debt would have been contained. Given that the actual debt evolution was closer to the non-credible case, one could argue that agents believed that the active stance of fiscal policy was temporary, perhaps in response to the Great Financial Crisis. As explained in Section 3.2, fiscal policy consolidation after 2009 was postponed several times. In the beginning, agents found the commitment to reducing deficit to be credible, given the fiscal record of responsibility of the two previous decades, and the need of a countercyclical impulse from the fiscal side. This was key to preventing a sharp increase in debt, fed by poor expectations of fiscal behavior. In this process, monetary policy remained focused on inflation control through interest rates, and avoiding a switch to fiscal dominance. Perhaps in the following years expectations of a switch to PF would need to be backed by deficits that fulfilled the LFPRH, as well as a sustainable path of public debt.
Adopting a broad perspective, the counterfactual exercises suggest that since 1989 monetary policy has tended to be active. With the exception of the 1995 – 1998 period initiated by the 1995 crisis, in which monetary policy was passive but did not represent a credible stance, monetary policy has been consistently active. This has been possible because the Central Bank has acted independently and decisively, striving for low and stable inflation. By contrast, fiscal policy has tended to switch back and forth. The consistency of an active monetary policy suggests that fiscal policy needs to be adjusted to maintain a strong macroeconomic framework and avoid an unstable policy equilibrium with high debt.

4 Conclusions

This paper comprises an analysis of the interaction between monetary and fiscal policies in Mexico during the last 35 years. Using a Markov-switching DSGE model estimation, five macroeconomic regimes are identified in which the stance of both regimes changed. Counterfactual exercises allow us to address the relevance of the different stances of both fiscal and monetary policies in the evolution of inflation and debt. We also highlight the importance of expectations in these dynamics.

From a policy perspective, our results stress the importance of following up the macroeconomic policy framework in order to identify stances that lead to fiscal imbalances and/or inflationary pressures requiring
action from fiscal and monetary authorities. Equally important is the task of anchoring expectations of macroeconomic policy stances, as a crisis of faith may hinder realization of objectives. This message is particularly relevant for Mexico in the current moment. The increase in national debt has been the result of an expansive fiscal policy, but monetary policy has remained active, avoiding an increase in inflation prior to 2016. The current evolution of debt and inflation needs macroeconomic policy action if a stable economic framework, low growth of prices and a sustainable debt trajectory are to be maintained.

Looking ahead, Mexico’s macroeconomic policy may be heading into a new period of interactions between a passive fiscal policy and an active monetary policy: both of these commitments depend on the success with which the Federal Government can maintain fiscal consolidation and the ability of the Central Bank to control inflation. We ought to underline the fact that monetary policy has been active almost uninterruptedly since 1989, thanks in part to the independence of the Central Bank. Adopting the regime sketched above would be optimum for Mexico, because in periods of monetary dominance the country has experienced stability, economic growth and capital inflows: just as the theory would predict.

Further work is necessary to model the international features of the economy and take into account the role of the exchange rate and external accounts in the implementation of monetary and fiscal policies. This might prove particularly fruitful for the analysis of some periods in Mexico in which, for instance, the exchange rate might have played a role in the evolution of debt and inflation, without affecting the stance of fiscal and monetary policies.

References


Cadavid Sánchez, S. and Ortiz Bolaños, A. (2017). Did the introduction of inflation targeting represent a regime switch of monetary policy in latin america? Unpublished manuscript, CEMLA.


Appendix

A Markov-switching representation and estimation of the model

Following the filter proposed by Kim et al. (1999) in this section we provide a simple explanation of the estimation process and construction of the counterfactual series.

The initial characterization of a first order Markov process implies that the state of nature in the period \( t \) is \( S_t \) (which is not observable) and depends on the previous states \( (S_{t-1}, S_{t-2}, \ldots, S_{t-k}) \) only through the most recent regime, \( S_{t-1} \). For simplicity, following the policy regimes for the model presented in section 2, \( S_t = \{PM/PF, PM/AF, AM/PF, AM/AF\} \), we are interested in the following conditional probabilities of \( p(S_t = i \mid S_{t-1} = j) \), where \( i \) and \( j \) are the possible states of \( S_t \), and we therefore get the following transition matrix for the structural parameters of the model:

\[
H^{sp} = \begin{pmatrix}
H_{PM/PF-PM/PF} & H_{PM/AF-PM/PF} & H_{AM/PF-PM/PF} & H_{AM/AF-PM/PF} \\
H_{PM/PF-PM/AF} & H_{PM/AF-PM/AF} & H_{AM/PF-PM/AF} & H_{AM/AF-PM/AF} \\
H_{PM/PF-AM/PF} & H_{PM/AF-AM/PF} & H_{AM/PF-AM/PF} & H_{AM/AF-AM/PF} \\
H_{PM/PF-AM/AF} & H_{PM/AF-AM/AF} & H_{AM/PF-AM/AF} & H_{AM/AF-AM/AF}
\end{pmatrix}
\] (A.1)

where the respective columns are constrained to sum one.

Multiplying \( H^{sp} \) by the vector of probabilities in \( S_{t-1} \), we get the predicted probabilities of being in each of the regimes at \( t \):

\[
\begin{pmatrix}
p(S_t = PM/PF) \\
p(S_t = PM/AF) \\
p(S_t = AM/PF) \\
p(S_t = AM/AF)
\end{pmatrix}
= H^{sp}
\begin{pmatrix}
p(S_{t-1} = PM/PF) \\
p(S_{t-1} = PM/AF) \\
p(S_{t-1} = AM/PF) \\
p(S_{t-1} = AM/AF)
\end{pmatrix}
\] (A.2)

By definition, the ergodic probabilities (or steady state probabilities), \( \omega = [p_{PM/PF} p_{PM/AF} p_{AM/PF} p_{AM/AF}]' \) remain constant after being multiplied by the transition matrix, \( H^{sp} \). The latter implies that \( \omega = H^{sp} \omega \), and therefore \( (I - H^{sp}) \omega = 0 \). Additionally, the ergodic probabilities must sum one: \( 1' \omega = 1 \). Combining both latter conditions, we have:

\[
\begin{bmatrix} I - P \\ 1' \end{bmatrix} \omega = \begin{bmatrix} 0 \\ 1 \end{bmatrix}
\] (A.3)

Now, considering a system with nine observables (described in 2.3) and four policy states, we have one of these operative in each period, generating the observable variables \( Y_t \). In that sense, the density function of \( Y_t \) is conditioned by the available information at \( t - 1 \), \( v_{t-1} \). Given the characterization of a Markov process, the density function is described as:
Equation (A.4) implies that the conditional joint density function is equal to the sum of 16 densities given the existence of the sixteen successions of regimes (derived from the possible combinations between $i$ and $j$). From the definition of conditional probability:

$$f(y_t | S_t = j, S_{t-1} = i, v_{t-1}) = \frac{f(Y_t, S_t = j, S_{t-1} = i | v_{t-1})}{p(S_t = j, S_{t-1} = i | v_{t-1})}$$  (A.5)

Given the existence of independent first order Markov processes, by definition:

$$p(S_t = j | S_{t-1} = i) = \frac{p(S_t = j, S_{t-1} = i | v_{t-1})}{p(S_{t-1} = i | v_{t-1})}$$  (A.6)

Combining (A.5) and (A.6), and using (A.4), we have the following expression for the joint density function:

$$f(Y_t | v_{t-1}) = f(Y_t | S_t = j, S_{t-1} = i, v_{t-1}) p(S_t = j | S_{t-1} = i) p(S_{t-1} = i | v_{t-1})$$  (A.7)

Given the previous description, it is necessary to describe some of the early steps of the procedure.

$t = 0$ The initial conditions are defined for the states vector $\beta_{0/0}^j$ and the covariance matrix $H_{0/0}^j$ for the states $PM/PF, PM/AF, AM/PF, AM/AF$. Additionally the probabilities of realization for each regime are supposed to be the same as the ergodic ones $\omega$. With the described information it is possible to generate the predictions for the next period, $t = 1$, for the states vector and the covariance matrix in a factor of 16. These elements correspond to the realization of one of the possible paths, with predicted probabilities that match with the transition probabilities (just for this step).

$t = 1$ At this point we have the first effective activation of one regime, and therefore, $\omega_1 = \{Y_1, Z_1\}$. Given that, we can find the first prediction of error vectors and covariances, the vector of updated states and the sixteen associated covariances matrices. Given that, it is possible to calculate the probability that the system is in one of the four regimes. In this case, the filtered probabilities that take into account the set of information $v_1$, are the following:

$$p(S_1 = j | v_1) = \sum_{i=1}^{4} p(S_1 = j, S_0 = i | v_1)$$

$$= \sum_{i=1}^{4} \frac{f(Y_1, S_1 = j, S_0 = i | v_0)}{f(Y_1 | v_0)}$$

$$= \sum_{i=1}^{4} \frac{f(Y_1 | S_1 = j, S_0 = i, v_0) p(S_1 = j, S_0 = i | v_0)}{f(Y_1 | v_0)}$$  (A.8)
Given the filtered probabilities for $t = 1$, it is possible to do the predictions for $t = 2$ about the realization of $S_2$. The possible paths are the multiplication of the previous 16 possible paths by the four regimes (64). The predicted probabilities for PM/PF, PM/AF, AM/PF, and AM/AF are obtained multiplying the transition matrix by the filtered probabilities in (A.8). The Markov characterization of the processes implies that:

$$
\begin{pmatrix}
    p(S_2 = PM/PF | v_1) \\
    p(S_2 = PM/AF | v_1) \\
    p(S_2 = AM/PF | v_1) \\
    p(S_2 = AM/AF | v_1)
\end{pmatrix}
= H^{sp} \begin{pmatrix}
    p(S_1 = PM/PF | v_1) \\
    p(S_1 = PM/AF | v_1) \\
    p(S_1 = AM/PF | v_1) \\
    p(S_1 = AM/AF | v_1)
\end{pmatrix}
$$

(A.9)

$t = 2$ For this period we have available the information set $v_2 = \{v_1, Y_2, Z_2\}$ and the second realization of the system for each regime. As before, now we can compute 16 prediction error vectors and their eight covariance matrices. Additionally, we have 16 update state vectors and their covariance matrices. For the filtered probabilities in $t = 2$ and the predicted ones for $t = 3$ we can use the same expression used in (A.9), changing the subscripts.

We can see that with four regimes, the Kalman filter quadruples the number of vector, prediction and updating matrices for each iteration. Given that, the computation of the filter could prove very demanding, so it is necessary to reduce the dimension of the Kalman filter and make it operative. The solution proposed by Kim et al. (1999) collapses the $4 \times 4$ updated state vectors and covariance matrices into 2 for each step. As in Bjørnland et al. (2018), we “collapse” the system right after the prediction step of the Kalman Filter, rather than right after the updating step as proposed by Kim et al. (1999). As noted by Alstadheim et al. (2013) and Bjørnland et al. (2018), this approach achieves numerically similar results with computational savings.