Policy Switches in Emerging Economies

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Job Market Paper

Abstract

Motivated by the repeated stabilization programs implemented by emerging economies during the last 30 years, I develop a dynamic stochastic general equilibrium model with Markov-Switching to study fiscal and monetary policies in emerging economies. I estimate the model for Mexico and find strong evidence of policy changes. Two Regimes are identified. The Active Monetary Policy Regime (AMP), in which monetary and fiscal policies respond to inflation and government debt, respectively; and the Active Fiscal Policy Regime (AFP), in which fiscal policy does not respond to government debt and monetary policy does not respond to inflation. AMP holds during short periods of time after macroeconomic crises during the 80s and 90s, and for a long period after 2002. The rest of the periods, AFP is in effect. I find that switches from AFP to AMP have strong stabilization effects at the cost of high output losses. Moreover, credibility in the persistence of the regime change is key to assess the effectiveness of the stabilization program.

Keywords: DSGE Markov-Switching model, Perturbation Methods, Bayesian Estimation, Emerging Markets.

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1 Introduction

During the last 30 years, several emerging economies such as Argentina, Brazil or Mexico, shifted between short periods of price stability and episodes of high inflation, consumption drops and acceleration of nominal exchange rate growth. In this highly volatile environment, these economies implemented repeated stabilization programs to attack the sources of instability and to control expectations. These stabilization programs encompassed a mix of fiscal and monetary measures capable of affecting the macroeconomic behavior of these economies.

The aim of this paper is to study whether variations in the macroeconomic behavior of these economies are associated to policy changes or, instead, to changes in the volatility of shocks. Distinguishing between these two scenarios is important for several reasons. First, this environment is not restricted to a particular economy; on the contrary, it is common to several emerging economies. Second, as opposed to developed economies, stabilization policies in emerging markets have to deal with extreme macroeconomic conditions, such as hyperinflations and currency crisis; therefore, a correct characterization of policy changes will lead to a better understanding of the effects of policy variations during periods of large distress. Finally, understanding how stabilization policies work in extreme environments may also provide a path of action to developed economies that face periods of macroeconomic crisis, as has recently been observed.

In order to answer this question, I develop a small open economy dynamic stochastic general equilibrium model with time-varying fiscal and monetary policy rules, and time-varying volatilities, to study the effects of policy changes in the macroeconomic dynamics of emerging economies. In particular, I assume that monetary/fiscal policies and volatilities are able to change accordingly to independent Markov-Switching stochastic processes. Moreover, rational expectation assumption imply that agents know the probability distributions of policy changes and incorporate them when computing their optimal plans.[1]

I estimate the model for Mexico and find strong evidence of repeated monetary and fiscal policy changes for the period 1980 to 2009. I find that during the 80s and 90s, monetary policy responded strongly to nominal disturbances only during short periods after macroeconomic crisis. In the spirit of Leeper (1991), these periods are associated to "active monetary policy" and "passive fiscal

[1]This implies that fiscal policy might be Non-Ricardian, i.e. the timing of taxes matter even under non-distortionary taxation. This result was first discussed by Davig and Leeper (2005).

policy", I will refer to these periods as "active monetary policy regime". During these periods, fiscal policy responds passively to government debt accumulation. In other words, these periods are associated to macroeconomic adjustment periods that start after large macroeconomic crisis and last for several quarters. More recently, after 2002, I find evidence of active monetary policy, even though in this case it does not occur in an environment of macroeconomic distress.

During the rest of the sample, fiscal policy does not respond to government debt while monetary policy does not respond to inflation. In this regime, fiscal policy is actively conducted while monetary policy passively accommodates to fiscal policy financing requirements. Also after Leeper (1991), these periods are associated to "active fiscal policy" and "passive monetary policy", for simplicity I refer to these periods as "active fiscal policy regime".

After characterizing the behavior of fiscal and monetary policies, I analyze the effects of policy changes on aggregate variables, specifically output, inflation and nominal exchange rate growth. I find that the dynamics of these variables in the model are different across the two regimes. To study their characteristics, I implement impulse responses, counterfactuals and simulation exercises. I find that changes from active fiscal to active monetary policies have strong stabilization effects, inducing, however, strong and persistent output costs.

Not surprisingly, the effectiveness of a change from active fiscal to active monetary policy strongly depends on private sector beliefs about the persistency of the new policy. In particular, I find that if the policy change is perceived as temporary, the effects in terms of stabilization are rather small. On the other hand, if the policy change is perceived as permanent, the stabilization effects are substantially larger and imply almost no additional output costs.

This paper is related to theoretical and empirical work that studies fiscal and monetary policy determination in emerging economies. This literature, however, has an important gap given that works under the assumption of fixed policy rules. This paper, on the other hand, is the first one, to my best knowledge, in studying repeated policy changes under rational expectations in small open economies in general, and in particular in emerging economies.

Previous studies that analyze policy determination in emerging markets, such as Mohanty and Klau (2004), Aizenman, Hutchison and Noy (2008) or Kaminsky, Reinhart and Vegh (2004) work with vector autoregressions or univariate statistical models with fixed parameters,[2] as well as,

[2]In particular, Mohanty and Klau (2004), study constant coefficient univariate Taylor rules in emerging markets.

more structural approaches such as Batini, Levine and Pearlman (2007), Curdia (2008), Elekdag, Justiniano, and Tchakarov (2006) and Garcia-Cicco (2009).[3]

This paper is also related to the literature on policy temporariness as Krugman (1979), Calvo (1987), Calvo and Mendoza (1994) and Rebelo and Vegh (2006). This literature assumes a temporary change in a macroeconomic policy, such as trade policy, exchange rate policy or tax policy. For instance, in the case of Krugman (1979) the temporariness appears because the new policy is not sustainable given the fundamentals of the economy. Under rational expectations, agents know the policy is not sustainable and, consequently will be abandoned in finite time. After abandonment, the economy is assumed to return to the original equilibrium and remain there forever. Note that, even though questions are similar, the approach of this literature is different from mine. In this paper, as agents know the stochastic distribution of parameters in fiscal and monetary policy rules, agents know at any point in time that there is a probability of policy change. Moreover, they know whether the policy change is permanent (in the case there is a absorbent regime) or not, and in this way, the abandonment of the policy change cannot be pinned down.

The model in this paper exhibit a regime in which fiscal policy does not respond strongly to government debt. Because of this feature, my paper is also related to the Fiscal Theory of the Price Level. This literature studies the tension between monetary and fiscal policy when fiscal policy is set independently of public sector liabilities.

Empirically, interaction between fiscal and monetary policies have been studied in several papers for a wide set of countries, both big and small economies, developed and, to a lesser extent, developing countries. Regarding developed economies, Melitz (1997) estimates reaction functions for a pool of 19 OECD countries and show that fiscal and monetary policies are closely related. However these results are sensible to the inclusion of U.S. and Germany. Favero (2002) finds that

They inquire whether monetary rules react to inflation and exchange rate and find strong responses of interest rates to both variables, reflecting "Fear of floating" behavior. However, performing robustness checks, they find evidence of parameter shifts for the case of Korea, Philippines, Thailand, Brazil, Mexico and Poland. On the other hand, Aizenman, Hutchison and Noy (2008) studies interest rate rules using dynamic panels for 16 emerging economies for the period 1989 to 2006. Kaminsky, Reinhart and Vegh (2004), studies how fiscal and monetary policies differ in developed, middle income and low income countries, also using fixed parameter models.

[3] Specifically, Batini, et. al (2007) study and rank different monetary policies in open economies with financial frictions. Curdia (2008) study monetary policy in a similar environment, however his main objective is to study monetary policy under sudden stops. Elekdag, Justiniano and Tchakarov (2006) instead estimate a financial friction model for Korean economy to study the importance of financial frictions. Also, Garcia-Cicco (2009) estimates a medium scale new Keynesian model to characterize the monetary policy in Mexico. It is important to mention that in most of these studies, authors are aware that policy changes might be an issue. For instance, Garcia-Cicco (2009) assume fixed policy rules, but time-varying targets.

price stabilization coexists with discretionary fiscal policy in the Euro Area. Favero and Monacelli (2003) finds that active fiscal policy was the rule for certain periods of U.S. economy.

Regarding emerging markets, Ramos and Tanner (2002) studies determinacy of fiscal policy for Brazil during the '90s. Zoli (2005) presents several tests to study whether fiscal policy is active or not, and fiscal and monetary policy interaction for emerging markets and find that Argentina and Brazil can be represented as economies under active fiscal policy regimes during the '90s while Chile and other emerging markets cannot. Regarding Mexico, evidence is ambiguous, not only depends on the sample period but also on the test he implements. It is important to note, however, this paper also assumes fixed coefficients and has to separate data in subsamples.

Methodologically, this paper is related to the "Great moderation" literature that studies policy changes in the U.S. economy. Specifically, it is related to papers that model policy changes as Markov Switching processes such as Sims and Zha (2006), Bianchi (2009), David and Leeper(2009).[4] However, these papers study U.S. experience, and hence, work under close economy assumption.

The rest of the paper goes as follows. In Section 2, I motivate my research by reviewing the features of stabilization programs in several emerging economies. In Section 3, I present the model. In Section 4, I discuss the solution, estimation methods, and prior distributions. Section 5, presents estimation results. Section 6, studies implications of my findings to monetary and fiscal policies. Section 7, studies the relevance of policy credibility in the success of stabilization policies. Section 8, establishes model comparison to alternative model specifications. Finally, Section 9 concludes.

2 On the time-invariance of policies: Empirical evidence from Emerging Markets

In this section, I briefly review some of the emerging markets' stabilization programs implemented since 1980s. I focus in the experiences of Argentina, Brazil, Ecuador and Mexico. However, this list could be expanded to other emerging and not emerging economies.[5]

[4] A different approach is to assume smooth time-variability of structural parameters. Some examples are Cogley and Sargent (2005), Fernandez-Villaverde and Rubio-Ramirez (2007) or Seoane (2010a), in which parameters are assumed to follow unit root processes for the former one, and autoregressive processes for the later ones. This strategy is also appealing as it does not constraint the economy to follow a finite number of regimes. However, due to computational tractability the type of stochastic processes to be assumes is limited.

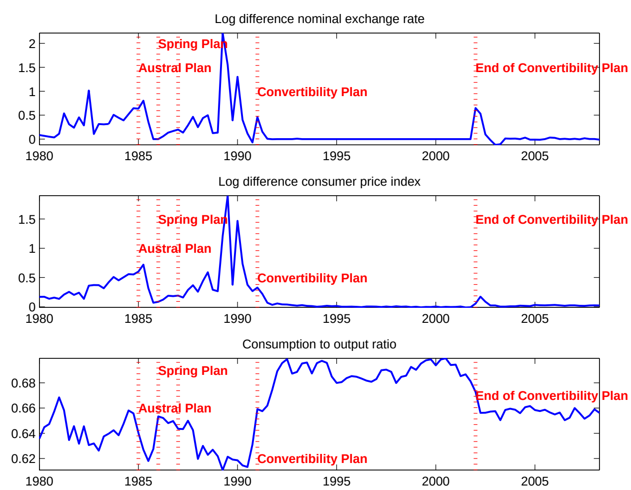
[5] For instance, early nineties imply a dramatic policy change for several European economies that adopted Euro. Currently, East Europe economies are undergoing policy changes in these direction.

2.1 Argentina

Argentina experienced several episodes of large instability and introduced multiple stabilization programs during the 80s and 90s. In June 1985, the government introduced "Austral Plan" that lasted until end of 1986. In 1987 and 1988, "Primavera Plan" was introduced in two stages. More recently, "Convertibility Plan", introduced in 1991, lasted for 10 years and was able to successfully stabilize inflation.

Figure 1 presents inflation, nominal exchange rate growth and consumption to output ratio in Argentina, jointly with implementation of stabilization programs, indicated by the red vertical lines,

Figure 1: Stabilization programs in Argentina.



As seen in the picture, macroeconomic dynamics significantly change after early 90s. During the 80s all series exhibit large variability while several stabilization programs were implemented. After 90s the behavior is remarkably different associated with the large rigidities imposed by Convertibility Plan.

Austral Plan was designed to induce fiscal and monetary discipline, and in this way affect inertial inflationary behavior and expectations. The program successfully stopped inflation during 1985-1986 but failed to keep stability as rigidities were relaxed.

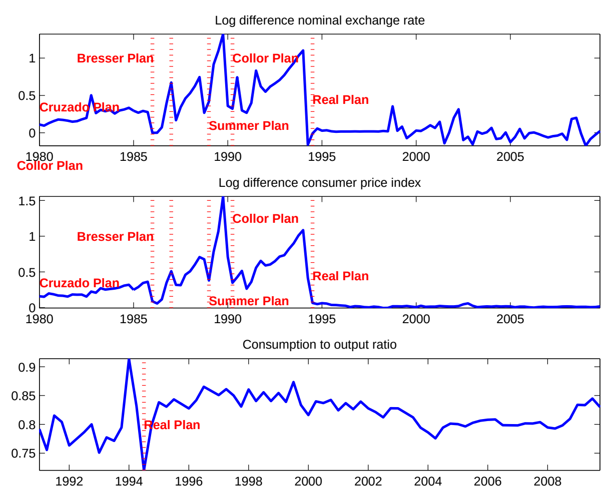
During 1987-1988, "Primavera Plan" was introduced in 2 stages. These plans were initially successful in stopping price and exchange rate instability, but in the medium run inflation exacerbated, leading to hyperinflationary levels while domestic currency strongly depreciated in 1989.

In early 1990s, Convertibility Plan was introduced. Central aspects of the plan were fixed exchange rate regime and financial reform that restricted the capability of Central Government to finance deficits by Central Bank. This was accompanied by major fiscal policy changes such as privatization of public firms and social security system. However, the program was abandoned in 2001 after large period of economic stagnation.

2.2 Brazil

Figure 2 presents macroeconomic dynamics for Brazil, the picture shows that after 1994 the dynamics of these series seem to change. As in the case of Argentina, before 1994, dynamics exhibit larger variability while several stabilization programs were implemented. Since mid 80s, Brazil introduced 5 stabilization programs. "Cruzado Plan" in 1986 followed by "Bresser Plan" in 1987. In 1989, Brazil introduced "Summer Plan" and during early 90s introduced "Collor Plan". However, stabilization was attained in 1994 with the Real Plan.

Figure 2: Stabilization programs in Brazil.



Programs implemented during the 80s where based on price, wage and exchange rate controls in order to deal with inertial inflation. However, they failed in controlling inflation in the medium run because of excess demand problems.

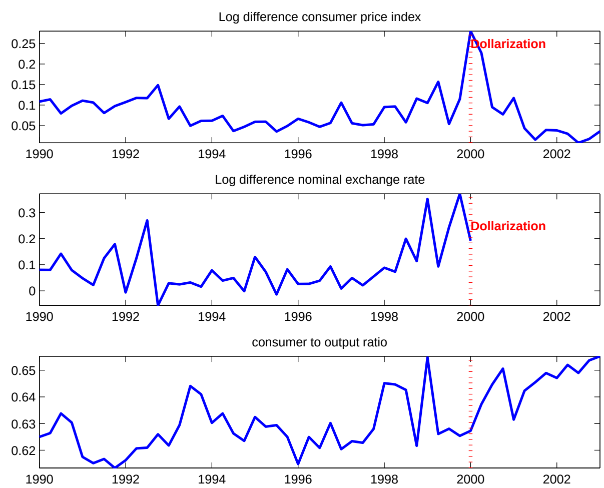
In 1990, government implemented "Collor Plan". This program was introduced together with liberalization of international trade and prices, and privatizations of public enterprises.

However, it was "Real Plan" the one that successfully controlled inflation in 1994. The core of the plan was a monetary reform, with the objective of price stabilization. One of the results of the plan was a reduction in government inflationary tax. In order to control exchange rates, Central Bank exchange rate policy included sterilization of foreign currency inflows through open market operations.

2.3 Ecuador

Probably among the most radical policy changes is the dollarization implemented by Ecuador in 2000. In a dollarized economy, prices are determined in foreign currency (US dollars), transactions are done in foreign currency and, as a consequence, central government lost seigniorage revenues.

Figure 3: Stabilization programs in Ecuador.

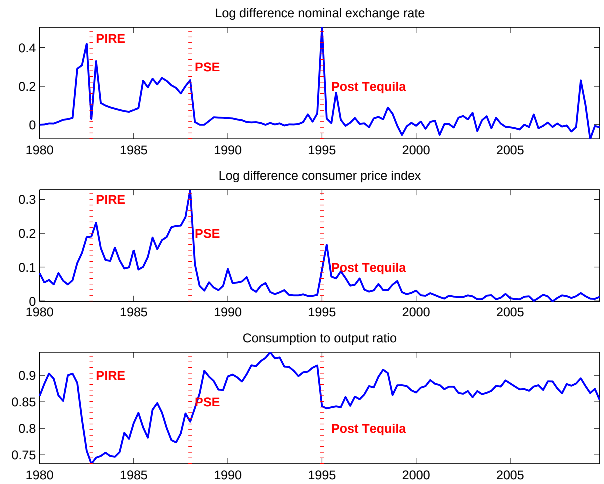


In order to make the transition smoother, Central bank of Ecuador fixed exchange rate in January 2000. Soon after that, the Congress approved the "Law for Ecuador Economic Transformation" that modified not only exchange markets but also, financial and monetary aspects in order to established US dollar as the legal currency and to prohibit debt indexation.

2.4 Mexico

In the case of Mexico we observe 3 major stabilization programs implemented since 1980. Figure 4 presents inflation, consumption to output ratio and nominal exchange rate growth together with "Program for immediate economic reorganization" in 1982, "Program for economic solidarity" in 1988 and in 1995 the stabilization program after Tequila Crisis. As can be seen in the picture, a clear pattern arise; high inflation and nominal exchange rate growth occur together with large variations of consumption to output ratio in the neighborhood of implementation of stabilization programs.

Figure 4: Stabilization programs in Mexico.



An orthodox stabilization program, "Program for immediate economic reorganization" (PIRE), was introduced in 1982 to constraint demand. Given exogenous shocks, in 1987, macroeconomic situation worsen dramatically and the government introduced the "Pacto de Solidaridad Economica" (PSE). This program included subsidies and government expenditure cuts together with improvements in collecting revenue policies, increases in the tariff of public services and a highly restrictive monetary policy that increased interest rates. The stabilization after this program was maintained by fiscal discipline measures.[6]

In 1995, Mexico implemented a program to stabilize the economy after 1994 Tequila Crisis that quickly fulfilled its objective. After a short period, during 1996, changes in subsidy policies were introduced in order to stimulate the recovery of the economy and to increase fiscal savings through a recovery of economic activity.

2.5 Summary

As can be seen in this section, stabilization programs are recurrent in emerging markets. Moreover, previous pictures provide evidence to think that these programs might have strong effects in the

[6]In the framework of the "Pacto para la Estabilidad y el Crecimiento Economico" (PECE).

macroeconomic performance of these economies. However, in all four cases, aggregate volatility seem to be larger during the 80s and early 90s, suggesting that also shocks affecting these economies might have been stronger. The next section presents the benchmark model that allows for policy and volatility changes that helps to understand the way macroeconomic dynamics, volatility and policy changes are related and, hence, understand the effects of policy changes in these economies.

3 The Model

In this section we present the benchmark model. The model is in the spirit of Gali and Monacelli (2005), Justiniano and Preston (2010a) and Monacelli (2005).

I model a small open economy populated by households, domestic firms, government and the rest of the world. Households face incomplete international asset markets, consume, trade government bonds and money. Domestic firms operate in monopolistically competitive markets and set prices accordingly to a Calvo lottery. The Government determines fiscal and monetary policies, in particular, determines primary surplus following a fiscal policy rule and interest rates following a monetary policy rule. Coefficients in the policy rules are allowed to change accordingly to a Markov-Switching process. The rest of the world trade goods and bonds with the domestic economy.

3.1 Households

Households optimization problem is to maximize the discounted value of their lifetime utility. I assume households derive utility form consumption, leisure and real money holdings,

$$\underset{\{c_t,n_t,B_t,D_t,M_t\}_{t=0}^{\infty}}{\text{Max}} \mathbb{E}_0\left\{\sum_{t=0}^{\infty}\beta^t\left[\frac{c_t^{1-\sigma}}{1-\sigma}-\frac{n_t^{1+\varrho}}{1+\varrho}+\frac{m_t^{1-\gamma}}{1-\gamma}\right]\right\},$$

where, $m_t = M_t/P_t$ and c_t is a consumption aggregator given by

$$c_t^{\frac{\eta-1}{\eta}} = (1-\zeta)^{\frac{1}{\eta}} c_{h,t}^{\frac{\eta-1}{\eta}} + \zeta^{\frac{1}{\eta}} c_{f,t}^{\frac{\eta-1}{\eta}},$$

where η denotes the elasticity of substitution between foreign and domestic goods and $(1-\zeta)$ is the home bias. Additionally,

$$c_{h,t} = \left[\int_0^1 c_{h,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}},$$

and

$$c_{f,t} = \left[\int_0^1 c_{f,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}},$$

are the usual Dixit-Stiglitz aggregator. In these expressions, j indexes varieties of consumption goods produced (domestically or abroad). ϵ is the elasticity of substitution between producers.

M_t/P_t are real money holdings and n_t denotes hours worked. σ determines the risk aversion of consumer, ϱ denotes the inverse Frisch elasticity and γ determines the elasticity of money demand to interest rate. It is assumed that $\sigma > 0$, $\varrho > 0$ and $\gamma > 0$.

Household's problem is subject to the set of period by period budget constraints,

$$P_t c_t + D_t + e_t B_t + T_t + M_t = D_{t-1} R_{t-1} + e_t B_{t-1} R^*_{t-1} \Phi_t + W_t n_t + \Pi_t + M_{t-1},$$

where $P_t^{1-\eta} = (1-\zeta) P_{h,t}^{1-\eta} + \zeta P_{f,t}^{1-\eta}$ is the consumption goods price level aggregator, with $P_{h,t}$ being the price of home produced goods and $P_{f,t}$ the price of foreign produced goods. D_t is nominal government debt, issued in domestic currency, e_t is the nominal exchange rate, B_t is foreign debt issued in foreign currency, R_{t-1} is the gross nominal rate of return on domestic bonds, R^*_{t-1} is the gross nominal rate of return on foreign bonds, Φ_t is the risk premium, W_t is the nominal wage, n_t denotes hours worked. I assume households own firms and Π_t are their benefits[7]. Finally, T_t are nominal transfers from/to the government.

Following Schmitt-Grohe and Uribe (2003) and Justiniano Preston (2010a), risk premium works as a stabilization device,

$$\Phi_t = exp\Big\{\chi\Big(\frac{\tilde{B}_t}{B_{ss}}\Big)\Big\},$$

where $\tilde{B}_t$ is the aggregate level of foreign debt, which is not internalized by the households.

Households choose consumption demand, labor supply and demand of domestic, foreign bonds and money holdings. Setting Lagrange multiplier as $\beta^t \frac{\lambda_t}{P_t}$, first order conditions for the households problem are,

[7] As in Justiniano and Preston (2010a), profits are equally distributed among households.

$$\lambda_t = c_t^{-\sigma}, \tag{3.1}$$

$$n_t^{\varrho} = \lambda_t \frac{W_t}{P_t}, \tag{3.2}$$

$$\frac{\lambda_t e_t}{P_t} = \beta \mathbb{E}_t \left[\frac{\lambda_{t+1} e_{t+1}}{P_{t+1}} R_t^* \Phi_{t+1} \right], \tag{3.3}$$

$$\frac{\lambda_t}{P_t} = \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{P_{t+1}} R_t \right], \tag{3.4}$$

$$m_t^{-\gamma} = \lambda_t - \beta \mathbb{E}_t \left[\frac{\lambda_{t+1} P_t}{P_{t+1}} \right]. \tag{3.5}$$

Households' first order conditions are standard. Note that equations 3.3 and 3.4 combined with 3.1, construct the usual uncovered interest rate parity condition, whereas 3.1 and 3.2 generates the intratemporal allocation condition between labor and leisure.

3.2 Domestic Firms

I assume there is a continuum of domestic firms that produce domestic consumption goods. They operate in perfectly competitive factor markets and monopolistically competitive product markets. Domestic firms use labor as the only input and rent it at the market rate. I assume that firms produce using labor in a Cobb-Douglas technology,

$$y_t(j) = z_t F\Big(n_t(j)\Big) - \kappa(j),$$

where $y_t(j)$ denotes output produced by firm j. z_t is a stationary TFP shock that will be described later. I assume $F\Big(n_t(j)\Big) = n_t(j)^{\alpha}$ and $\kappa(j)$ is a fixed cost that guarantees zero profits in steady state.[8] The optimal labor demand is a static problem with optimality condition given by,

$$mc_t(j) = \frac{W_t}{P_{h,t} z_t F_n(n_t)}, \tag{3.6}$$

where $mc_t(j)$ is the real marginal cost of firm j in period t.

[8]Fixed cost is constant because the model assumes no growth. If the model has growth, the fixed cost has to growth at the same rate as output growth.

I follow Calvo (1983) and assume firms set prices accordingly to a Calvo lottery. Hence, firms will adjust prices at period t with probability $(1-\theta)$, but they will not be able to do so with probability θ. If they can update prices, they will choose it optimally in order to maximize the present value of profits.

A firm that change prices at period t will face a demand curve in period s given by,

$$y_{h,s}(j) = \left(\frac{P_{h,t}(j)}{P_{h,s}}\right)^{-\epsilon} A_s = \left(\frac{P_{h,t}(j)}{P_{h,s}}\right)^{-\epsilon} \left[c_{h,t} + g_t + c^*_{h,t}\right],$$

where A_t is aggregate absorption.

Firm j dynamic optimization problem is to set prices in order to maximize

$$\mathbb{E}_t \sum_{s=t}^{\infty} \theta_h^{s-t} Q_{s,t} y_{h,s}(j) \left[P_{h,t}(j) - P_{h,s} mc_s(j)\right].$$

Intertemporal first order condition is,

$$\mathbb{E}_t \sum_{s=t}^{\infty} \theta_h^{s-t} Q_{s,t} y_{h,s}(j) P_{h,s} \left[\frac{\epsilon-1}{\epsilon} \frac{P_{h,t}(j)}{P_{h,s}} - mc_s\right] = 0.$$

That can be rearranged as

$$x_t^1 = (\bar{p}_{h,t})^{1-\epsilon} A_t \frac{\epsilon-1}{\epsilon} + \theta_h Q_{t,t+1} \left(\frac{\bar{p}_{h,t}}{\bar{p}_{h,t+1}}\right)^{1-\epsilon} \pi^{\epsilon}_{h,t+1} x^1_{t+1}, \tag{3.7}$$

$$x_t^1 = (\bar{p}_{h,t})^{-\epsilon} A_t mc_t + \theta_h Q_{t,t+1} \left(\frac{\bar{p}_{h,t}}{\bar{p}_{h,t+1}}\right)^{-\epsilon} \pi^{1+\epsilon}_{h,t+1} x^1_{t+1}. \tag{3.8}$$

3.3 Rest of the World

It is standard to model the rest of the world by a demand function.

$$c^*_{h,t} = \left(\frac{P^*_{h,t}}{P^*_t}\right)^{-\lambda} y^*_t,$$

where y^*_t is foreign output, $P^*_{h,t}$ is the price that foreign consumers pay for one unit of domestic goods while P^*_t is the international consumer price level. λ is the rest of the world elasticity of substitution between foreign and domestic goods.

3.4 Government: Fiscal and Monetary Rules

Government determines monetary and fiscal policy. Consolidated Central Bank and Government budget constraint is given by

$$x_t = d_{t-1}\frac{R_{t-1}}{\pi_t} - d_t + \frac{m_{t-1}}{\pi_t} - m_t, \tag{3.9}$$

where x_t is the fiscal primary surplus, $d_t = D_t/P_t$ and $m_t = M_t/P_t$. For simplicity, I assume that government only demands domestic goods and the ratio of government consumption goods to output is constant. Hence, under this setup, fiscal policy is conducted by lump sum transfers. In particular, I assume government will set primary surplus following this feedback rule,

$$x_t = x_{ss} + \gamma^d(S_t^c)\left[\frac{d_t}{y_t} - \frac{d_{ss}}{y_{ss}}\right] + \gamma^y(S_t^c)\left[y_t - y_{ss}\right] + \epsilon_t^f, \tag{3.10}$$

where S_t^c is a stochastic process that follows a Markov Process. Variables indexed with ss are evaluated in steady state. y_t is aggregate output and ϵ_t^f is a fiscal shock that will be described later. This variable is known by the agents in the model and evolves accordingly to a transition matrix P^c.

On the other hand, I assume monetary policy follows a interest rate rule, with feedbacks to inflation and nominal depreciation rate,

$$\frac{R_t}{R_{ss}} = \left[\frac{R_{t-1}}{R_{ss}}\right]^{\rho^r}\left[\frac{\pi_t}{\pi_{ss}}\right]^{\gamma_\pi(S_t^c)}\left[\frac{\xi_t}{\xi_{ss}}\right]^{\gamma_\xi(S_t^c)} exp(\epsilon_t^m), \tag{3.11}$$

where ξ_t is the nominal depreciation rate. ϵ_t^m is a monetary shock that will be described in the next section.

3.5 Stochastic Processes

This model has three domestic and three foreign shocks. Foreign disturbances are foreign output shocks, y_t^*, foreign inflation shocks, π_t^*, and foreign interest rate shocks, r_t^*. Domestic shocks are exogenous shocks to the total factor productivity z_t, and monetary, ϵ_t^m and fiscal policy shocks ϵ_t^f.

Besides these shocks, volatility and policy rule coefficients change according to two independent regimes, S_t^v and S_t^c.

I assume that TFP and foreign shocks follow mean reverting autoregressive processes of order one. Denoting ϵ_t^i to the innovation of shock i in period t, I assume $\epsilon_t^z \sim N(0, \sigma^z(S_t^v))$, $\epsilon_t^m \sim N(0, \sigma^m(S_t^v))$, $\epsilon_t^f \sim N(0, \sigma^f(S_t^v))$, $\epsilon_t^{r^*} \sim N(0, \sigma^{r^*}(S_t^v))$, $\epsilon_t^{y^*} \sim N(0, \sigma^{y^*}(S_t^v))$, $\epsilon_t^{\pi^*} \sim N(0, \sigma^{\pi^*}(S_t^v))$.

4 Solution and Estimation

In this section I briefly discuss the solution method and estimation strategy.

4.1 Perturbation in Markov Switching models

In this paper I use first order perturbation solution method as in Foerster, Rubio-Ramirez, Waggoner and Zha (2010). This solution method is an application of perturbation methods to Markov Switching problems. The advantage of this solution method over other methods such as the one developed by Chow (2010) or Farmer, Waggoner and Zha (2006) is that it allows me to introduce Markov-Switching from the primitives of the model.

If we denote Y_t the vector of non-predetermined variables and X_t the vector of predetermined endogenous variables, the solution by using first order perturbation has this form,

$$Y_t = g_x(i)X_t + g_\epsilon(i)\epsilon_t + g_\chi(i),$$

$$X_{t+1} = h_x(i)X_t + h_\epsilon(i)\epsilon_t + h_\chi(i),$$

where $h_x(i)$, $g_x(i)$, $h_\chi(i)$, $g_\chi(i)$, $h_\epsilon(i)$ and $g_\epsilon(i)$ are coefficient matrices of the linear solution for regime i, ϵ_t are structural shocks and χ is the perturbation parameter.

The last term is important because if different regimes has different steady state, first order solution is not certainty equivalent. Those terms are zero if all regimes have the same steady state.

Once I construct a solution, it is key to check whether the solution is unique. The solution is unique only if the eigenvalues of the following T matrix are all less than one in absolute terms, for all possible T,

$$T = \begin{bmatrix} p(1,1)(h_x(1) \otimes h_x(1)) & p(1,2)(h_x(2) \otimes h_x(2)) & ... & p(1,n)(h_x(n) \otimes h_x(n)) \\ p(2,1)(h_x(1) \otimes h_x(1)) & p(2,2)(h_x(2) \otimes h_x(2)) & ... & p(1,n)(h_x(n) \otimes h_x(n)) \\ \vdots & \vdots & \vdots & \vdots \\ p(n,1)(h_x(1) \otimes h_x(1)) & p(n,2)(h_x(2) \otimes h_x(2)) & ... & p(n,n)(h_x(n) \otimes h_x(n)) \end{bmatrix},$$

where $p(i,j)$ is the probability of switching from regime i to regime j.

Checking for determinacy is straightforward. However, this step might be time consuming depending on the number of regimes, predetermined and non-predetermined variables.

4.2 Estimation Strategy

In this paper, I estimate the model using Bayesian Methods. In particular, I use a Random Walk Metropolis-Hastings algorithm[9], which requires the evaluation of the posterior density $L(\theta|Y)p(\theta)$, where θ denotes the vector of parameters to be estimated, Y the vector of observables, $L(\theta|Y)$ is the likelihood function and $p(\theta)$ is the prior function, priors are standard densities described in the next section.

Initial condition and search direction for McMc are determined through a maximization of the posterior mode using Simulated Annealing minimization routines.[10]

To evaluate the likelihood function $L(\theta|Y)$ I solve the model for a set of proposal parameters and discard the draw if there is no equilibrium or multiple equilibriums. If unique equilibrium exist, I evaluate the likelihood using Kim's Filter as in Kim and Nelson (1999).

Kim's Filter is a generalization of Kalman Filter that takes care of different regimes. In standard Kalman Filter, we want to forecast the unobserved states at time t by using the vector of observations available up to $t-1$. However, in the Markov Switching case, we have to condition on each particular regime also. As pointed out in Kim and Nelson (1999), at each new iteration the filter has to condition on the total number of regimes, hence if n is the number of regimes, in $t = 1$ we will have n forecasts of the state vector, in $t = 2$ we have n^2 forecasts, and so on. For this reason, an approximation is required. Kim's Filter works by collapsing the forecasts into n forecast

[9] See An and Schorfheide (2007).
[10] See Moller-Andreasen (2010).

at each time. Intuitively, the way the filter works is by keeping the n forecasts that are more likely to have happened.

4.3 Data

I construct a dataset of 9 variables for Mexico covering the period 1980Q1 to 2009Q4 at quarterly frequency. The dataset contains monetary, fiscal and national account variables. I use linearly detrended output, consumption to output ratio, primary surplus to output ratio, government debt to output ratio, domestic nominal interest rate, consumer price index inflation, nominal depreciation rate, international nominal interest rate and international consumer price index inflation rate.

Primary surplus and government debt are from Central Bank of Mexico while domestic nominal interest rate, consumer price index, output and consumption that are from OECD. Nominal exchange rate is from IFS.

Data is nominal in original sources and I deflate them using consumer price index. Given that the model does not have capital, my definition of output does not include investment.

International nominal interest rate and international consumer price index inflation rate are U.S. 3 months T-Bill rate and U.S. inflation rate from FRED at St. Louis FED, respectively.

4.4 Priors and Calibration

In this paper I calibrate ζ to 0.28, which is the average share of imports to output for the sample period. A small number of parameters are set to match certain steady state values in the model to their data counterpart. In particular I set inflation in steady state to match the average in the data of 6%, steady state terms of trade is set to 0.59, government debt to output ratio is equal to 32% and trade balance to output ratio is 0.57%. Also, R_{ss} is equal to the sample average 1.07.

Priors for all autocorrelations of stochastic process and smoothing parameter of interest rate rule, ρ^i, are assumed to be $Beta(0.57, 0.23)$, for $i = r^*, z, y^*, r, \pi^*$. As can be seen priors imply a mild correlation. Prior for the transition matrices are such that the diagonal elements are assumed to be $Beta(0.9, 0.06)$. Finally, priors for volatilities are assumed to be the same for all variables and across regimes, $\sigma^i(S_t^v = j)$, are $Gamma(0.25, 0.11)$ for $i = r^*, z, y^*, \pi^*, m, f$ and $j = 1, 2$.

For preference and technology parameters I assume the following prior distributions,

Table 1: Priors for preference and technological parameters

Parameter	Distribution
η	Gamma(2.4 , 0.2)
θ	Beta(0.8 , 0.025)
σ	Gamma(0.75 , 0.2)
α	Beta(0.44 , 0.11)
ψ	Normal(0.03 , 0.05)
ϵ	Normal(4 , 0.1)
ϱ	Gamma(0.6 , 0.34)
λ	Gamma(0.22 , 0.21)
γ	Gamma(1.2 , 0.69)

As can be seen priors are standard probability distributions. The mean of these distributions are standard in the open economy literature. Note, that for all parameters standard deviations of the probability distributions of priors are high in terms of the magnitude of those parameters. Next table presents prior distributions for policy parameters,

Table 2: Policy Rules Parameters

Parameter	Distribution Regime 1	Distribution Regime 2
γ^{π}	Gamma(0.44,0.41)	Gamma(2,0.89)
γ^{ξ}	Beta(0.28, 0.15)	Beta(0.28,0.15)
γ^{d}	Beta(0.025,0.023)	Beta(0.28,0.15)
γ^{y}	Normal(-0.5,0.5)	Normal(-0.5,0.5)

As can be seen priors under Regime 1 and Regime 2 are different. In particular, I assume that priors under Regime 1 are such that both monetary and fiscal policies are less responsive to inflation and government debt than under Regime 2. However, if we evaluate the model in the mean of the priors distributions, both regimes imply that monetary policy responds strongly to inflation. I assume these priors because that is the strategy followed by previous papers in this literature, i.e. new Keynesian models in small open economies assume that monetary policy responds strongly to inflation because they need it to find determinate solution.

5 Estimation Results

In this section and the next one, I study the main estimation results of the benchmark model. I start by discussing posterior distributions. In the next section, I study the main features of monetary and fiscal policies during 1980Q1-2009Q4.

Given the calibrated parameters, Table 3 presents the mean of the posterior distribution and 95% credible set for preference and technology parameters,

Table 3: Posterior Means

Parameter	Value	95 % Credible Set
η	2	[1.9 ,2.1]
θ	0.61	[0.59 ,0.62]
γ	0.86	[0.78 ,0.94]
α_0	0.45	[0.39 ,0.51]
ψ	0.054	[0.046 ,0.063]
ϵ	3.8	[3.7 ,3.9]
ρ^r	0.61	[0.58 ,0.65]
ρ^z	0.97	[0.96 ,0.98]
ρ^{y^*}	0.77	[0.73 ,0.81]
ρ^{r^*}	0.99	[0.99 ,0.99]
ρ^{π^*}	0.98	[0.98 ,0.98]
γ	13	[11 ,14]
λ	0.27	[0.21 ,0.34]
ϱ	0.15	[0.094 ,0.2]

Note: Computed using 500,000 draws of McMc.

As shown in the table, Mexican economy exhibit a low degree of price stickiness, $\theta = 0.61$, that implies on average a price duration of about two and a half quarters. Hence, prices are reseted every seven months, this is about two months less than Justiniano and Preston (2010a) findings for Canada. This finding is reasonable given Mexican economy has been significantly more inflationary than Canadian economy during similar time spawn.

The mean of the posterior distribution for α is 0.45, this value is similar to standard calibrations as in Mendoza (1995), in which labor share also for Mexico goes from 0.3 to 0.43 depending on the sector. Also, Chari and Kehoe (2003) finds evidence of $\alpha = 0.42$ for Mexico in a single sector model. Regarding ϵ, the posterior mean is slightly smaller than standard calibrations, which assume it around 6 in order to generate a markup of 1.2, however, this is mainly done for developed economies. The point estimate in this paper generates a markup of 1.3. Note additionally, that interest rate smoothing component of the interest rate rule is $\rho^r = 0.61$.

In Table 4, I present posterior means and credible sets for interest rate rule and fiscal rule coefficients for the two regimes,

Table 4: Policy Rule Parameters

Regime 1 (AMP)	Post. Mean	95 %	Regime 2 (AFP)	Post. Mean	95 %
$\gamma^{\pi}(S_t^c = 1)$	0.012	[0.0025 ,0.022]	$\gamma^{\pi}(S_t^c = 2)$	0.4	[0.37 ,0.44]
$\gamma^{\xi}(S_t^c = 1)$	0.36	[0.32 ,0.39]	$\gamma^{\xi}(S_t^c = 2)$	0.03	[0.014 ,0.045]
$\gamma^{d}(S_t^c = 1)$	3.7e-005	[9.2e-006 ,6.4e-005]	$\gamma^{d}(S_t^c = 2)$	0.11	[0.081 ,0.14]
$\gamma^{y}(S_t^c = 1)$	0.23	[0.21 ,0.24]	$\gamma^{y}(S_t^c = 2)$	0.19	[0.18 ,0.21]

Note: Computed using 500,000 draws of McMc.

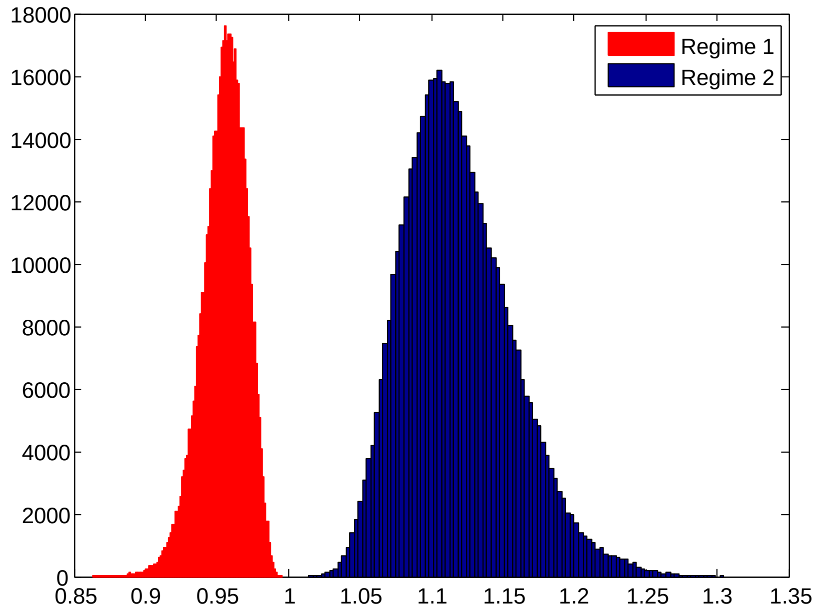
As can be seen in the table, under Regime 1 monetary policy is not responsive to inflation. However, it responds significantly to the nominal exchange rate growth. On the other hand, in this same regime, fiscal policy does not respond to debt accumulation. Note, on the other hand, that under Regime 2, monetary policy responds in a strong way to inflation, but the response to the growth rate of nominal exchange rate is mild, while fiscal policy responds strongly to debt accumulation.

In order to show that monetary policy is not active during Regime 1, but it is active during Regime 2, we need to calculate the "Activism Parameter". In this model, the activism parameter is given by,

$$a(S_t^c) = \frac{\gamma^{\pi}(S_t^c) + \gamma^{\xi}(S_t^c)}{1 - \rho^r}$$

In a model without Markov-Switching, if activism parameter is less than 1 it means that monetary policy does not react strong enough to eradicate sunspots, in this case we would have an indeterminate equilibrium if the model has no fiscal policy rule, or a determinate equilibrium if induced by fiscal policy. If, instead is larger than 1, monetary policy responds strong enough to control inflationary expectations, which, in a model without Markov-Switching, we would need fiscal policy to accommodate to monetary policy for equilibrium to exist. In our case with Markov-Switching, this is not necessarily the case; however, it is still helpful to characterize the behavior of monetary policy. Figure 5 presents the posterior distribution of activism parameter during Regime 1 and Regime 2,

Figure 5: Activism Parameter for Regime 1 and Regime 2



Note: Posterior distributions computed using 500,000 McMc draws.

Note that this picture indicates that under Regime 2, monetary policy is active, whereas under Regime 1 it is not. Following Leeper (1991), Regime 1 is such that fiscal policy is actively conducted while monetary policy passively accommodates to it. I will denote this regime as ”active fiscal policy regime”. On the other hand, under Regime 2, monetary policy responds actively to nominal disturbances while fiscal policy accommodates to monetary policy, hence in the spirit of Leeper (1991), this regime is active monetary policy with passive fiscal policy regime. I will denote this Regime as “active monetary policy regime”.

Note additionally, Table 5 indicates that the active fiscal policy regime is more persistent than the active monetary policy regime,

Table 5: Policy Rule Transition Probabilities

Transition Probability	Posterior Mean	95% Credible Band
$p^c_{1,1}$	0.97	[0.96 ,0.98]
$p^c_{2,2}$	0.95	[0.94 ,0.96]

Note: Computed using 500,000 draws of McMc.

This result should not be underestimated. Previous work assumes that monetary policy responds in a strong way to inflation. The reason of this assumption is that previous studies impose time independent feedback rules and do not consider the case in which fiscal policy does not respond to government debt.[11] In this way, in order to solve for a determinate equilibrium, authors have to assume that monetary policy responds in a strong way to inflation and depreciation rates for every period.

The model also assumes an independent Markov Process for volatilities. Table 6 presents posterior means and credible sets of posterior distribution of variances for both regimes

Table 6: Volatilities

Regime 1	Post. Mean	95 %	Regime 2	Post. Mean	95 %
$\sigma^z(S^v_t = 1)$	0.16	[0.14 ,0.18]	$\sigma^z(S^v_t = 2)$	0.0026	[0.0023 ,0.0028]
$\sigma^m(S^v_t = 1)$	0.035	[0.029 ,0.041]	$\sigma^m(S^v_t = 2)$	0.0016	[0.0015 ,0.0017]
$\sigma^f(S^v_t = 1)$	0.065	[0.056 ,0.073]	$\sigma^f(S^v_t = 2)$	0.0023	[0.0019 ,0.0027]
$\sigma^{r^*}(S^v_t = 1)$	0.0022	[0.0016 ,0.0026]	$\sigma^{r^*}(S^v_t = 2)$	0.00075	[0.00062 ,0.00089]
$\sigma^{\pi^*}(S^v_t = 1)$	0.095	[0.083 ,0.11]	$\sigma^{\pi^*}(S^v_t = 2)$	0.12	[0.11 ,0.14]
$\sigma^{y^*}(S^v_t = 1)$	0.0086	[0.0059 ,0.011]	$\sigma^{y^*}(S^v_t = 2)$	0.027	[0.023 ,0.032]

Note: Computed using 500,000 draws of McMc.

The previous table indicates that Regime 1 can be associated to the high volatility regime for domestic shocks. However, the volatility of foreign inflation and foreign demand are larger during Regime 2. Table 7, presents the probability of each regime,

[11] Just recently we can study this kind of models, as tools for solving time varying policy rules with Markov switching models are relatively new.

Table 7: Transition Probabilities for Volatilities

Transition Probability	Posterior Mean	95% Credible Band
$p^v_{1,1}$	0.63	[0.57 ,0.69]
$p^v_{2,2}$	0.82	[0.78 ,0.85]

Note: Computed using 500,000 draws of McMc.

As can be seen, the regime with higher domestic volatility, Regime 1, is the less persistent regime with a probability of staying in the same regime of 63%. Note, however, the probability of staying in the same regime under regime 2 is 82%, even though higher, there is still 18% probability of changing regimes.

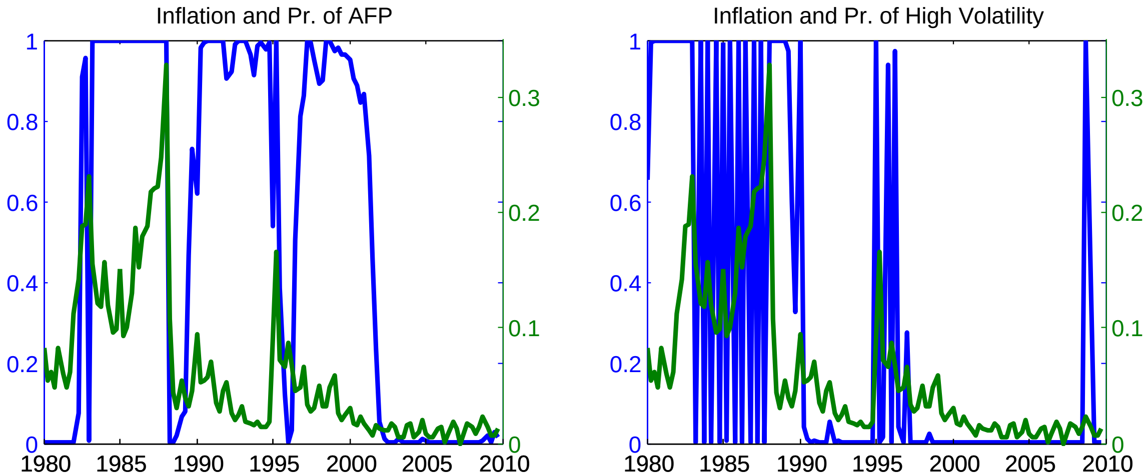
6 Characterizing Fiscal and Monetary Policies

In this section, I study the model implications' about monetary and fiscal policy regimes. First, I study the probability of changing regimes during the last 30 years, which will allow me to identify the periods of strong and weak responses of monetary policy. Second, I perform variance decomposition exercise. Third, I study which is the impact and persistency of monetary and fiscal policy shocks.

6.1 Regime Probabilities

Figure 6 presents inflation, together with the probability of being in a active fiscal policy regime and the probability of high volatility regime (Volatility Regime 1),

Figure 6: Inflation and Transition Probabilities



Note: Right axis measures smoothed probabilities (blue lines), left axis measures log difference of price index (green lines).

As can be seen in the figure, before 2000, probability of active monetary policy regime is high only during a few quarters after the end of severe macroeconomic disturbances. In particular, in early 80s after late seventies inflationary process, after 1982 "Debt Crisis", during 1988 after a large period of macroeconomic instabilities such as 1985 and 1986 foreign shocks, and after 1995 "Tequila" financial and political crisis.

Fiscal and monetary policies changed quite often starting in 1980s. At the key of these reforms there was the change of revenue system, in particular value added taxation (VAT) was introduced. "Program for immediate economic reorganization" after 1982 included privatization of government firms and mainly orthodox measures to constraint demand. The adjustment period during 1987/1988 encompassed policy changes were articulated around the "Pact for economic solidarity" . Building blocks of this program were reduction on public employment, reduction of subsidies and privatization of government firms and the use of the resources generated by them to reduce the level of fiscal debt. On the revenue side, indexation of fiscal system was introduced in order to fight the depreciation of fiscal resources. After 1991 the tightening on government expenditures was relaxed, especially to finance social development programs (education, health, etc.).

At the end of 1994 beginning of 1995, a new stabilization program was required. This program included fiscal and monetary reforms. On the fiscal side, there was a suspension of government investment projects and an increase of VAT. On the other hand, monetary policy was conducted to control prices together with a flexibilization of exchange rate regime.

In 1996 most of the adjustment policies started to be abandoned or relaxed in order to boost the recovery of the real economy. Subsidies and tax incentives were introduced.

After Mexico stabilization post-1995 crisis, estimates in this section find evidence of high probability of fiscal dominant regime until 2001. The increase in the probability of active monetary policy regime coincides with changes in the way Central Bank of Mexico conducted monetary policy recently.

Regarding volatilities, note that high volatility regimes is in effect almost all the periods between 1980-1990, and during the Tequila crisis in 1994-1995. These high volatility periods are associated to crisis episodes. As can be seen probability of high volatility increases again during U.S. recent crisis.

6.2 Variance Decomposition

In this section, I study the contribution of each structural shock to the volatility of output, inflation and nominal exchange rate growth, conditional on different combinations of coefficient and volatility regimes.

This exercise is important because it provides insights on the relative importance of domestic and foreign shocks conditional on the macroeconomic environment, i.e. whether the economy is in high or low volatility or active monetary or fiscal policy. Moreover, this section will be important to understand the role of policy shocks in aggregate variability. Importantly, the model will characterize the role of the shocks after taking into account policy changes.

Table 6.2 presents the results for all possible regime combinations,

Table 8: Variance Decomposition

	TFP	Mon. Pol.	Fisc. Pol.	R^*	π^*	Y^*
Active Fiscal Policy and High Volatility Regime						
Output	0.83	0.11	5.2e-005	0.00052	0.043	0.014
Inflation	0.15	0.21	0.00099	0.0019	0.58	0.059
Nom. Exc. Rate Growth	0.086	0.35	0.00087	0.0027	0.48	0.074
Active Monetary Policy and High Volatility Regime						
Output	0.91	0.083	1e-007	0.00018	0.00091	0.0084
Inflation	0.057	0.63	1.2e-005	0.0038	0.22	0.087
Nom. Exc. Rate Growth	0.21	0.63	3.7e-006	0.0039	0.065	0.092
Active Fiscal Policy and Low Volatility Regime						
Output	0.88	0.0027	9.1e-006	0.0043	0.1	0.015
Inflation	0.1	0.0032	0.00011	0.0097	0.85	0.04
Nom. Exc. Rate Growth	0.069	0.0064	0.00012	0.016	0.85	0.06
Active Monetary Policy and Low Volatility Regime						
Output	0.98	0.002	1.8e-008	0.0015	0.0022	0.0092
Inflation	0.085	0.021	2.9e-006	0.043	0.72	0.13
Nom. Exc. Rate Growth	0.43	0.029	1.2e-006	0.062	0.29	0.19

Note: Theoretical variance decompositions conditioning on each regime.

As can be seen in the table, foreign shocks have substantial contribution to the volatility of these three variables. In particular foreign inflation has substantial effect in domestic inflation and nominal depreciation rate in many of the regimes. Shocks to foreign demand are also important, whereas foreign interest rate has a minor share in aggregate variability.

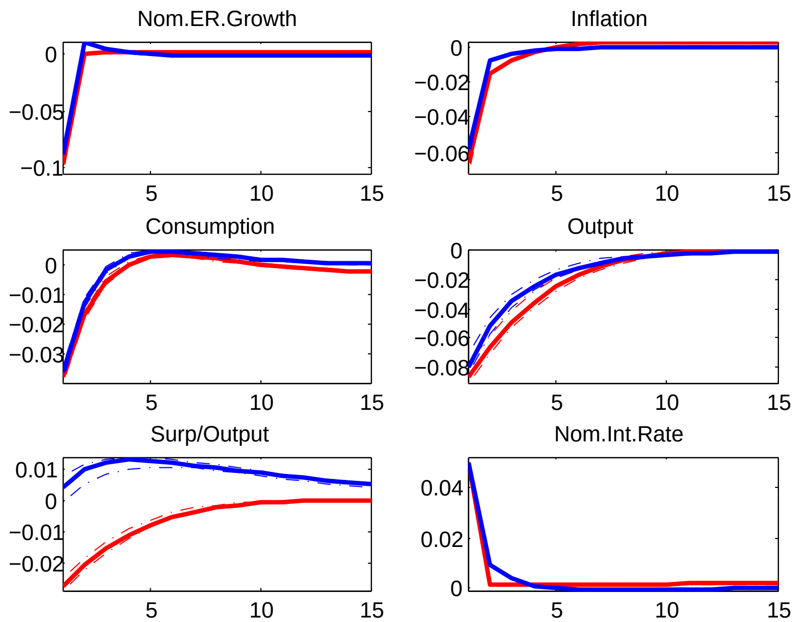
Additionally, TFP shocks have a major importance in explaining the variability of output in all the regimes. It has, however, smaller effect in the variability of inflation and depreciation rate.

Importantly, note that monetary policy shocks represent strong contribution to the variability of these variables in high volatility regimes, specifically monetary policy explains a large share of the variability of inflation and nominal exchange rate growth, and has a substantial effect in output variability. Fiscal policy shocks, instead, have a small effect in the variability of these variables.

6.3 The effects of policy shocks

In order to fully characterize fiscal and monetary policies, in this section I study how policy shocks affect dynamics of the model under different policy arrangements. Figure 7 presents impulse response functions for a set of endogenous variables after one standard deviation monetary policy shock under volatility regime 1, both for active monetary policy and active fiscal policy regimes.

Figure 7: Impulse Response Functions to one standard deviation Monetary Policy Shock.

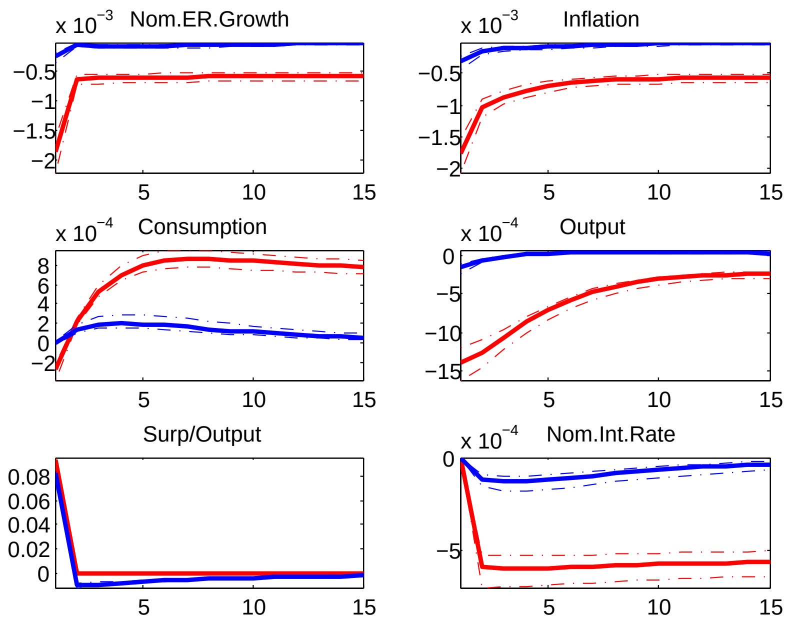


Note: one standard deviation shock to ϵ_t^m in the high volatility regime. AFP is in red line and AMP is in blue line.

As can be seen from the previous picture, monetary policy shocks have qualitatively similar effects on most endogenous variables conditional on each regime. A tightening in the monetary policy is recessive both during active monetary policy and active fiscal policy regimes. Under both regimes, it generates different responses of the fiscal surplus. The reason of this difference is that a positive shock to interest rate reduces private demand for money and increases private demand for government bonds, hence, under active monetary policy regimes, fiscal surplus has to adjusts for the increasing demand for bonds by increasing surplus.

Figure 8 presents impulse response functions after one standard deviation fiscal policy shock under active fiscal and monetary policy regimes,

Figure 8: Impulse Responses to Fiscal Policy Shock



Note: one standard deviation shock to ϵ_t^f in the high volatility regime. AFP is in red line and AMP is in blue line.

In this case, in line with the results on variance decomposition, the effects of fiscal policy shocks are quantitatively smaller than the monetary policy shock. However, in this case, the response of variables are very different under active monetary or active fiscal policy regimes.

Note that in this model, a fiscal adjustment has a recessive and deflationary effect which affects interest rate downwards through interest rate rule. The dynamic effect is a quick recovery of output and an increase in consumption motivated by the reduction in inflation and the expansive effect of monetary loosening.

7 Policy changes and credibility

In this section, I study which are the effects of policy changes and how does credibility affect the outcome of a stabilization policy. I do this using simulations and counterfactual analysis.

I start by simulating an inflationary environment. As we saw in the previous section, the main sources of inflation are monetary shocks in the high volatility regime, and foreign inflation shocks in the low volatility regime, hence I will focus in these two cases. The exercise will evaluate a policy change under these two environments and the key will be to understand the role of credibility in these scenarios.

The second exercise is to compute counterfactuals to answer the question of what would have happened if agents in the model believe that policy changes that actually occurred during 1988 and 1995 were permanent and transitory, respectively.

7.1 Simulations

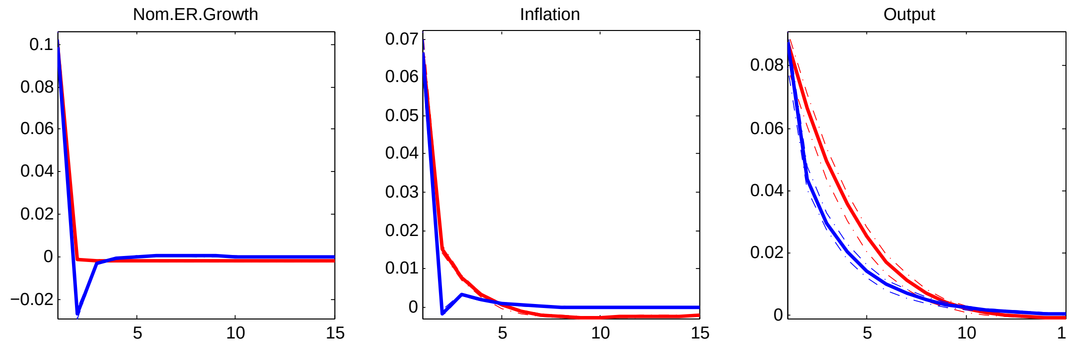
In this section, I perform two exercises, specifically I simulate inflationary environments originated from different sources. I start by simulating an inflationary environment from a negative monetary policy shock and I show that policy changes in this case have a mild effect; the reason is that the inflationary effect of this shock is not persistent. Then, I simulate an inflationary environment from a foreign inflation shock. I find that a policy change has strong effects in the dynamics of the endogenous variables given that this shock generates a highly persistent inflationary environment.

Let's start with a negative monetary shock that generates inflation at $t = 0$ and assume the economy is in an active fiscal policy regime, then introduce a policy change from active fiscal to active monetary policy, at period $t = 2$.[12]

Figure 9 presents the dynamics of nominal exchange rate growth, inflation and output that follow after this shock,

[12] I implement the policy change at period 2 because, as we saw in the previous section, a monetary policy shock has large impact effects but not persistent effects.

Figure 9: Policy Change after monetary policy shock.

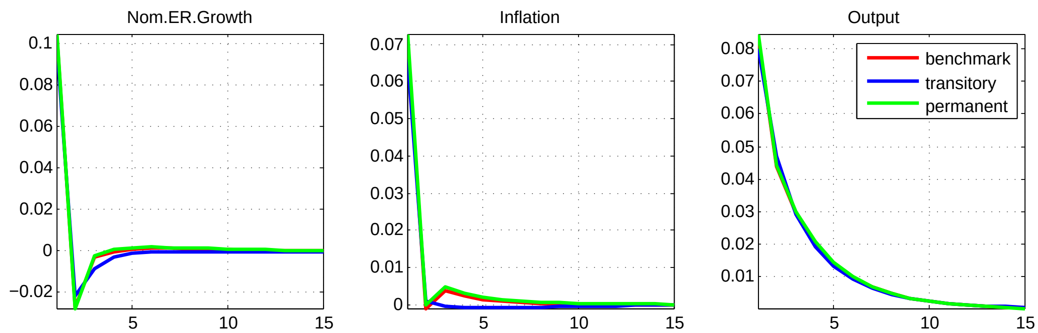


Note: Red line represents the dynamics without policy change, blue line represents the dynamics with policy change at $t = 2$.

Note that there are substantial effects from this policy change, even though inflation is not very persistent. However, the largest effect occurs before the fifth quarter. The reason is that monetary policy shocks generate small inflationary persistence. It is important to point out that dynamics in the short run are significantly affected. As can be seen, a policy change reduces the variability of the three variables as convergence to steady state is faster than the no policy change dynamics. Moreover, a policy change generates substantial output loss and inflation drop in the short run.

The next picture presents the same exercise but altering the credibility of the agents about the persistency of the policy change.

Figure 10: Policy Change after monetary policy shock under alternative credibility environments.



Note: Red line represents dynamics with actual credibility, blue line represents the dynamics when policy change is perceived as permanent, green line represents the dynamics when policy change is perceived as transitory.

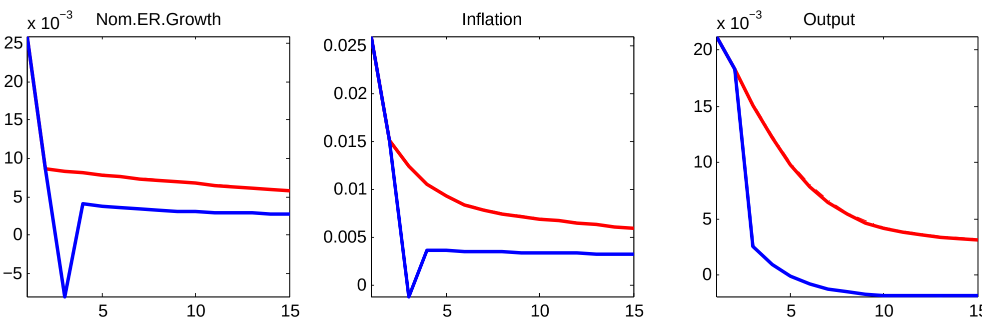
In this picture I present results dynamics after a negative monetary policy shock at $t = 0$ followed by a change from active fiscal to active monetary policy at period $t = 2$ under three alternative transition matrices.

The "benchmark" dynamics characterizes the paths of variables when agents in the model think that transition probabilities of the Markov matrices are equal to the ones estimated in previous section. The "transitory" dynamics present the results of same exercise when agents perceive that the policy change is going to last only one period and after that the economy will stay forever in the active fiscal policy regime, i.e. they think $p^c(S^c_{t+1} = 1|S^c_t = 1) = 1$ and $p^c(S^c_{t+1} = 2|S^c_t = 1) = 0$. On the other hand, the "permanent" dynamics are the results of the same exercise when agents perceive the policy change is permanent, i.e. $p^c(S^c_{t+1} = 2|S^c_t = 2) = 1$.

As we observed in the previous figure, dynamics under different assumptions are similar. Whether agents believe that the policy change is only one period, it has no major implications as compared to the case in which they think the change is permanent. The reason is that most of the effect of a policy change occurs in the first period of implementation. Next exercise will show that results are significantly different when persistent inflationary shocks occur.

During low volatility regimes, foreign inflation shocks are, instead, the ones that explain the largest share of inflation. Moreover, this variable has a strong effect also during high volatility regimes. Now I repeat the previous exercise but starting from a foreign inflation shock, hence, I simulate a positive foreign inflation shock that generates inflationary environment at $t = 0$ and assume the economy is in an active fiscal policy regime. Introduce a policy change from active fiscal to active monetary policy, at period $t = 3$. Figure 11 presents some endogenous dynamics,

Figure 11: Policy Change after foreign inflation shock.



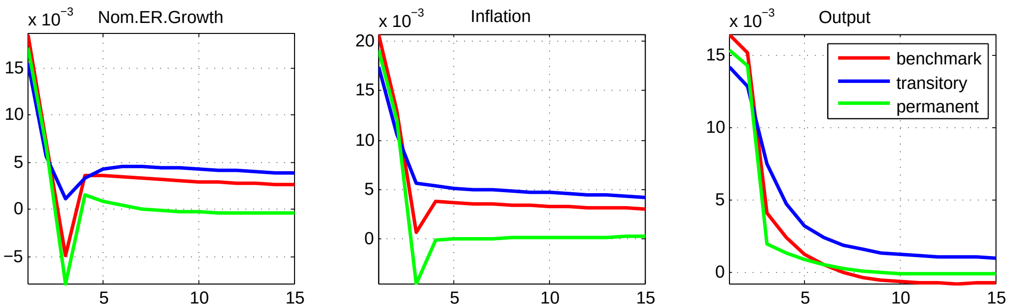
Note: Red line represents dynamics without policy change, blue line represents the dynamics with policy change at $t = 3$.

As can be seen in the picture, in this case a change from active fiscal to active monetary policy after a foreign inflation shock generates a major effect in the dynamics of these variables; this is so because the foreign inflation shock has persistent effect in the dynamics of inflation and exchange rate. First, reductions in inflation and depreciation rates are immediate. Additionally, there are major, and persistent, output costs associated to the policy change.

Note that inflation and growth rate of exchange rate exhibit a large initial adjustment. This occurs because of the interest rate rule. These series have to accommodate strongly so the new rule hold because of the smoothing component of the rule. If the smoothing component were zero, no overshooting would be required.

Next figure presents the results from alternative beliefs about persistence of the regime change. Recall that if agents perceive the policy change as transitory, they think $p^c(S^c_{t+1} = 1|S^c_t = 1) = 1$ and $p^c(S^c_{t+1} = 2|S^c_t = 1) = 0$. Additionally, if dynamics are perceived as "permanent", agents think $p^c(S^c_{t+1} = 2|S^c_t = 2) = 1$.

Figure 12: Impulse Responses to Foreign Inflation Shock under alternative credibility environments.



Note: Red line represents dynamics with actual credibility, blue line represents the dynamics when policy change is perceived as permanent, green line represents the dynamics when policy change is perceived as transitory.

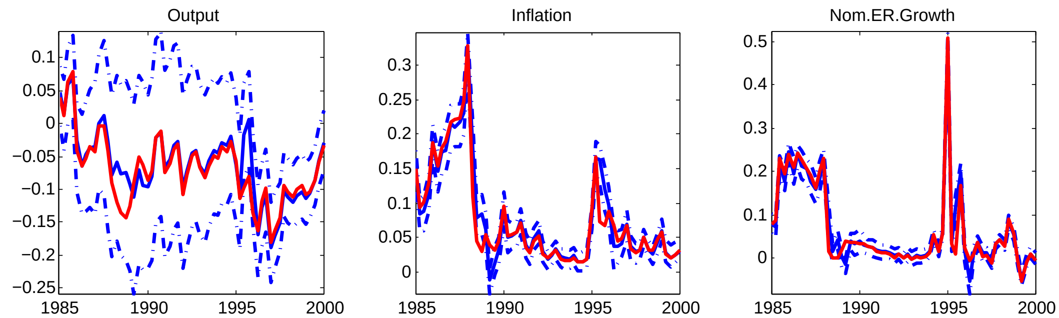
As can be seen from the previous picture, credibility about the policy has major effects in this case in which inflationary shock is persistent. Note that if the policy is perceived as permanent, stabilization of prices and exchange rate growth are immediate and at almost not additional output losses, compared to the benchmark case. On the other hand, if agents perceive the policy change as completely transitory, the policy change is not effective.

7.2 Counterfactuals

After the simulation exercises we can ask which would have happened if the stabilization in 1988 and 1995 would have experience a larger (lower) credibility about the persistence of the policy. In this section I answer this question.

In the next two pictures, I present a similar exercise to the one in the simulation section. I show counterfactual dynamics by altering the credibility agents have about the persistency of the policy change. As in the previous section, the "benchmark" series are the actual series. The counterfactual dynamics and 68% error bands for Figure 13, are the ones in which agents perceive that the policy change in 1988 and 1995 will last only one period and after that the economy will stay forever in the active fiscal policy regime. Hence, they think $p^c(S^c_{t+1} = 1|S^c_t = 1) = 1$ and $p^c(S^c_{t+1} = 2|S^c_t = 1) = 0$. In contrast, Figure 14 presents counterfactual for the "permanent" dynamics, that is when agents perceive the policy change is permanent, i.e. $p^c(S^c_{t+1} = 2|S^c_t = 2) = 1$.

Figure 13: Policy changes perceived as transitory.

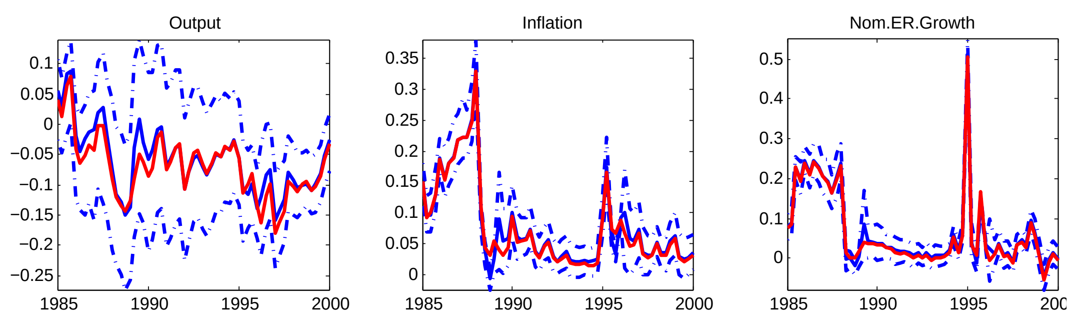


Note: Red line represents actual dynamics, blue line represents counterfactual dynamics. Dashed lines represent 68% credible bands.

As can be seen, counterfactuals for output are not statistically different than observed series. However, for the case of inflation and nominal exchange rate growth, I find that if agents perceive the policy as completely transitory, the stabilization effect after 1998 program is less effective than the benchmark case. Additionally, same is observed after 1995 Tequila crisis.

For the second counterfactual exercise we have,

Figure 14: Policy changes perceived as permanent



Note: Red line represents actual dynamics, blue line represents counterfactual dynamics.

As can be seen both inflation and nominal exchange rate growth are significantly smaller after stabilization programs in 1988. After Tequila crisis, instead, it seems that if policy change is perceived as permanent, it have a substantial effect only on inflation, but not on nominal exchange rate growth.

In this section, counterfactual exercise allows us to use the actual structure of shocks implied by the model estimation. The findings of this section are in line with the ones in previous section when we assume different beliefs for the private sector. Credibility in the persistence of the stabilization policies matters for price and exchange rate dynamics.

8 Model Comparison

It remains showing whether data favors the model with policy changes over fixed coefficients models and alternative formulations. I do this in this section by computing marginal data density of competing models, the benchmark model, a model with only volatility changes and a model with only coefficient changes.

I follow Sims, Waggonner and Zha (2008) that modified Gelfand and Dey (1994) and Geweke (1999) approach to efficiently handle time-varying parameters model.

Following previous notation, the marginal density function is defined as

$$P(Y_T) = \int_{\Theta} p(Y_T|\theta)p(\theta)d\theta.$$

This function can be expressed as

$$P(Y_T)^{-1} = \int_{\Theta} \frac{h(\theta)}{p(Y_T|\theta)p(\theta)} p(\theta|Y_T)d\theta,$$

and approximated by

$$P(Y_T)^{-1} = \frac{1}{M} \sum_{j=1}^{M} \frac{h(\theta^j)}{p(Y_T|\theta^j)p(\theta^j)}.$$

Gelfand and Dey (1994) and Geweke (1999) propose a normal distribution to approximate $h(\theta)$. However, as discussed in Sims, et.al. (2008), standard modified harmonic mean (MHM) approach from Gelfand and Dey (1994) and Geweke (1999) might be a poor approximation in Markov switching models, because the posterior density is usually non-Gaussian. In order to overcome this problem, they propose to compute the marginal posterior using a more general density, the elliptical distribution.

Following this approach, Table 9 presents marginal data densities for the benchmark model, that allows for changes in policy rules coefficients and volatilities, a version of the same model that only allows for changes in coefficients, and 3 other variants: the benchmark model with the rest of the world modeled as a VAR(1), called "Alternative Model 1", a version in which interest rate rule responds to output, "Alternative Model 2", and a version that allows for higher probability of policy changes during high volatility regime, "Alternative Model 3".

Table 9: Model Comparison

	p = 0.1	p = 0.5	p = 0.9
Benchmark Model	2225.1	2228.3	2232
Alternative Model 1	2140.6	2144.8	2148.2
Alternative Model 2	2160.1	2165.8	2170.7
Alternative Model 3	2183.1	2188.6	2192.1
MS only in volatilities	1843.5	1846.3	1851.5

As can be seen from the previous table, the model with both coefficients and volatility changes do substantially better than both models with constant parameters in policy rules.

In this way, the data supports policy changes in fiscal and monetary policies in emerging markets. Moreover, the table also indicates that the benchmark model slightly outperforms the three alternative specifications.

9 Conclusions

In this paper, I provide evidence that supports that, during the last 30 years, emerging economies shifted repeatedly between periods of high macroeconomic volatility, inflation and acceleration of exchange rate growth, with periods of price and macroeconomic stability; additionally we know that in this environment, these economies implemented several stabilization programs.

Motivated by these facts, I develop a dynamic stochastic general equilibrium model with Markov-Switching in fiscal/monetary policy rules and volatilities, to inquire how the variations in macroeconomic performance relate to policies and volatility changes.

I estimate the model for Mexico using the last 30 years of data. I find strong evidence of policy changes. In particular, I identify two Regimes. The active monetary policy regime (AMP), in which monetary and fiscal policies respond to inflation and government debt, respectively; and the active fiscal policy regime (AFP), in which fiscal policy does not respond to government debt and monetary policy does not respond to inflation. The active monetary policy regime holds during short periods of time after macroeconomic crises during the 80s and 90s, and for a long period after 2002.

On the other hand, active fiscal policy regime holds during most of the time and is the more persistent one. The importance of these findings is major. Monetary analysis in emerging economies has been conducted under the assumption of a permanent active monetary policy regime. This was required in order to solve the models for a unique equilibrium. However by introducing non-Ricardian fiscal policy and Markov-Switching in the simple New-Keynesian model for open economies, I am able to relax that assumption.

Then, I study the properties of policy shocks and policy changes. I find that monetary policy shocks generate substantial aggregate variability during high volatility regimes and, in particular, explain a large share of the volatility of inflation and exchange rate growth. On the other hand, fiscal policy shocks have a minor contribution to variability of output, inflation and exchange rates.

Regarding policy changes, I find that changes for active fiscal policy to active monetary policy induce stabilization at the cost of high output looses. However, credibility in the persistence of the policy change matters. If the agents in the model perceive the policy to be permanent, the benefits from stabilization are substantially larger than the case in which agents think there is a probability of abandonment of the policy. On the other hand, if agents think that stabilization program is not persistent, the benefits from stabilization are undermined.

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