Essays in the Macroeconomics of Emerging Countries

by

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Dissertation submitted in partial fulfillment of the requirements for the degree of
Doctor of Philosophy in the Department of Economics
in the Graduate School of Duke University
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Abstract

(Economics)

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Abstract

This dissertation is a collection of essays with the main objective of estimate and understand macroeconomic behavior of emerging countries by the lenses of modern tools in general equilibrium modeling.

In the first chapter, I study whether structural parameters of Small Open Economy Real Business Cycle models are constant when applied to Emerging Markets data. Using data from Argentina, I estimate a small open economy model with trend shocks and working capital constraints, augmented with time varying parameters. I find that so called "structural" parameters suffer substantial changes in the period 1983-2008. Structural instabilities arise from both technological and financial sources. Given these findings, I inquire which are the features of the data that parameter drifts capture. I review emerging markets facts and find parameter instabilities play a key role in addressing for the variability observed in the data.

In the second chapter, I study policy changes in emerging countries. 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.

To my parents.

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1

A Drifter's Tale: Business Cycles in Emerging Markets

1.1 Introduction

Business cycle in emerging markets is different from the one in developed economies. In the former ones, consumption volatility is usually larger than output volatility and trade balance tends to be largely counter-cyclical, while in the later ones, consumption smoothing is observed and trade balance usually exhibits a mild countercyclicality.[1] However, there is no agreement on the appropriate theoretical framework to rationalize these facts. While some authors, like Kydland and Zarazaga (2003), argues that emerging markets can be represented with a standard stationary RBC model, other authors highlight the importance of nonstationary shocks or explicitly

[1] A detailed description of these facts for a large number of developed and developing countries can be found in Aguiar and Gopinath (2007) and Neumeyer and Perri (2005).

modeling market frictions as devices to account for data puzzles.[2]

In this paper, I study whether so called "structural" parameters of small open economy models are constant when they are used to fit emerging markets data. For this purpose, I use quarterly data from Argentina for the period 1983Q1-2008Q4 to estimate a real business cycle model. Specifically, I propose a small open economy real business cycle model with two additional features: stochastic trend and working capital constraints. Stochastic trend models have been largely studied since Aguiar and Gopinath (2007).[3] In this paper, authors find that stochastic trends are at the core of emerging markets business cycle facts. I follow Neumeyer and Perri (2005) in modeling working capital constraint. This feature has proven to be useful in capturing the countercyclical relation of domestic output and consumption with international interest rates. I decide to build on this model because it is at the frontier of emerging markets business cycle research.

In order to challenge this model I allow for parameter instabilities. In particular, I allow for time variation in parameters that regulate access to international financial markets (interest rate elasticity to foreign debt and working capital constraints sen-

[2] For instance, Aguiar and Gopinath (2007) presents a model with shocks to the trend of total factor productivity and concludes that the volatility of trend shocks is the key difference between developed and emerging economies, i.e. it is larger for emerging markets than for developed small open economies, inducing the facts observed in the data. In contrast, Boz et al. (2008) arrives to different conclusions following different estimation exercises and argues that the trend shocks' volatility of developing small open economies and developed small open economies do not differ from each other, and, different dynamics are due to informational frictions. Garcia-Cicco et al. (2010) reinforces the idea that standard real business cycle models with trend shocks might not be an appropriate representation of emerging economies using a large span of annual data for Argentina. In turn, Neumeyer and Perri (2005) highlights the importance of working capital constraints and interest rate shocks to generate the observed facts and to rationalize the way real interest rates correlates with output and other macroeconomic variables.

[3] See Garcia-Cicco et al. (2010) and Boz et al. (2008).

sitivity), production (capital share) and depreciation rate (which allow for parameter changes in the technological aspect of the model). I assume time-varying parameters follow AR(1) processes, as in Fernández-Villaverde and Rubio-Ramirez (2007).

I find that data strongly supports parameter instabilities. Both technological and financial parameters drift significantly during the 1983-2008 period. Moreover, parameter changes have a substantial effect in the variability of national accounts data.

Several authors study dynamic stochastic general equilibrium models in developed economies and use parameter instabilities to capture structural breaks in the data.[4] For instance, the literature on the Great Moderation exploits these features in order to capture changes in the volatility of macroeconomic aggregates observed in U.S. during the '80s. Following this literature, a natural question is which are the features of the data that parameter instabilities captures in the case of small open economy models for emerging markets data. In order to answer this question I review the set of emerging markets business cycle facts using Argentinean data. On top of standard results, I question structural stability of aggregate series. Eventhough this is a well known feature of emerging markets data, it is systematically studied only in emerging markets finance literature. I show that we cannot reject the null hypothesis of multiple structural breaks in output series for a large set of emerging markets. Moreover, structural breaks are associated to the Sudden Stop episodes[5]. Given this, I find that periods in which data suffers structural breaks are associated to large turbulence of structural shocks and large changes in the parameters of the

[4] See Justiniano and Primiceri (2008) and Fernández-Villaverde and Rubio-Ramirez (2007).

[5] See Mendoza (2006), Calvo (1998), Calvo and Reinhart (1998).

model.

Methodologically, this paper is related to a growing literature on estimation of models with parameter instabilities. Cogley and Sargent (2005), Sims (1999) and Primiceri (2005), estimate vector autoregression models with coefficient instabilities and/or time-varying volatilities. However, this literature focuses in the Great Moderation. On the other hand, on the same topic, more recent papers estimate dynamic stochastic general equilibrium models with parameter instabilities, for instance, King (2006), Justiniano and Primiceri (2008) and Fernández-Villaverde and Rubio-Ramirez (2007) with the objective of answering similar questions from a microfundated approach.

An increasing literature supports parameter instabilities from an empirical point of view. For instance, Harrison (2002) argues, using a panel of countries, that in the period 1960-1997 the trend of labor share decreased both in developed and developing countries. Similar results are obtained by Krueger (1999) for U.S. economy. On the other hand, at business cycle frequencies and imposing a Cobb-Douglas production function, Young (2004) shows countercyclicality of the labor share in U.S. In the literature of measuring sources of growth, Coremberg (2002) also considers time-varying labor and capital shares for the case of Argentina. Additionally, substantial work has also been done in the case of depreciation rates, as in Dueker et al. (2006) and Ambler and Paquet (1994).

This paper also contributes to a large literature documenting the stylized facts of emerging economies at business cycle frequencies. However, this is, to my best knowledge, the first paper that considers structural breaks, documents changes in statistical moments and study the way they relate to parameter instabilities in structural models.

The rest of the paper proceeds as follows. In section 1.2, I discuss the model and the parameter instability assumption. In section 1.3, I review the solution method, estimation procedure and priors determination. In section 1.4, I present estimation results and show evidence of structural parameter instabilities. Section 1.5, provides empirical evidence of structural breaks in emerging markets data and reviews emerging markets statistical facts. Section 1.6, conduct experiments and exercises that shed light on the relation of parameter instabilities and structural breaks observed in the data. Section 1.7, concludes.

1.2 A Model with Parameter Drift

The model presented in this section is a version of small open economy real business cycle model with shocks to the trend of technology shocks[6] and working capital constraints[7] , augmented with parameter instabilities. I build on Garcia-Cicco et al. (2010). I first discuss the households' and firms' problems and then discuss the specification of time-varying parameters and shocks. In the rest of the chapter, I will use capital letters to denote variables in levels and lowercase letters in order to denote variables in effective units.

1.2.1 The problem of the households

Assume the economy is populated by households that maximize the present discount value of expected utility. Households consume a unique good, C_t and offer labor,

[6] As in Aguiar and Gopinath (2007) and Garcia-Cicco et al. (2010).

[7] As in Neumeyer and Perri (2005).

H_t, and capital, K_t, services to the production sector, and have access to a risk free asset, D_t, that is traded internationally at an interest rate, R_t, that is exogenously given to the agents.

Hence, households' problem is given by the following optimization program,

$$max \;\; U = E_0 \sum_{t=0}^{\infty} \beta^t u(C_t, H_t), \tag{1.1}$$

subject to an infinite set of instantaneous budget constraint,

$$\frac{D_t}{R_{t-1}} + r_t^k K_{t-1} + w_t H_t = D_{t-1} + C_t + I_t + \frac{\phi}{2}\left(\frac{K_t}{K_{t-1}} - g\right)^2 K_{t-1}, \tag{1.2}$$

$$I_t = K_t - (1 - \delta_t) K_{t-1}, \tag{1.3}$$

where g is the average growth rate of the economy.[8]

In order to fully characterize the problem, we will assume the closing device is given by an external debt elastic interest rate[9]

$$R_t = R^f + \psi_t\left(e^{\frac{D_t}{X_t d^{ss}}}\right) + r_t^*, \tag{1.4}$$

where r_t^* is an autorregresive mean reverting foreign interest rate shock. Finally, the functional form of the instantaneous utility function is assumed GHH, [10]

$$u(C_t, H_t) = \frac{\left(C_t - \frac{X_t H_t^{\omega}}{\omega}\right)^{1-\sigma}}{1-\sigma}, \tag{1.5}$$

[8] In this section I follow the notation in Garcia-Cicco et al. (2010).

[9] As discussed in Schmitt-Grohe and Uribe (2003), this is required to avoid a unit root in the Euler equation.

[10] Greenwood et al. (1988).

Even-though the problem is standard, some comments should be added. First, as we are working with an open economy, we need to impose a convex function for adjustment costs of capital that is given by $\frac{\phi}{2}(\frac{K_{t+1}}{K_t} - g)^2$ with $\phi > 0$, otherwise, capital will instantaneously adjust to differences between international interest rate and marginal product of capital, which would ultimately imply that investment is too volatile and counterfactual behavior of trade balance. Second, notice that the depreciation rate and the interest rate debt elasticity are time dependent, while the remaining parameters are time independent. In section 1.2.3, I specify stochastic processes for time-varying parameters.

1.2.2 The problem of the firms

Firm's problem is assumed to be standard profit maximization problem subject to working capital constraints as in Neumeyer and Perri (2005). Hence, I will assume that the economy is populated by a large number of identical firms. These firms operate in competitive factor and goods markets. Hence, they rent capital, K_t, and labor services, H_t, from the households at given market prices. Firms produce a unique good that can be used for consumption or investment. We assume the economy is subject to a technological stationary shock (Total Factor Productivity shock) and a trend shock. Additionally we allow both capital share and the fraction of labor input that has to be paid in advance, to be time-varying.

Under this setup, the problem of the firm is given by,

$$max \Pi_t = Q_t - \kappa_t (R_{t-1} - 1) w_t H_t - r_t^k K_t - w_t H_t \tag{1.6}$$

$$Q_t = A_t K_t^{\alpha_t} (X_t H_t)^{1-\alpha_t} \tag{1.7}$$

Where Q_t, H_t, K_t denote output, labor and capital demanded by the firm in period t, respectively.

w_t, r_t^k denote the rental rate of labor and capital, respectively. X_t is a labor augmenting stochastic factor that grows at a rate g_t, then $g_t = X_t/X_{t-1}$.

κ_t is used to denote the fraction of labor services that the firm has to pay in advance, i.e. before production takes place, in period t. If it is zero, firms problem reduces to standard profit maximization problem. The firms' problem includes a term $\kappa_t(R_t - 1)w_tH_t$ which is the repayment of working capital firm need to borrow in order to pay labor services.

Growth rate and stationary productivity shocks follow autoregressive processes of order 1, that are assumed to be mean reverting,

$$log\left(\frac{g_t}{g}\right) = \rho^g \times log\left(\frac{g_{t-1}}{g}\right) + \sigma^g \epsilon_t^g, \tag{1.8}$$

$$log\left(\frac{A_t}{A_{ss}}\right) = \rho^a \times log\left(\frac{A_{t-1}}{A_{ss}}\right) + \sigma^a \epsilon_t^a, \tag{1.9}$$

Where ϵ_t^a and ϵ_t^g are $\sim Niid(0,1)$ and $\sim Niid(0,1)$ respectively, and $\rho^a < 1$ and $\rho^g < 1$.

1.2.3 Introducing Parameter Instabilities

We assume that ψ_t, κ_t, δ_t and α_t are time-varying, and follow AR(1) stochastic processes:

$$log(\psi_t) = (1 - \rho^\psi)log(\psi^{ss}) + \rho^\psi log(\psi_{t-1}) + \sigma^\psi \epsilon_t^\psi \tag{1.10}$$

$$log(\delta_t) = (1-\rho^{\delta})log(\delta^{ss}) + \rho^{\delta}log(\delta_{t-1}) + \sigma^{\delta}\epsilon_t^{\delta} \tag{1.11}$$

$$log(\alpha_t) = (1-\rho^{\alpha})log(\alpha^{ss}) + \rho^{\alpha}log(\alpha_{t-1}) + \sigma^{\alpha}\epsilon_t^{\alpha} \tag{1.12}$$

$$log(\kappa_t) = (1-\rho^{\kappa})log(\kappa^{ss}) + \rho^{\kappa}log(\kappa_{t-1}) + \sigma^{\kappa}\epsilon_t^{\kappa} \tag{1.13}$$

I assume all processes are mean reverting, i.e. $|\rho^{\psi}| < 1$, $|\rho^{\delta}| < 1$, $|\rho^{\alpha}| < 1$, $|\rho^{\kappa}| < 1$. This is a convenient assumption in order to have a well defined steady state in order to solve the model using a linear approximation around that point. Processes are specified in logarithms in order to guarantee that parameters are non-negative.

Note that I implicitly assume that agents are aware of parameter instabilities, they know law of motions of these parameters and probability distributions of innovations. Hence, as long as parameters are time-varying, they become a state variable for the agents' optimization problem. In other words, it is a fully rational expectations model. It is straightforward to note that the source of change in parameters can be multiple. Given that the model does not provide an explicit structure for it, we cannot rule out alternative interpretations of these changes.

Note that ρ, ϕ, σ^a, σ^g, β, σ and ω are assumed to be constants. The first four parameters are constant because they do not affect decision rules up to first order. On the other hand, β, σ and ω are time independent in order to focus on potential instabilities in technological and financial sectors.

1.3 Solution and Estimation Methods

We will solve the model using log-linear approximation around the unique steady state.[11] As we pointed out in previous sections, the choice of log-linear solution

[11] Log-linear approximations are commonly used in open macroeconomics literature, hence we skip a detailed explanation of this step and refer the reader to standard references, i.e. Blanchard and

methods is not without loss of generality, specifically because it conditions which parameters are allowed to change, however, it is still a good starting point to study time-varying parameters in emerging economies.[12]

To estimate the model, I choose a full information estimation approach using Bayesian tools. I use 4 observables: private consumption (C) and output (Y), measured at fixed prices base year 1993 in logarithms. A third variable is trade balance to output ratio (TB/Y), also in real terms. Finally, the last observable is real interest rate (R) in logarithms. All variables have been seasonally adjusted using X-12 filter.[13] We denote the observable vector by:

$$obs_t = \left(Y_t, C_t, \frac{TB_t}{Y_t}, R_t \right)', \tag{1.14}$$

Following standard notation,[14] the set of parameters to be estimated is,

$$\Theta = \{\gamma, \omega, \phi, \psi^{ss}, \kappa^{ss}, \delta^{ss}, \alpha^{ss}, \rho^a, \rho^g, \sigma^a, \sigma^g, \sigma^r, \sigma^\delta, \sigma^\psi, \sigma^\alpha, \sigma^\kappa, \rho^\delta, \rho^\psi, \rho^\alpha, \rho^\kappa\},$$

Our goal is to characterize the posterior distribution of the parameters given the data and prior information.[15]

Kahn (1980), Sims (2002), Schmitt-Grohé and Uribe (2004). In this paper, I use the method as in Schmitt-Grohé and Uribe (2004).

[12] I am currently working in extensions in order to consider stochastic volatility model of emerging markets.

[13] Sources and details are available in the Appendix.

[14] See An and Schorfheide (2007) or Garcia-Cicco (2008).

[15] For details on Bayesian estimation procedures, see An and Schorfheide (2007).

$$p(\Theta|obs) = \frac{L(obs|\Theta)p(\Theta)}{p(obs)} \propto L(obs|\Theta)p(\Theta),$$

where $p(\Theta|obs)$ is the posterior density of parameters conditional on the observed data, $L(obs;\Theta)$ is the probability that the observed data has been generated by the set of parameters given by Θ, $p(\Theta)$ is the prior distribution that summarizes econometricians beliefs about unknown parameters and $p(obs)$ is the marginal likelihood give by

$$p(obs) = \int L(\Theta|obs)p(\Theta)d\Theta$$

I assume priors for each parameter are independent of each other and follow the distribution specified in Table 1.1.

Table 1.1: Priors

Parameter	Distribution	Mean	Variance
γ	Gamma	2.25	0.33
ω	Normal	3	0.015
ϕ	Gamma	0.15	0.025
ρ^a	Beta	0.75	0.0046
ρ^g	Beta	0.75	0.0046
σ^r	Gamma	0.25	0.0125
σ^a	Gamma	0.25	0.0125
σ^g	Gamma	0.25	0.0125
ψ^{ss}	Gamma	0.15	0.0225
α^{ss}	Beta	0.28	0.0029
δ^{ss}	Beta	0.03	5.3863e-004
κ^{ss}	Beta	0.8	0.062
ρ^α	Beta	0.75	0.0046
ρ^δ	Beta	0.75	0.0046
ρ^ψ	Beta	0.75	0.0046
ρ^κ	Beta	0.75	0.0046
σ^α	Gamma	0.25	0.0125
σ^δ	Gamma	0.25	0.0125
σ^ψ	Gamma	0.25	0.0125
σ^κ	Gamma	0.25	0.0125

As can be seen in the table, I assume same priors for volatilities and autocorrelations of parameters that drift. As priors are assumed to be independent, the prior distribution, $p(\Theta)$, is given by the product of each parameter's probability distribution function.

In order to evaluate the posterior function, under normality assumption, I use Kalman Filter to evaluate $L(obs|\Theta)$. I maximize the posterior mode and then implement a Random Walk Metropolis-Hastings algorithm starting from the maximized mode, simulate 1 million draws and keep the last 500,000 to evaluate the posterior densities. In all the exercises I aim an acceptance rate of 40 %.

The standard Metropolis-Hastings algorithm has to be modified when working with time-varying parameters. This happens because time-varying parameters have to take into account parameters' bounds. For instance, even though α_t is time dependent, it has to be between 0 and 1 for all t, same for depreciation rates, working capital constraint sensibility. Instead ψ_t is required only to be positive for all t. For this reason, for each draw of the Metropolis-Hastings algorithm, after evaluating $L(obs|\Theta)$ using Kalman Filter I have to compute smoothed paths for α_t, κ_t, δ_t, ψ_t and discard draws that imply that smoothed estimates of these parameters violate their bounds for any t.

1.4 Are Small Open Economy's structural parameters constant? The Case of Argentina

This section studies the first question of this paper. Are structural parameters of small open economy models really deep parameters when fitting emerging markets data?

I start by calibrating steady state values in order to match steady state values to averages in the data.

Table 1.2: Calibration

Parameter	Value
$\frac{D_{ss}}{Y_{ss}}$	0.27
G	1.0059
R	1.05

Note: Averages using 1983-2008 Argentinean data.

As can be seen in Table 1.2, I assume the debt to GDP ratio is 27%, equal to the average of ratio of private foreign debt to GDP for Argentina for the period 1983-2008. The steady state of growth rate is 1.0059, which is equal to the linear trend of Argentina real GDP. The steady state of interest rate of foreign debt is calibrated to the average value of 1.05 for the same period.[16]

1.4.1 Structural Estimation

Remaining parameters are estimated using Bayesian techniques as described in previous section. Table 1.3 presents posterior means and 95% credible sets.

[16] Data details and sources are in Appendix.

Table 1.3: Estimation Results

Parameter	Posterior Mean	95% Credible Set
γ	3.2	[2.3 ,4.1]
ω	1	[1 ,1.1]
ϕ	10	[8.5 ,11]
ψ^{ss}	0.00044	[0.00026 ,0.00061]
κ^{ss}	0.74	[0.6 ,0.87]
δ^{ss}	0.033	[0.028 ,0.038]
α^{ss}	0.34	[0.3 ,0.37]
ρ^{g}	0.93	[0.89 ,0.95]
ρ^{a}	0.83	[0.74 ,0.9]
ρ^{ψ}	0.74	[0.61 ,0.86]
ρ^{r}	0.5	[0.44 ,0.56]
ρ^{κ}	0.84	[0.75 ,0.92]
ρ^{α}	0.999	[0.99 ,0.9999]
ρ^{δ}	0.93	[0.92 ,0.94]
σ^{g}	9e-005	[5.3e-005 ,0.00013]
σ^{a}	1.4e-005	[4.7e-006 ,2.7e-005]
σ^{ψ}	0.24	[0.085 ,0.43]
σ^{κ}	0.03	[0.011 ,0.057]
σ^{r}	0.002	[0.0013 ,0.0029]
σ^{α}	0.00018	[0.00015 ,0.00021]
σ^{δ}	0.039	[0.026 ,0.055]

Note: Posterior means are calculated using the last 500,000 draws after convergence of the Metropolis-Hastings Algorithm.

As can be seen from the table, parameters estimates are in line with findings in related literature. Note that working capital constraint parameter is estimated to 74% of wage bill, which is a high number but significantly smaller to the one calibrated in Neumeyer and Perri (2005). Additionally, all autorregresive processes are mildly persistent, except the one of α_t. Persistency of TFP shock and trend shock are in line with previous findings for different sets of Argentinean data.

Rest of the parameters are estimated to standard values, α_{ss} is 0.34, which implies a labor share of 0.66. This is in line with Bergoeing et al. (2002), in which they suggest values for labor share from 0.42 to 0.70. On the other hand the data implies a high capital adjustment cost. Big capital adjustment costs are in line with Garcia-Cicco et al. (2010), however authors work with annual data and constraints this estimate to be less than 8 and hence find posterior means that goes from 3.3 to 4.6 depending on the model and 95% credible sets that goes from 3 to 6.5. On the other hand, I find a small but significantly positive elasticity of interest rate to foreign debt. This result is also in line with previous literature, for instance Garcia-Cicco et al. (2010) calibrates this parameter to 0.001.[17]

1.4.2 Model Comparison

In this section, my objective is to answer the main question of the paper, whether data supports time-varying parameter small open economy emerging market model instead of fixed parameter models. To answer this question I compute marginal data densities.

I do this following Geweke (1999) and Gelfand and Dey (1994) numerical pro-

[17] As already pointed out, eventhough magnitudes are of a similar order, differences in point estimates arise because Garcia-Cicco et al. (2010) use annual data.

cedure that constructs the Modified Harmonic Mean estimator. The main task in model comparison is to construct the marginal data density conditional on a model,[18]

$$p(obs|M) = \int_{\tilde{\Theta}} p(obs|\Theta, M)p(\Theta|M)d(\Theta)$$

where M indexes the model and $\tilde{\Theta}$ denotes the parameter space with respect to which we integrate. It can be shown[19],

$$\frac{1}{p(obs|M)} = \frac{\int_{\tilde{\Theta}} f(\Theta)d(\Theta)}{\int_{\tilde{\Theta}} p(obs|\Theta, M)p(\Theta|M)d(\Theta)} \quad (1.15)$$

where

$$f(\Theta) = \frac{1}{p(2\pi)^{k/2}}|\Sigma_m|^{-1/2}exp(-0.5(\Theta - \Theta_m)\Sigma_m^{-1}(\Theta - \Theta_m))I(\Theta \in \tilde{\Theta})$$

and θ_m is the posterior mean and Σ_m is the variance covariance matrix from the posterior simulator and $I(\Theta \in \tilde{\Theta})$ is an indicator function that is zero if condition in parenthesis does not hold. In order to compute the marginal data density, we approximate expression 1.15 by posterior simulation.[20]

Table 1.4 presents marginal data densities for time-varying parameters model and fixed parameters model.

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[18] This section follows Geweke (1999) and An and Schorfheide (2007)

[19] See Geweke (1999).

[20] For a detailed description of the method see Geweke (1999) and Gelfand and Dey (1994).

Table 1.4: Marginal Data Density

Model	$p = 0.1$	$p = 0.5$	$p = 0.9$
Parameter Drift	-108.6	-106.6	-104.5
Fixed Parameters	-310.5	-308.8	-307.4

Note: Marginal Posteriors are calculated using Harmonic Mean, as in Geweke (1999), using values of the MCMC posterior likelihood for the last 500,000 draws.

As can be seen in the table, the marginal density of the parameter drift model is significantly larger than fixed parameter one for $p = 0.5, p = 0.1$ and $p = 0.9$. In this way, data strongly supports time-varying parameter model when fitting Argentinean data. This evidence suggests that structural parameters of small open economy models are not constant when matching the features of Argentina's business cycles. Hence, if we want to represent Argentina's business cycle using small open economy type model, we want to consider time-varying parameters model, given than standard model oversimplifies certain aspects of this economy.

In the rest of the paper, I approach the question of what might be the parameter instabilities capturing. In the next section, I take a closer look to Argentinean data and study structural breaks in the series of output. Given the evidence on structural breaks, I study the smoothed series of time-varying parameters and the structural break episodes and find that substantial variability occur during periods of structural breaks. Then, I asses how relevant are parameter instabilities in generating observed variability of the data.

1.5 Reviewing Business Cycle Facts: the case of Argentina

In this section, I study Argentina's aggregate data and reconsider standard stylized facts. In particular, this section presents business cycle facts and study the structural stability of macroeconomic aggregates and statistical moments by subsamples. Structural breaks in emerging markets have been documented in emerging markets finance literature such as Nguyen and Bellalah (2008). However there has been no systematic study of the topic and is not usually studied when studying the fitting of real business cycle macroeconomic models to the emerging markets experience.

Table 1.5: Observed Moments: Argentina 1983-2008

Moment	1983.1-2008.2	Std. Dev.
σ^{GDP}	9.261	(0.8406)
σ^{Con}	10.24	(0.9204)
σ^{inv}	24.93	(2.11)
σ^{tby}	3.39	(0.3247)
σ^{r}	3.469	(0.3324)
$\rho^{tby,g}$	-75.87	(7.489)
$\rho^{r,g}$	-73.4	(7.24)

Note: Volatilities and standard errors are in percentage terms. Output, consumption and investment are linearly detrended.

Table 1.5 presents the well known facts about emerging markets aggregate data. As can be seen, aggregate consumption is more volatile than output, but less volatile than investments, while trade balance and interest rates are strongly countercyclical. The evidence on this table, however, might be an over-simplification. In Table 1.6, I show that Argentinean output is subject to multiple structural breaks, suggesting that in order to compute the statistical moments in Table 1.5, it would be important to take care of these episodes,

Table 1.6: Testing for structural breaks of GDP

Test	Date
Bai Perron**	1990Q3 &1998Q4 & 2003Q2

Note: Bai and Perron test the null of no structural breaks against multiple breaks (unknown number of breaks and dates). ** Significant at 1 %

As can be seen in previous table, output in Argentina is subject to multiple structural breaks during the sample period, as Bai Perron's test rejects the null of no structural breaks in the third quarter of 1990, fourth quarter of 1998 and second quarter of 2003. The following table revise Argentinean stylized facts dividing the sample in four subsamples accordingly to the structural break dates.

Table 1.7: Observed Moments: Argentina

Moment	1983.1-2008.2	1983.1-1990.2	1990.3-1998.3	1998.4-2003.1	2003.2-2008.2
σ^{GDP}	9.261	8.985	7.189	10.98	9.747
	(0.8406)	(1.511)	(1.171)	(2.329)	(1.937)
σ^{Con}	10.24	10.07	8.387	12.68	8.83
	(0.9204)	(1.676)	(1.359)	(2.646)	(1.771)
σ^{inv}	24.93	19.94	20.07	32.63	24.12
	(2.11)	(3.197)	(3.002)	(5.7)	(4.275)
σ^{tby}	3.39	1.697	2.732	4.739	2.253
	(0.3247)	(0.3048)	(0.4635)	(1.068)	(0.4814)
σ^{IR}	3.469	1.159	1.074	5.053	5.263
	(0.3324)	(0.2092)	(0.185)	(1.136)	(1.091)
$\rho^{tby,g}$	-75.87	-88.98	-89.61	-98.03	-93.39
	(7.489)	(16.22)	(15.57)	(22.99)	(20.34)

Note: Volatilities are standard errors are in percentage terms. Output, consumption and investment are linearly detrended.

Table 1.7, reports volatilities of real GDP, private consumption, investment, trade-balance-to-output ratio and real interest rates, in percentage terms, for Argentina both for the whole sample 1983Q1 to 2008Q2 and four subsamples 1983Q1 to 1990Q2, 1990Q1 to 1998Q2, 1998Q3 to 2003Q1 and 2003Q2 to 2008Q2. These episodes are associated to dramatic political and economic disturbances; in 1989 and 1990 Argentina suffered both an anticipated change in government parties and two large hyperinflations. The period comprised by 1990Q1 to 1998Q2 was one of relative macroeconomic success. Year 1998 is, instead, the starting of a large stagnation period that ended with the large recession in the end of 2001, one of the largest economic crises in the twentieth century accompanied by financial crises and default of foreign debt. The critical period ended by the beginning of 2003 where macroeconomic recovery started due to good international conditions. This last period runs until the end of our sample, period that coincides with a dramatic deceleration of economic growth in part associated to international crisis and domestic turbulence.

As can be seen, over the whole sample, there is no evidence of consumption smoothing, investment is close to three times larger than output and trade balance is remarkably less volatile and, interest rate volatility is extremely high.[21]

In Table 1.7 we also present volatilities for each subsample. A major particularity is that volatility, after a reduction during the 90's, tends to increase significantly implying a large increment during the last 25 years. As can be seen in the table, output volatility increases from 8.3% to 12% and trade balance to output ratio volatility and investment volatility duplicates in the same period. Note however, that in terms of consumption smoothing not all periods are alike. In particular, the last period shows mild evidence of consumption smoothing.

Table 1.7 also reports the correlation of output with trade balance. As can be seen, output is largely negatively correlated with trade balance to output ratio and this correlation seem to be increasing (in absolute value) across subsamples.

Argentina is not the only case in which data is affected by structural breaks. In Table A.1 in Appendix 1, I show this is the case for a large set of emerging mar-

[21] Same moments were computed using Hodrick-Prescott filter with smoothing parameter $\lambda = 1600$ and results are robust to the detrending strategy. It is also similar to the relation obtained by prior authors such as Neumeyer and Perri (2005) for a similar dataset. The relative volatility of consumption to GDP is smaller than the one reported by Aguiar and Gopinath (2007), this is the case because the authors use a shorter data set running from 1993 to 2002.

kets including not only Latin-American economies but also East-Asian economies. Moreover, structural breaks are not observed in developed small open economies.

The evidence presented indicates that structural breaks are an important feature of emerging markets and they should be captured by a model that aims to represent their business cycle facts. A natural question comes from the previous two sections, i.e. do are structural breaks relate to parameter instabilities? or in other words, what does the model imply about time-varying parameters around the episodes of structural instability? I address the question in the next section.

1.6 Parameter Drifts, Shocks and Business cycle facts

In this section I study the implications of the model regarding unobserved shocks and parameter drifts. I divide the study in 2 parts, first I study smoothed unobserved parameter drifts and shocks and their relation to structural breaks identified in the previous section. Then, I study variance decomposition and impulse responses both regarding technological and interest rate shocks and parameter drift shocks.

1.6.1 Smoothed shocks and drifting parameters

This section studies the evolution of smoothed shocks and parameters with drift. The key question this section focuses is the role of shocks and parameter changes in assessing observed variability and structural breaks. Figure 1.1 plots the smoothed path of technological shocks and interest rate shock together with the output structural breaks reported in previous section.

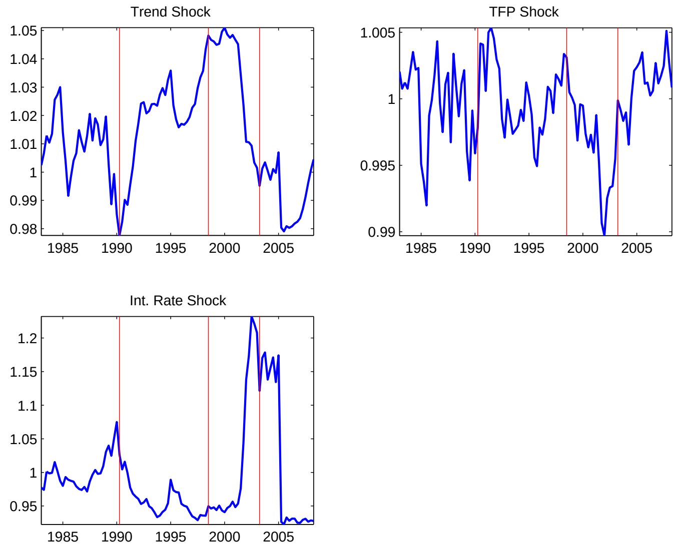

Figure 1.1: Smoothed TFP and Interest Rate Shocks

Note: Computed by Smoothed Kalman Filter. Vertical lines denote output structural breaks from Bai and Perron (1998) Test.

As can be seen in the figure, the variability of the trend has been substantially large during the last 25 years. More importantly, strong changes in the trend are observed in periods close to times of structural breaks. As can be seen, prior to 1990, the trend fluctuates around 1.01 and suffers two strong negative shocks, the first one in 1985 and the second one in 1990. These drops occur together with bad realizations of the stationary technological shock. After 1990 the trend exhibits a large increase with peaks in 1995 and 1998, these 2 episodes of persistent drops in the trend are associated to foreign Tequila and Asian crises. After that, the trend growth of the economy stagnates and in 2001 suffered significant reductions.

Stationary technological shocks, on the other hand, have been fluctuating significantly around the steady state value and with much lower persistence than trend shocks. Specifically, on top of the comovements with trend shocks described on last paragraph, note that periods of trend growth occurred together with significant stationary technological downturns such as the period 1991-1992 or 1998-2001 that occurred together with an stagnation of the trend.

Finally, note that interest rate shocks mimic the behavior of interest rate. This indicates that the model consider that large part of the behavior of interest rate is exogenously determined instead of being driven by interest rate elasticity to debt. The variation of interest rate shocks is also related to break dates. As can be seen, the shock peaks in 1990 and 2003, suggesting that not only domestic technological shocks can be associated to the breaks.

However, these three shocks are not the only driving forces of our model. In order to complete the picture, we need to study parameter changes. Figure 1.2 presents the path of time-varying parameters and break dates.

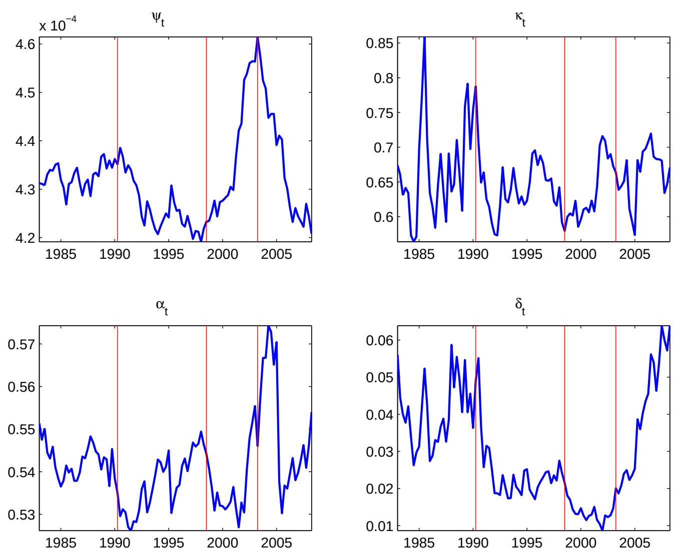

FIGURE 1.2: Smoothed Drifting parameters

Note: Computed by Smoothed Kalman Filter. Vertical lines denote output structural breaks from Bai and Perron (1998) Test.

As can be seen from the figure, parameters change in a significant way. Sensibility of interest rate to debt also mimics the behavior of interest rate, indicating that the cost of additional debt is significantly higher during crises, as peaks during early nineties, 1995 and 2002. Note importantly that after 1990 and 2003's breaks, the sensitivity to foreign debt decreases significantly and exhibits a complete change of behavior. The period under Convertibility Plan (1991-2002) exhibit a lower degree of sensitivity of interest rate to foreign debt, indicating that the access to international credit was less responsive to indebtness level, as opposed to the previous decade. Around 2002 crisis, the elasticity of interest rate to foreign debt peaks and starts decreasing while times were going back to normal.

Additionally, note that before each macroeconomic crisis, working capital constraints faced by firms become tighter, as larger shares of wage stipend are required to be fulfilled in advance. During the recovery period, this shares decrease. In that sense, the costs of working capital constraints are countercyclical. This is intuitive given that during big uncertainty crisis, labor suppliers require larger funds in order to insure themselves. In particular, note that κ_t peaks during inflationary periods, such as mid-85 and '86 and during 1989 and 1990. After stabilization was attained, decreases and fluctuates around 65%, but still in this period, sudden increases are observed in 1995 and 2002, Tequila and Argentinean crises.

Capital share exhibits a lower volatility. However, it seems to be the case that capital share decreases before and during crises, but quickly increases during recoveries. This can be the case because during crises firms use production technologies that are more labor intensive than in periods of recovery. This does not mean that firms are hiring more during crisis; instead it could be understood that both labor and capital demand drop in such a way that technology is more labor intensive.

Finally, depreciation rates seem to have a low degree of variability prior to 2002 crisis. After 2002, depreciation rate significantly increases with the recovery of the economy, this is intuitive given a higher utilization of installed capital.

1.6.2 Variance Decomposition

So far we studied the behavior of shocks and parameter changes and their relation to emerging markets facts. However, we still need to study whether parameter changes are important in capturing observed variability. In Table 1.8 we check that parameter drift plays a role in explaining it.

Table 1.8: Variance Decomposition

	TB/Y	Y	C	R
Trend Shocks	40.9	24.83	31.5	6.978
Stationary TFP	0.06775	0.0331	0.04122	0.01054
Interest Rate	0.4498	0.04647	0.04892	81.53
ψ_t	0.0002243	2.455e-005	1.891e-005	0.01209
κ_t	0.005651	0.008205	0.009065	0.0004304
α_t	49.07	68.32	60.06	9.854
δ_t	9.502	6.759	8.339	1.616

Note: Volatility generated by each shock as share of total volatility.

As can be seen in the table, a large part of the variability of observed data is explained by the trend shocks. TFP and interest rate shocks explain a low portion of observables variability, except for the case of interest rate.

Regarding shocks to time-varying parameters, depreciation rate and capital share explain a large portion of observables variability. As can be seen, the former one explains around 10% of the variability of trade balance to output ratio and consumption and 7% of the variability of output, whereas the later one explains between 50 to 60% of the variability of trade balance to output ratio, output and consumptions, and almost 10 % of the variability of interest rate. On the other hand, changes in financially related variables have a minor effect, not larger to 1.5% in any case. In summary, parameter instabilities have a fundamental effect in explaining the variability observed in the data.

The evidence presented so far present variance decomposition at horizon 0. Figure 1.3, presents variance decomposition at different horizons.

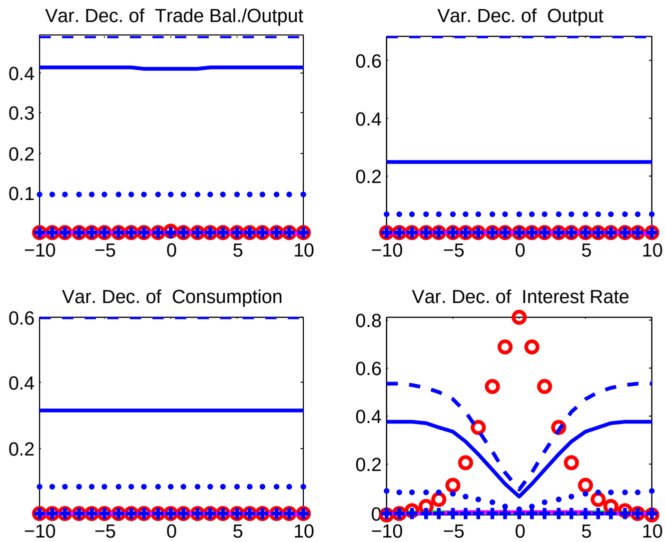

FIGURE 1.3: Variance Decomposition

Note: Blue line stands for trend shocks, green line TFP shocks, circles for interest rate shocks, purple for ψ_t shocks, plus for κ_t shocks, minus α_t shocks, points δ_t shocks.

As can be seen, explained variability at any horizon are stable for all variables except interest rate. The large variability of interest rate that is explained by interest rate shocks is only contemporaneous, parameter drifts lags and leads have strong explanatory the largest the horizon we consider.

1.6.3 Impulse Responses

The study of impulse responses of productivity, interest rate and parameter drift shocks is important to understand first order effects of parameter instabilities and what kind of dynamics they capture.

Figures A.1 to A.3 presents impulse response functions with respect to trend shocks, stationary technological shocks and interest rate shocks respectively. As can be seen in the figure, both stationary productivity shock and growth rate shock have, as expected, expansionary effects. Trend shocks are much more persistent but the impact of both shocks is substantial. However, note that both shocks have different implications in terms of correlations between output and trade balance to output ratio. While trend shocks generate strong countercyclical behavior, stationary productivity shock generates procyclical behavior. This is in line with Aguiar and Gopinath (2008) findings. These results also indicate that trend shocks are source of consumption excess volatility as implies larger responses of consumption than output.

Note, on the other hand, foreign interest rate shocks have recessive effects, and implies larger consumption than output drops.

Figures A.4 to A.7, presents the impulse response functions of endogenous variables to shocks to the time-varying parameters. In this framework, parameter drifts have first order effects on endogenous variables. As can be seen in the pictures, ψ_t and κ_t have recessive effects, as expected. By depressing domestic consumption and output, they positively affect trade balance to output ratio inducing larger savings. Note that these shocks exhibit a significantly smaller magnitude than productivity and interest rate shocks.

On the technological side, δ_t shocks have negative effect in consumption and output, this is reasonable given a wealth effect created by wealth destruction. Instead α_t have positive effects on consumption and output.

As can be seen in these last figures, they all imply that consumption responds stronger than output to parameter drift shocks. This is, hence, potentially important to understand the lack of consumption smoothing in emerging economies.

1.7 Concluding Remarks

Emerging markets' business cycle is different from the one of developed economies. However, there is no consensus on how to model these differences. In this paper, I review the question whether small open economy real business cycle models are suitable to represent emerging markets dynamics. The main objective of this paper is to study whether structural parameters of small open economy real business cycle models are time-varying when applied to model emerging markets data.

In particular, I consider a state of art small open economy model with shocks to the trend of technology and working capital constraints in the firms' optimization problem and extend it to allow for capital share, interest rate elasticity, depreciation rate and working capital constraint elasticity to change across time. I use this model to fit Argentinean data and compare it with the fixed parameters version.

I show that data supports that both technological and financial parameters exhibit substantial time variation during the last 25 years. Moreover, parameter changes play an important role in explaining fluctuations of Argentinean data. Specifically, variance decomposition exercises show that capital share and depreciation rates play an important role in the variability of consumption, output and trade balance.

The model also implies that trend shocks are an important source of variability for all variables. Instead, stationary productivity shocks and interest rate shocks seem to play minor role in addressing variability of observed variables.

Parameter drifts have no unique interpretation. Ultimately, this paper shows that the best small open economy model might be too stylized to capture important aspect of emerging markets technological and financial features.

2

Policy Switches in Emerging Economies

2.1 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 these economies' macroeconomic performance.

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 exogenous shocks. Distinguishing between these two scenarios is crucial in order to make an appropriate characterization of policy design and the effects of policy shocks. Pursuing these tasks 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, 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 this paper, I develop a dynamic stochastic general equilibrium model that can address these questions. Specifically, I allow for time-varying fiscal and monetary policy rules and time-varying volatilities, in an otherwise standard small open economy new-Keynesian model. Coefficients in policy rules and volatilities are assumed to change accordingly to independent Markov-Switching processes.

I estimate the model for Mexico and find strong evidence of repeated monetary and fiscal policy changes during the period 1980-2009, as well as several changes in the volatilities of exogenous shocks. In particular, I identify two regimes for the monetary and fiscal policies. In the first one, monetary policy responds strongly to inflation while fiscal policy responds strongly to government-debt-to-output ratio. Following Leeper (1991), this regime is associated to active monetary policy and passive fiscal policy regime (I will refer to this regime as "active monetary policy").[1] In the second regime, fiscal policy is conducted independently of government-debt-

[1] The intuition for referring to this kind of monetary policy as "active monetary policy" comes from the fact that, under this regime, monetary policy actively fights inflation while fiscal policy accommodates to the endogenous dynamics of government debt.

to-output ratio and monetary policy does not respond strongly to inflation. Also after Leeper (1991), this regime can be associated to active fiscal policy regime and passive monetary policy regime (which for simplicity will be denoted as “active fiscal policy”).[2]

I find that for the period 1980-2000, active monetary policy regime did actually hold only during short periods after macroeconomic crisis. Hence, this regime is associated to the macroeconomic adjustment that starts after macroeconomic turbulence and last for several quarters. More recently, after 2002, I find evidence of active monetary policy regime, even though in this case it did not occur in an environment of macroeconomic distress. During the rest of the sample, active fiscal policy regime is in place.

After characterizing the behavior of fiscal and monetary policies, I analyze the effects of policy changes on macroeconomic performance. I find that the dynamics of output, consumption, inflation and the growth rate of nominal exchange rates 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

[2] This regime refers to passive monetary policy/active fiscal policy, because monetary policy passively accommodates to fiscal policy financing requirements, which, in turn, is conducted independently of government debt.

change is perceived as permanent, the stabilization effects are substantially larger and imply almost no additional output costs.

This paper is related to a recent literature that studies fiscal and monetary policy design in emerging economies. Previous studies that address policy determination in emerging markets, such as Mohanty and Klau (2005), Aizenman et al. (2008) or Kaminsky et al. (2004) work with vector autoregressions or univariate statistical models with fixed parameters,[3] as well as, more structural approaches such as Batini et al. (2007), Cúrdia (2008), Tchakarov et al. (2005) and Garcia-Cicco (2008).[4] As can be seen, most researchers work under the assumption of time invariant monetary and fiscal policy rules.[5] Considering emerging markets' recent history, this assumption introduces a significant gap in the literature. This paper, to my best knowledge, is the first one in studying repeated policy changes under rational expectations in small open economies in general, and in particular in emerging economies.

[3] In particular, Mohanty and Klau (2005), study constant coefficient univariate Taylor rules in emerging markets. 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 instability for the case of Korea, Philippines, Thailand, Brazil, Mexico and Poland. On the other hand, Aizenman et al. (2008) studies interest rate rules using dynamic panels for 16 emerging economies for the period 1989 to 2006. Kaminsky et al. (2004), studies how fiscal and monetary policies differ in developed, middle income and low income countries, also using fixed parameter models.

[4] Specifically, Batini et al. (2007) studies and rank different monetary policies in open economies with financial frictions. Cúrdia (2008) studies monetary policy in a similar environment, however his main objective is to study monetary policy when economies are subject to sudden stops. Tchakarov et al. (2005) instead estimates a financial friction model for Korean economy in order to study the importance of financial frictions. Also, Garcia-Cicco (2008) estimates a new Keynesian model with the objective of characterizing the monetary policy in Mexico and to discuss the feature of monetary policy analysis in emerging economies. 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 (2008) assumes fixed policy rules, but assumes time-varying targets.

[5] A remarkable exception is Del Negro and Obiols-Homs (2001) that design a VAR model that allows for parameter changes.

This paper is also related to the literature on “policy temporariness” such as Krugman (1979), Calvo (1987), Calvo and Mendoza (1994), Mendoza and Uribe (2000) and Rebelo and Vegh (2008). This literature studies the distortions that can occur due to temporary changes in a macroeconomic policy, such as trade policy, exchange rate 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.[6]

The model in this paper exhibits a regime in which fiscal policy does not respond strongly to government-debt-to-output ratio. 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, devel-

[6] Importantly, a policy change in my framework is not a surprise given that it is part of agents' expectations.

oped and, to a lesser extent, developing countries. Regarding developed economies, Mélitz (1997) estimates reaction functions in 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 (2003) finds, for the Euro Area, that price stabilization can happen even when fiscal policy is discretionary. Favero and Monacelli (2003) focus, on the other hand, in the U.S. economy and finds that active fiscal policy was actually in place for a large part of its recent macroeconomic history.

These kind of studies are not exclusively about developed economies. Regarding emerging markets, Tanner and Ramos (2003) studies the way fiscal policy has been conducted in Brazil during the '90s. Also, Zoli (2005) presents several tests to study whether fiscal policy is active or not, and fiscal and monetary policy interaction for emerging markets and finds 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 also 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 (2010), Davig and Leeper (2007).[7] However, these papers study U.S.

[7] A different approach is to assume smooth time-variability of structural parameters. Some examples are Cogley and Sargent (2005), Fernández-Villaverde and Rubio-Ramirez (2007) or Seoane (2010), 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

experience, and hence, work under close economy assumption.

The rest of the paper goes as follows. In Section 2.2, I motivate my research by reviewing the main features of stabilization programs in several emerging economies. In Section 2.3, I present the model. In Section 2.4, I discuss the solution, estimation methods, data and prior distributions. Section 2.5, presents estimation results. Section 2.6, studies implications of my findings to monetary and fiscal policies. Section 2.7, studies the relevance of policy credibility in the success of stabilization policies. Section 2.9, establishes model comparison to alternative model specifications. Finally, Section 2.10, concludes.

2.2 Policy Changes: Evidence from Emerging Markets

Emerging economies implemented repeated stabilization programs during the last 30 years. In this section, I briefly review recent experience of several of these economies. I focus in the experiences of Argentina, Brazil, Ecuador and Mexico. However, this list could be expanded to other emerging and not emerging economies.[8]

2.2.1 Argentina

Figure 2.1 presents inflation, nominal exchange rate growth and consumption to output ratio in Argentina, jointly with implementation of stabilization programs, indicated by red vertical lines,

type of stochastic processes to be assumes is limited.

[8] 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.

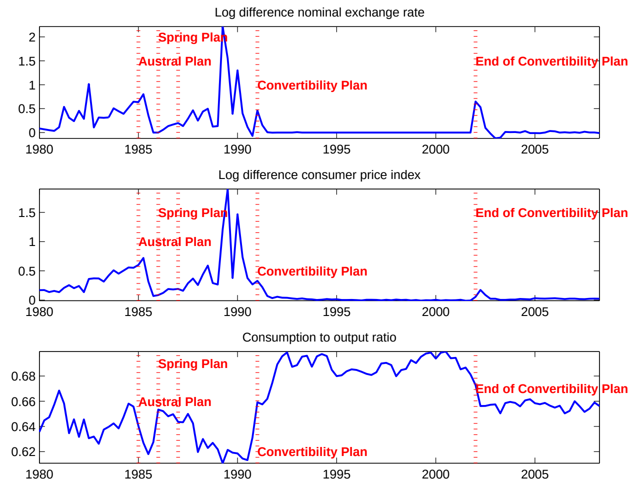

FIGURE 2.1: Stabilization programs in Argentina.

Note: Inflation and growth rate of nominal exchange rate are log-difference of consumer price index and nominal exchange rate, respectively, with respect to previous period, in quarterly terms. CPI and nominal exchange rate are from IFS-IMF. Consumption-to-output-ratio is from INDEC.

Argentina experienced several episodes of macroeconomic instability and introduced multiple stabilization programs during the 1980s and 1990s. 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.[9] More recently, "Convertibility Plan", introduced in 1991, lasted for 10 years and was able to successfully stabilize inflation.

As seen in the picture, macroeconomic dynamics significantly changed after early 1990s. During the 80s all series exhibit large variability while several stabilization programs were implemented. After 1991 the macroeconomic behavior is remarkably different, associated with the large rigidities imposed by Convertibility Plan.

[9] For a detailed characterization of these stabilization programs, see Kiguel (1991) and Fanelli and Frenkel (1989).

Austral Plan was designed to induce fiscal and monetary discipline and, in this way, affect inertial inflationary behavior and expectations. As discussed in Kiguel (1991), 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.

The introduction of "Convertibility Plan" in early 1990s was able to put an end to the hyperinflationary period. 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.[10]

2.2.2 Brazil

Figure 2.2 presents inflation, growth rate of nominal exchange rate and consumption-to-output-ratio for Brazil. As in the previous picture, stabilization programs are denoted by the red vertical lines.

The picture shows a remarkable change in the behavior of the data that occurred after 1994. Before this year, inflation and exchange rate dynamics exhibited larger variability while several stabilization programs were implemented. Since 1986, Brazil introduced 5 stabilization programs. "Cruzado Plan" in 1986 followed by "Bresser

[10] See Galiani et al. (2003).

Plan" in 1987.[11] In 1989, Brazil introduced "Summer Plan" and during early 90s introduced "Collor Plan". However, stabilization was attained in 1994 with the "Real Plan".

Programs implemented during the 80s where based on price, wage and exchange rate controls. As in the case of Argentina, the main objective was to deal with inertial inflation. However, these plans were not able to keep inflation under control in the medium run because they did not operate to control the demand side of the economy.

In 1990, government implemented "Collor Plan". As part of this program, the government liberalized international trade and prices and started with a period of privatizations.

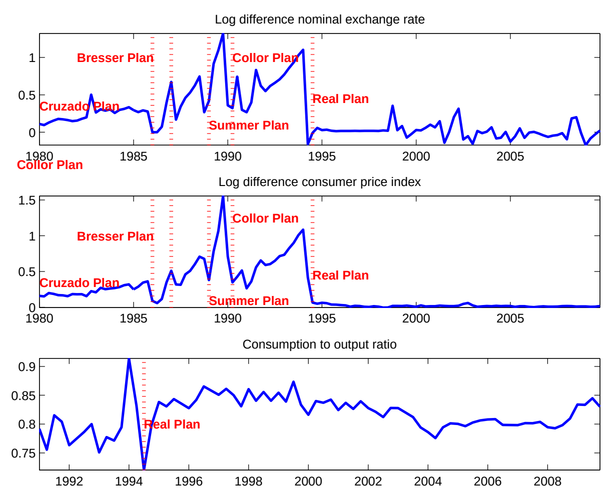

Figure 2.2: Stabilization programs in Brazil.

Note: Inflation and the growth rate on nominal exchange rate are logarithm differences of prices and nominal exchange rate, respectively, with respect to previous period, in quarterly terms. Data is from Central Bank of Brazil.

[11] See Bresser-Pereira (1990).

However, it was "Real Plan" the one that successfully controlled inflation in 1994. A monetary reform, with the main objective of price stability, was at the core of the program. As a result of the stabilization, the government successfully reduced inflationary taxation. A second feature at the core of the program was the control of nominal exchange rates. In order to attain the stability of nominal exchange rates the Central Bank implemented open market operations in order to sterilize foreign currency inflows.[12]

2.2.3 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 (U.S. dollars), transactions are done in foreign currency and, as a consequence, central government looses seigniorage revenues.

[12] A more detailed description of the measures taken to get price and exchange rate stability, as well as the problems generated by those measures, can be found in Herrera (2005).

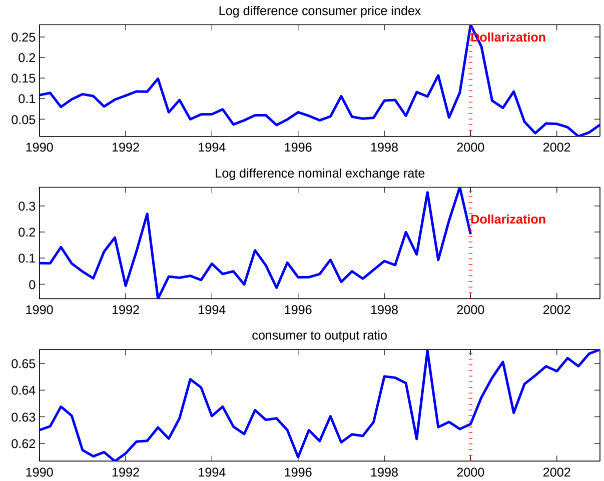

FIGURE 2.3: Stabilization programs in Ecuador.

Note: Inflation and the growth rate on nominal exchange rate are logarithm differences of prices and nominal exchange rate, respectively, with respect to previous period, in quarterly terms. Data is from IFS-IMF.

As depicted in Cabezas et al. (2001), 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 establish US dollar as the legal currency and to prohibit debt indexation.[13]

2.2.4 Mexico

In the case of Mexico we observe three major stabilization programs implemented since 1980. Figure 2.4 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

[13] A detailed description of the institutional aspects of the dollarization in Ecuador and some results of the program can be found in Cabezas et al. (2001).

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.

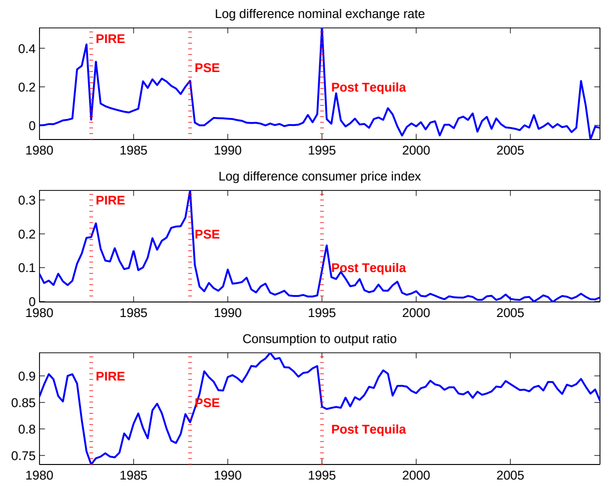

FIGURE 2.4: Stabilization programs in Mexico.

Note: Inflation and the growth rate on nominal exchange rate are logarithm differences of prices and nominal exchange rate, respectively, with respect to previous period, in quarterly terms. Data is from Central Bank of Mexico.

An orthodox stabilization program, "Program for immediate economic reorganization" (PIRE), was introduced in 1982. The main object of this program was to restrict aggregate demand. Given exogenous shocks, in 1987, macroeconomic situation worsen dramatically and the government introduced the "Pacto de Solidaridad Economica" (PSE). This program included reduction in subsidies and government expenditure, as well as changes in revenue policies, increases in the tariffs of public services and a highly restrictive monetary policy that, ultimately, increased domestic interest rates. The stabilization after this program was maintained by fiscal discipline measures.[14]

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, the main objective of this was to stimulate the macroeconomic recovery and, as a by-product, increase fiscal savings as long as economy recovered.[15]

2.2.5 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 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.

Evidence in this section also suggests that in order to study macroeconomic dynamics in emerging economies we have to focus in those small time spawns in which policies do not change, or instead, we have to consider the possibility of changes in policy rules. The first strategy is clearly undesirable if we plan to pursue estimation exercises.

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

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

[15] For a detail on these stabilization programs, see Chavez Presa and Budebo (2000) and Jarque et al. (1993).

in these economies.

2.3 The Model

In this section we present the benchmark model. The model is in the spirit of Gali and Monacelli (2005), Justiniano and Preston (2010) and Monacelli (2006).

The model is based on the one in Justiniano and Preston (2010), 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 domestic 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.

2.3.1 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 according to the following function,

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

where, $m_t = M_t/P_t$ are real money holdings, n_t denotes hours worked 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) and ϵ is the elasticity of substitution between producers.

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,

$$P_t c_t + D_t + e_t B_t + T_t + M_t = D_{t-1} R_{t-1} + e_t B_{t-1} R_{t-1}^* \Phi(\tilde{B}_t, B_{ss}) + W_t n_t + \Pi_t + M_{t-1},$$

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, $\Phi(\tilde{B}_t, B_{ss})$ 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[16]. Finally, T_t are nominal transfers from/to the government.

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

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

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,

$$\lambda_t = c_t^{-\sigma}, \tag{2.1}$$

$$n_t^{\varrho} = \lambda_t \frac{W_t}{P_t}, \tag{2.2}$$

$$\frac{\lambda_t e_t}{P_t} = \beta \mathbb{E}_t \left[\frac{\lambda_{t+1} e_{t+1}}{P_{t+1}} R_t^* \Phi_{t+1} \right], \tag{2.3}$$

$$\frac{\lambda_t}{P_t} = \beta \mathbb{E}_t \left[\frac{\lambda_{t+1}}{P_{t+1}} R_t \right], \tag{2.4}$$

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

$$m_t^{-\gamma} = \lambda_t - \beta \mathbb{E}_t \left[\frac{\lambda_{t+1} P_t}{P_{t+1}} \right]. \tag{2.5}$$

Households' first order conditions are standard. Note that equations 2.3 and 2.4 combined with 2.1, construct the usual uncovered interest rate parity condition, whereas 2.1 and 2.2 generates the intratemporal allocation condition between labor and leisure.

2.3.2 Domestic Firms

I assume there is a continuum of domestic firms with monopolistic power that produce different varieties of 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.[17] The optimal labor demand is a static problem with optimality condition given by,

$$mc_t(j) = \frac{W_t}{P_{h,t} z_t F_n(n_t(j))}, \tag{2.6}$$

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

[17] Fixed cost is constant because the model assumes no growth. If the model has growth, the fixed cost has to grow 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 discounted value of profits.

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

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

where A_t is aggregate absorption.

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

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

Intertemporal first order condition is,

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

That can be rearranged as

$$x_t^1 = (\bar{p}_{h,t})^{1-\epsilon} A_t \frac{\epsilon - 1}{\epsilon} + \theta Q_{t,t+1} \left(\frac{\bar{p}_{h,t}}{\bar{p}_{h,t+1}}\right)^{1-\epsilon} \pi^{\epsilon}_{h,t+1} x^1_{t+1}, \qquad (2.7)$$

$$x_t^1 = (\bar{p}_{h,t})^{-\epsilon} A_t mc_t + \theta Q_{t,t+1} \left(\frac{\bar{p}_{h,t}}{\bar{p}_{h,t+1}}\right)^{-\epsilon} \pi^{1+\epsilon}_{h,t+1} x^1_{t+1}. \qquad (2.8)$$

2.3.3 Rest of the World

A key assumption in small open economy models is that domestic economy does not influence rest of the world prices nor quantities. For this reason, it is standard to model the rest of the world by a set of exogenous shocks and a demand function. In particular, it is usually assumed that foreign consumption of domestically produced goods is a function of foreign prices and foreign output, given by,

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

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. Details on the foreign variables are postponed until we discuss the properties of exogenous shocks.

2.3.4 Fiscal and Monetary Policies

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

$$x_t = d_{t-1}\frac{R_{t-1}}{\pi_t} - d_t + \frac{m_{t-1}}{\pi_t} - m_t, \tag{2.9}$$

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 set primary surplus following this feedback rule,

$$x_t = x_{ss} + \gamma^d(S_t^c)\left[\frac{d_t}{y_t} - \frac{d_{ss}}{y_{ss}}\right] + \gamma^y(S_t^c)\left[y_t - y_{ss}\right] + \epsilon_t^f, \tag{2.10}$$

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. S_t^c is a stochastic process that follows a Markov Switching Process. This variable is known by the agents in the model and evolves accordingly to a transition matrix P^c that will be discussed in the next section.

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

$$\frac{R_t}{R_{ss}} = \left[\frac{R_{t-1}}{R_{ss}}\right]^{\rho^r}\left[\frac{\pi_t}{\pi_{ss}}\right]^{\gamma_\pi(S_t^c)}\left[\frac{\xi_t}{\xi_{ss}}\right]^{\gamma_\xi(S_t^c)} exp(\epsilon_t^m), \tag{2.11}$$

where ξ_t is the growth rate of nominal exchange rate. ϵ_t^m is a monetary shock that will be described in the next section.[18]

2.3.5 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,

[18] Note that the smoothing parameter of the interest rate rule does not depend on time. Even though this might be interesting for some questions, in order to study how responsive monetary policy is, it does not seem to be crucial. Moreover, ideally, there would be no reason to assume that it should changes in the same way the rest of the parameters in the rule changes.

r_t^*. Domestic shocks are exogenous shocks to the total factor productivity z_t, 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 $\epsilon_t^z \sim N(0, \sigma^z(S_t^v))$, $\epsilon_t^m \sim N(0, \sigma^m(S_t^v))$, $\epsilon_t^f \sim N(0, \sigma^f(S_t^v))$, $\epsilon_t^{r^*} \sim N(0, \sigma^{r^*}(S_t^v))$, $\epsilon_t^{y^*} \sim N(0, \sigma^{y^*}(S_t^v))$, $\epsilon_t^{\pi^*} \sim N(0, \sigma^{\pi^*}(S_t^v))$.

Regarding S_t^v and S_t^c, for the benchmark case, I assume they are independent and that each of them can take two values. Hence transition matrices are given by,

$$P^v = \begin{bmatrix} p^v_{(1,1)} & p^v_{(1,2)} \\ p^v_{(2,1)} & p^v_{(2,2)} \end{bmatrix},$$

and

$$P^c = \begin{bmatrix} p^c_{(1,1)} & p^c_{(1,2)} \\ p^c_{(2,1)} & p^c_{(2,2)} \end{bmatrix},$$

Given the independence assumption, the model exhibits a 4 regimes Markov-Switching which transition matrix is given by $P = P^v \otimes P^c$.

2.4 Solution and Estimation

In this section, I briefly discuss the solution method, estimation strategy and describe the data definition and sources. Given that I will implement a Bayesian estimation, this section also discusses prior distributions.

2.4.1 Perturbation in Markov Switching models

In this paper I use first order perturbation solution method as in Foerster et al. (2010). This solution method is an application of perturbation methods to Markov Switching problems. The advantage of this solution method over alternative methods such as the one developed by Cho (2009) or Farmer et al. (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 the following 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 have different steady state, first order solution is not certainty equivalent. Those terms are zero if all regimes have the same steady state. This is the case of the current paper, given that, as seen in the previous section, Markov Switching affects only policy rules and volatilities, which terms are set to zero in steady state.[19]

Once a solution is constructed, it is key to check whether the solution is unique.[20]

[19] The non-stochastic steady state is calculated by setting all continuous and Markov-Switching shocks to zero.

[20] The solution we find with this method is in the set of MSV solutions and the unicity of MSV solution does not imply unicity in a more general class of solutions. See the discussion in Davig and Leeper (2007), Farmer et al. (2009) and Bianchi (2010).

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.

2.4.2 Estimation Strategy

In this paper, I estimate the model using Bayesian Methods. In particular, I use a Random Walk Metropolis-Hastings algorithm[21], which requires the evaluation of the posterior density $L(\Upsilon|Y)p(\Upsilon)$, where Υ denotes the vector of parameters to be estimated, Y the vector of observables, $L(\Upsilon|Y)$ is the likelihood function and $p(\Upsilon)$ 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.[22]

To evaluate the likelihood function $L(\Upsilon|Y)$ I solve the model for a set of proposal parameters and discard the draw if there is no equilibrium or multiple equilibriums.

[21] Details and pseudo-codes can be found in An and Schorfheide (2007).

[22] See Andreasen (2010). The matlab codes are available at Martin M. Andreasen's web page https://sites.google.com/site/mandreasendk/home-1.

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. If we estimate a model without Markov-Switching, we would just rely on the Kalman Filter in order to evaluate the likelihood. 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, there will be no unique forecast, as it will depend on which regime is the economy at each period t. Hence, it is required 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 at each time. Intuitively, the way the filter works is by keeping the n forecasts that are more likely to have happened.

2.4.3 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. As the model does not have trend, I use linearly detrended output. The remaining real variables are expressed as ratios with respect to output, consumption to output ratio, primary surplus to output ratio, government debt to output ratio.

Additionally, I include a domestic nominal interest rate[23], consumer price index

[23] I use the interest rate at which the Central Bank make advances to banks and financial intermediaries.

inflation, the growth rate of nominal exchange 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 it 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. consumer inflation rate from FRED at St. Louis FED, respectively.

2.4.4 Priors and Calibration

In this paper, a small set of parameters is fixed. 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.[24] 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 autocorrelations of stochastic processes and smoothing parameter of interest rate rule, ρ^i, are assumed to be $Beta(0.57, 0.23)$, for $i = r^*, z, y^*, r, \pi^*$, which, as can be seen, imply a mild autocorrelation. Prior for the transition matrices are

[24] Sample averages for the period 1980Q1-2009Q4.

such that the diagonal elements are assumed to be $Beta(0.9, 0.06)$.[25]

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 2.1: 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 , 0.35)
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 in line with previous studies in the open economy literature. For instance, Justiniano and Preston (2010) finds $\sigma = 0.88$ for Canada, which is included in the 95% confidence band, usual findings for θ are in the order of 0.6 to 0.8. Davig

[25] Note that we do not need to impose priors for the probability of moving from regime i to regime j, given that this probability is equal to $(1 - p_{(1,1)})$.

et al. (2006) calibrate $\gamma = 2.6$ while priors for γ imply a 95% confidence band that includes 0.25 to 2.8. Frisch elasticity is in the range of recent estimates as the 95% Confidence band reange from 0.12 to 1.5. α is in line with estimates by Bergoeing et al. (2002), ψ is such that on average, the risk premium is of 300 basic points, as observed on the EMBI++ and in line with Garcia-Cicco (2008). ϵ generates a mark-up of 1.3 which is in line with other studies and micro studies for OECD economies as in Martins et al. (1996). Elasticity of substitution between home and foreign goods in the rest of the world, λ, is in line with Balke et al. (2010) that estimates it to 0.3 for US. Additionally, note that for all parameters standard deviations of the probability distributions of priors are high in terms of the magnitude of those parameters.

It remains to discuss prior distributions for policy parameters, which are presented in the following table,

Table 2.2: 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. In particular, the response of monetary policy to inflation under regime 1 is in line with findings in Zoli (2005) for the non-inflation targeting period of Mexico whereas the one for regime 2 is the same as in Garcia-Cicco (2008). Also response to growth rate of nominal exchange rate is in line with Justiniano and Preston (2010a).

Note, however, prior distributions regarding these parameters are very loose. For instance, 95% confidence band for γ^{π} ranges from 0.01 to 1.6 for $S_t = 1$ and from 0.6 to 4 for $S_t = 2$. On the other hand, for γ^{d} they range from 0.0006 to 0.09 and 0.04 to 0.65. Even though they might seem small, they include a large set of values for which both fiscal and monetary policies might be aggresively respnding to endogenous variables or not.

Additionally, if we evaluate the model in the mean of the priors distributions, both regimes imply that monetary policy responds strongly to inflation. I assume the prior functions to have this feature in order to match 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.[26]

2.5 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 of structural parameters and the features of policy parameters and volatilities. In the next section, I study the main characteristics of monetary and fiscal policies during 1980Q1-2009Q4.

[26] Given that there is no previous literature to base this priors, I implement several robustness exercises by relaxing priors for $\gamma^{\pi}(S_t = 1)$, and my findings do not change.

Table 2.3: Posterior Means

Parameter	Value	95 % Credible Set
η	2	[1.9 ,2.1]
θ	0.61	[0.59 ,0.62]
σ	0.86	[0.78 ,0.94]
α	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.

Given the calibrated parameters discussed in previous section, Table 2.3 presents the mean of the posterior distribution and 95% credible set for preference and technology parameters.

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 quarters. Hence, prices are reseted every six months, this is one quarter less than Justiniano and Preston (2010) 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, Bergoeing et al. (2002) 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 2.4, I present posterior means and credible sets for interest rate rule and fiscal rule coefficients for the two regimes,

Table 2.4: Policy Rule Parameters

Regime 1 (AFP)	Post. Mean	95 %	Regime 2 (AMP)	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 does not respond aggressively under Regime 1, but it does under 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 strongly 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. On the other hand, if the parameter is larger than 1, monetary policy responds strongly enough to control inflationary expectations, which, in a model without Markov-Switching, we would need fiscal policy to accommodate to monetary policy for an equilibrium to exist.

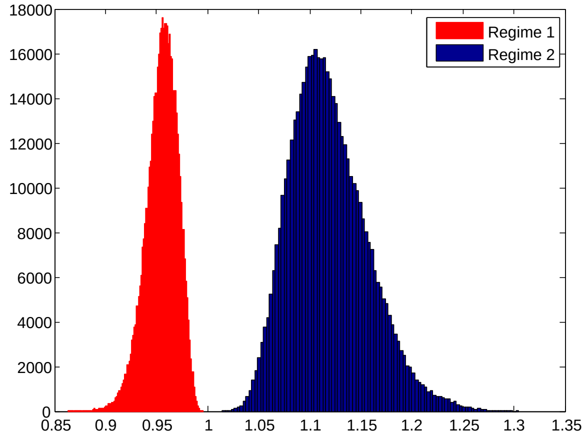

FIGURE 2.5: Activism Parameter for Regime 1 and Regime 2

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

In the case of DSGE Markov-Switching model, we can characterize monetary policy in the same way, but the conditions for uniqueness and existence are not the same as shown by Davig and Leeper (2007)[27]. Figure 2.5 presents the posterior distribution of activism parameter during Regime 1 and Regime 2.

Note that the previous picture indicates that under Regime 2, monetary policy is actively conducted, in the sense that responds strongly enough nominal disturbances, 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 reLeeper (1991)Leeper (1991), this regime is active

[27] Intuitively, in an economy without fiscal policy rule you could have small deviations from the so called "Taylor Principle" given that the alternative regime responds strongly and persistently enough. Additionally, for the case of Markov Switching with fiscal and monetary policies, some regimes might be such that both policies are not responsive enough or both policy are largely responsive, depending on the transition probabilities.

monetary policy with passive fiscal policy regime. I will denote this Regime as "active monetary policy regime".

Table 2.5 presents transition probabilities for Regime 1 and Regime 2. Note that the table indicates that active fiscal policy regime is more persistent than the active monetary policy regime,

Table 2.5: 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 nominal disturbances for any period t. 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.[28] 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. Under that assumption we would actually miss a regime in which monetary policy's objective is not to pin down expectations, but instead, to accommodate to fiscal policy financing requirements.[29]

The model also assumes an independent Markov-Switching Process for volatilities

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

[29] This finding is in line with evidence found by Zoli (2005) for Mexico and other emerging economies.

of domestic and foreign shocks. Table 2.6 presents posterior means and credible sets of posterior distribution of variances for both regimes

Table 2.6: Volatilities

Regime 1	Post. Mean	95 %	Regime 2	Post. Mean	95 %
$\sigma^z(S_t^v = 1)$	0.16	[0.14 ,0.18]	$\sigma^z(S_t^v = 2)$	0.0026	[0.0023 ,0.0028]
$\sigma^m(S_t^v = 1)$	0.035	[0.029 ,0.041]	$\sigma^m(S_t^v = 2)$	0.0016	[0.0015 ,0.0017]
$\sigma^f(S_t^v = 1)$	0.065	[0.056 ,0.073]	$\sigma^f(S_t^v = 2)$	0.0023	[0.0019 ,0.0027]
$\sigma^{r^*}(S_t^v = 1)$	0.0022	[0.0016 ,0.0026]	$\sigma^{r^*}(S_t^v = 2)$	0.00075	[0.00062 ,0.00089]
$\sigma^{\pi^*}(S_t^v = 1)$	0.095	[0.083 ,0.11]	$\sigma^{\pi^*}(S_t^v = 2)$	0.12	[0.11 ,0.14]
$\sigma^{y^*}(S_t^v = 1)$	0.0086	[0.0059 ,0.011]	$\sigma^{y^*}(S_t^v = 2)$	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. Note however, that the largest differences in volatilities across regimes occur for domestic sources such as TFP, monetary and fiscal policies. Foreign disturbances exhibit a statistically, but numerically small, differences in volatilities.

Table 2.7, presents transition probabilities for each regime,

Table 2.7: 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 one 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. Hence, volatility regimes are not as persistent as policy rules' coefficients regimes.

2.6 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.

2.6.1 Regime Probabilities

Figure 2.6 presents inflation, together with the probability of being in the active fiscal policy regime and the probability of high volatility regime (Volatility Regime 1),

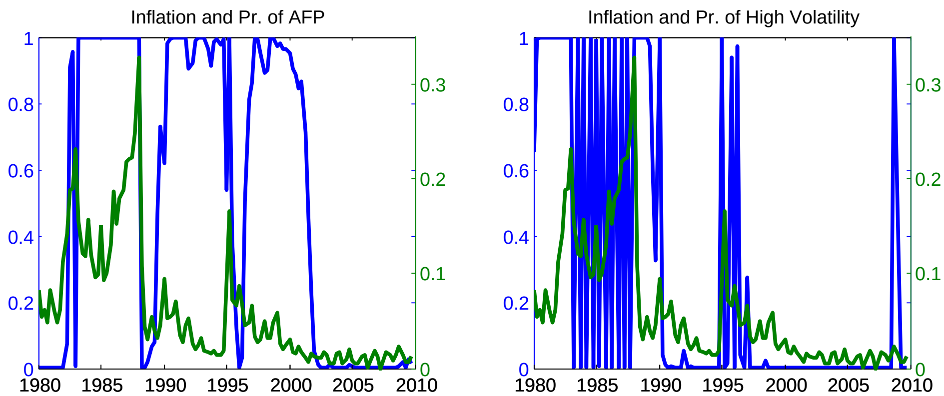

FIGURE 2.6: Inflation and Transition Probabilities

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 year 2000, the probability of being in an active monetary policy regime is high only during a few quarters after the end of severe macroeconomic disturbances. In particular, as discussed in the motivation section of the paper, active monetary policy regimes are in effect in early 80s after late 70s inflationary process, after 1982 "Debt Crisis", associated to the "Program for immediate economic reorganization" (PIRE), during 1988 after a large period of macroeconomic instabilities originated in 1985 and 1986 foreign shocks, related to the "Pact for economic solidarity" (PSE) and after last quarter of 1994 "Tequila" financial and political crisis.

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

In this way, the model accommodates to characterize the implementation of stabilization programs and the recent "Inflation Targeting" period as active monetary policy regimes/ passive fiscal policy regimes.

During the rest of the sample, from the beginning of the sample until 2001, the model finds a high probability of active fiscal policy / passive monetary policy regime. Note that for calibration and estimation purposes, the literature has, so far, discarded this regime. As will be shown later, recognizing this regime is important as macroeconomic dynamics are remarkably different from the active monetary policy regime.

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. However, regarding this last episode it is important to point out that the behavior of inflation does not seem to be affected as it was in early episodes, this finding might correspond to the fact that active monetary policy was on effect during the recent episode.

2.6.2 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. Table 2.6.2 presents the results for all possible regime combinations,

Table 2.8: 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.

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.

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. This results imply a smaller variability induced by monetary policy than the one found in previous studies that do not allow for policy changes, such as Garcia-Cicco (2008). Fiscal policy shocks, instead, have a small effect in the variability of these variables.

2.6.3 The effects of policy shocks

Previous section discussed which share of observed variability is due to fiscal and monetary policy shocks. In order to fully characterize fiscal and monetary policies conditional on each regime, in this section I study how policy shocks affect dynamics of the model under different policy arrangements.

Figure 2.7 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.

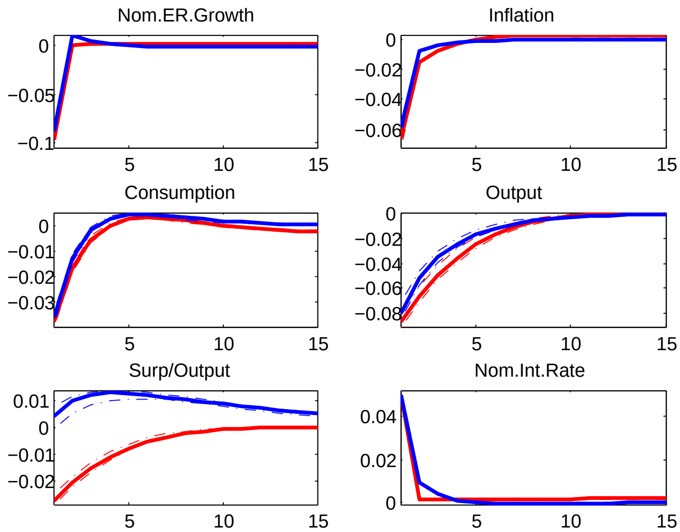

FIGURE 2.7: Impulse Response Functions to one standard deviation Monetary Policy Shock.

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

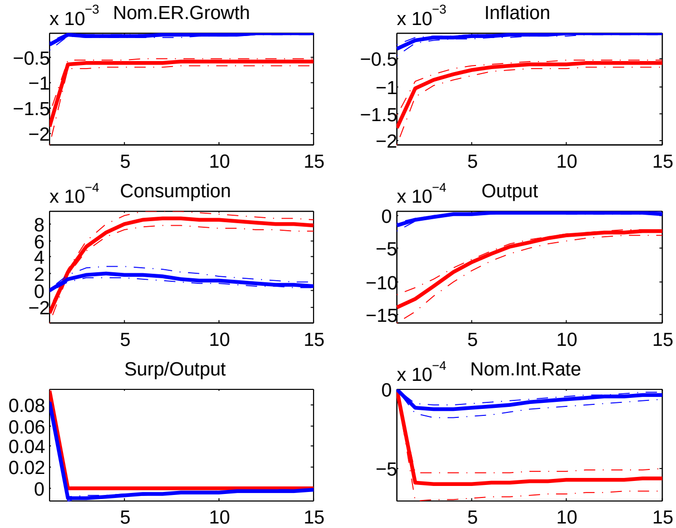

FIGURE 2.8: Impulse Responses to Fiscal Policy Shock

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.

2.7 Policy changes and credibility

This section studies which are the effects of policy changes and how does credibility affect the outcome of a stabilization policy. In this section, I do this using simulations exercises. In the following section I will study the most recent stabilization episodes using the actual structure of shocks via counterfactual exercises.

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 focus in these two cases. The exercise will evaluate a policy change under these two inflationary environments.

2.7.1 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 $t = 2$.[30]

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

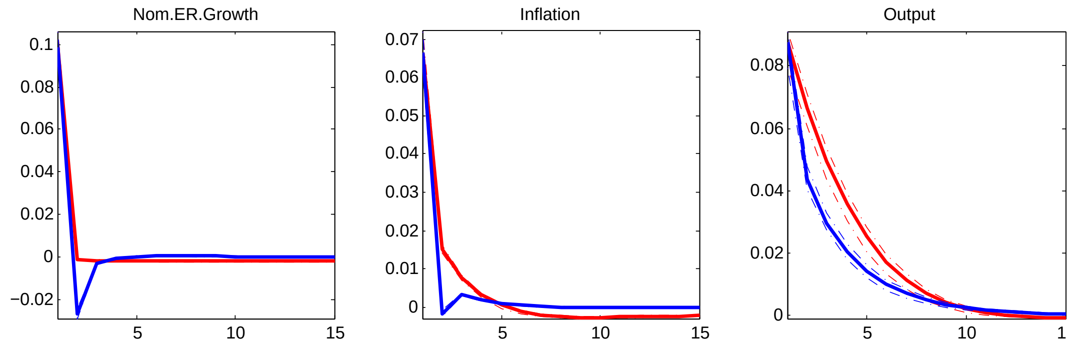

FIGURE 2.9: Policy Change after monetary policy shock.

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

Figure 2.9 presents the dynamics of nominal exchange rate growth, inflation and output that follow after this shock.

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.

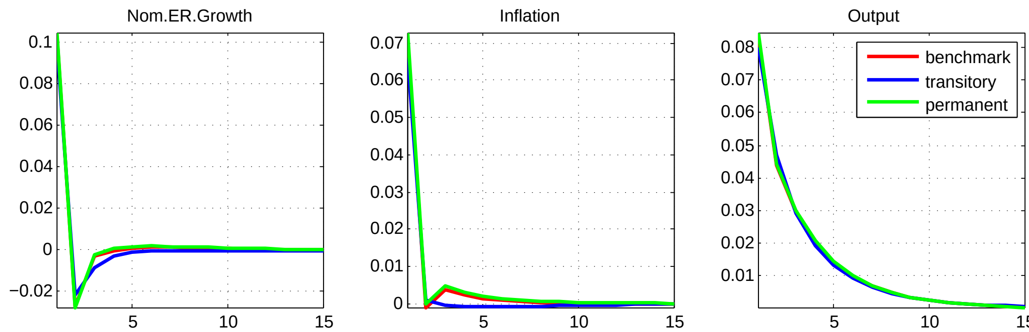

FIGURE 2.10: Policy Change after monetary policy shock under alternative credibility environments.

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 2.11 presents some endogenous dynamics,

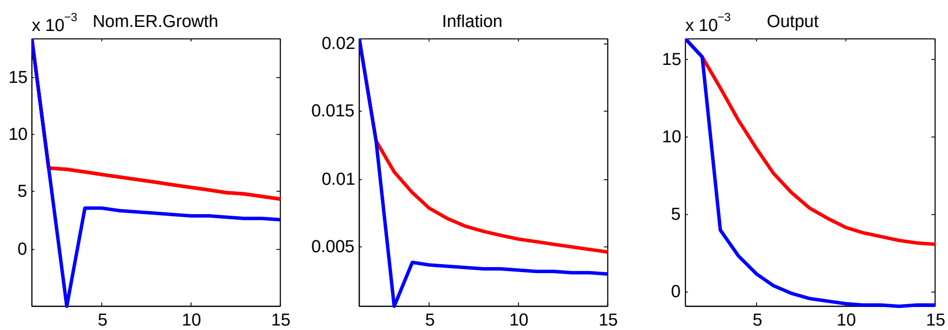

FIGURE 2.11: Policy Change after foreign inflation shock.

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. This adjustment, additionally, tigers the stabilization/recessive mechanism by inducing an increase in real interest rate that motivates output drop and the subsequent adjustment.

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 $p^c(S^c_{t+1} = 2|S^c_t = 2) = 1$.

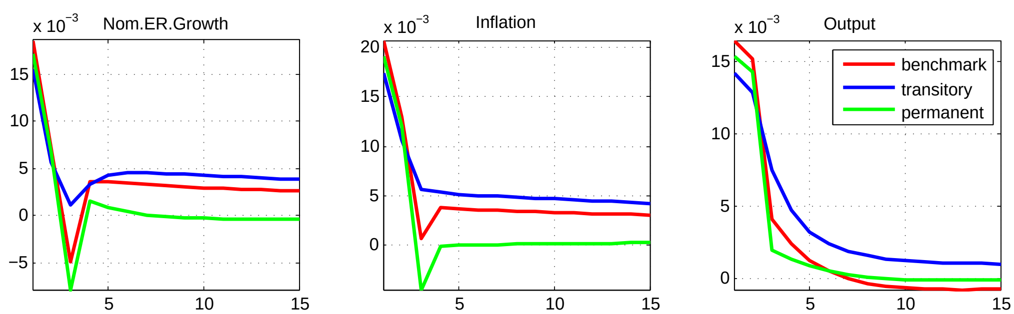

FIGURE 2.12: Impulse Responses to Foreign Inflation Shock under alternative credibility environments.

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.

2.8 Counterfactual Stabilization

The previous section shows that Mexican economy switched repeatedly between Active Monetary Policy and Active Fiscal Policy regimes and between periods of high and low domestic and foreign volatilities. In this section, I explore two questions, first I study the effect of policy changes in the stabilization episodes observed during 1988, after implementation of Program for Economic Solidarity, and after 1994 Tequila Crisis, the two major stabilization programs in the last 30 years. This first exercise sheds light on what drove stabilization, whether they are due to actual policy changes or, instead, changes in the volatility of shocks. Second, I study the role of credibility about the persistency of the policy change.

2.8.1 Good Luck vs Good Policy

Did changes in macroeconomic behavior that occurred after 1988 and 1995 associated to policy changes or changes in volatilities? In this section, I study this question by running counterfactual exercises. Figure 2.13 presents counterfactual exercises around 1988 stabilization program.

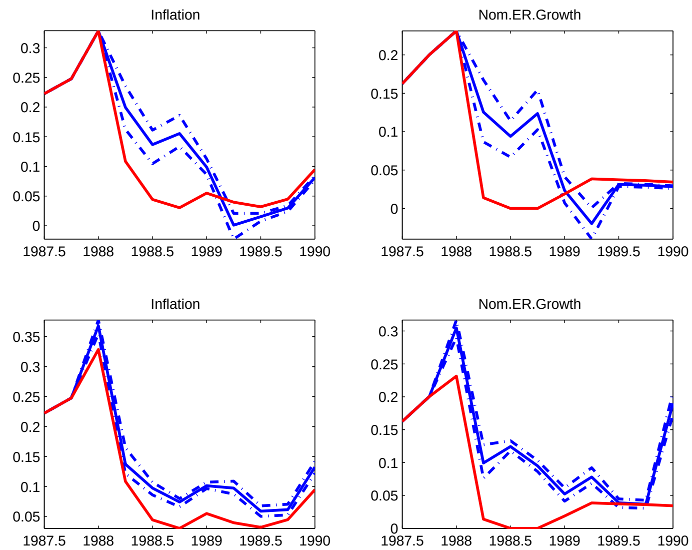

FIGURE 2.13: Good Luck versus Good Policy 1988

Note: Top panel presents counterfactual series obtained by assuming no policy change, whereas bottom panel assumes no volatility changes. Red line are actual series, blue line are counterfactual series and 68% confidence bands are represented by dashed lines.

Counterfactuals in top panel pictures in the figure 2.13 represents what would have happened if no stabilization program would have been applied in 1988. As can be seen, if no stabilization program would have been applied, inflation and growth rate of nominal exchange rate would have been significantly larger during the whole 1988. After that period, these series over adjust compared to observed series. Hence, two main features comes from this picture, policy change is important for stabilization, but at least in part stabilization is not only due to policy changes. Additionally, active monetary policy regime reduce volatility of these series during the stabilization period.

To complete the exercise, bottom panel pictures in the figure presents observed series in red and the counterfactuals of what would have happened if the economy would have exhibit low domestic and high foreign volatility during 1988-1990, in blue. As can be seen, most of the stabilization observed in inflation remains regardless volatility changes, in particular the large stabilization during 1988's first quarter. Note, on the other hand, the volatility of observed and counterfactual series for inflation do not exhibit major differences. Note that these pictures do not replace high volatility by low volatility, but instead, changes high domestic volatility by high foreign volatility shock.

Figure 2.14, repeat the exercise for the 1995 stabilization program after Tequila crisis.

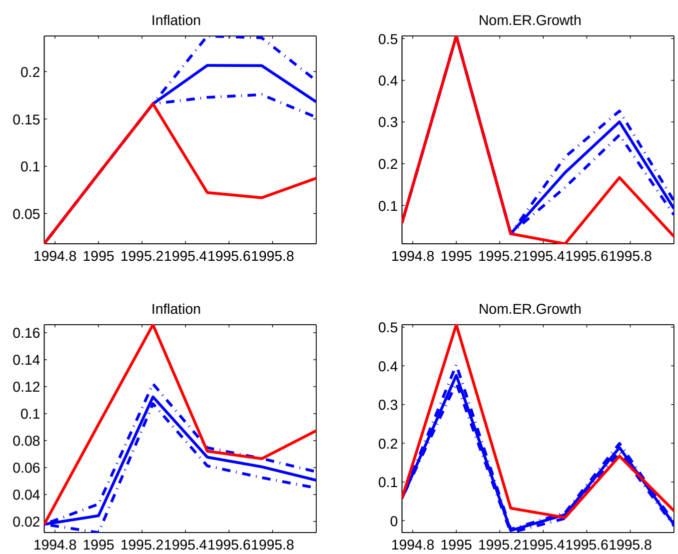

FIGURE 2.14: Good Luck versus Good Policy 1995

Note: Top panel presents counterfactual series obtained by assuming no policy change, whereas bottom panel assumes no volatility changes. Red line are actual series, blue line are counterfactual series and 68% confidence bands are represented by dashed lines.

In contrast to the findings in Figure 2.13, if no stabilization would have been implemented, inflation would have not decreased after 1995 first quarter. This is associated to an increase in growth rate of nominal exchange rate after that same period.

2.8.2 Credibility

In this section I study which is the role of credibility in the success of a stabilization program by running two counterfactual exercises.

In the next two pictures, 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 the top panels of Figure 2.15, are the ones in which agents perceive that the policy change in 1988 will last only one period and after that the economy will stay forever in the active fiscal policy regime. Hence, private sector thinks $p^c(S^c_{t+1} = 1|S^c_t = 1) = 1$ and $p^c(S^c_{t+1} = 2|S^c_t = 1) = 0$. On the other hand, bottom panel presents counterfactual for the "permanent" dynamics, that is when agents perceive the policy change is permanent, i.e. $p^c(S^c_{t+1} = 2|S^c_t = 2) = 1$.

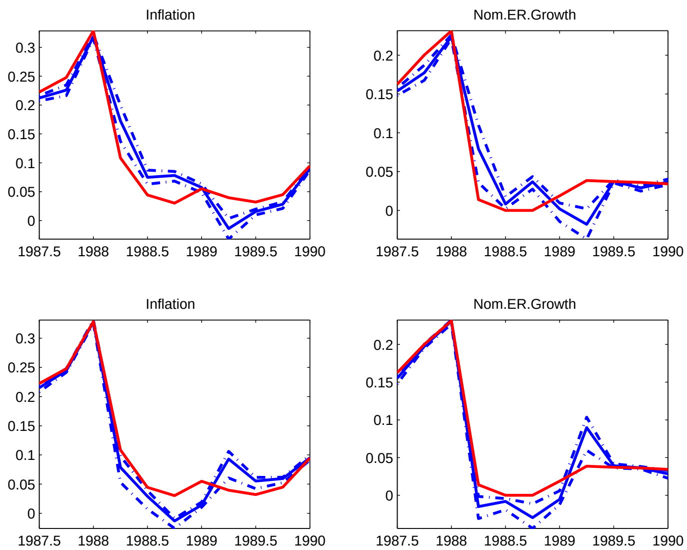

FIGURE 2.15: Stabilization Program Credibility 1988

Note: Top panel presents counterfactual series obtained by assuming private sector perceives the policy change as temporary, whereas bottom panel assumes the perception is permanent. Red line are actual series, blue line are counterfactual series and 68% confidence bands are represented by dashed lines.

In contrast, Figure 2.16 presents the same exercises for the 1995 stabilization program,

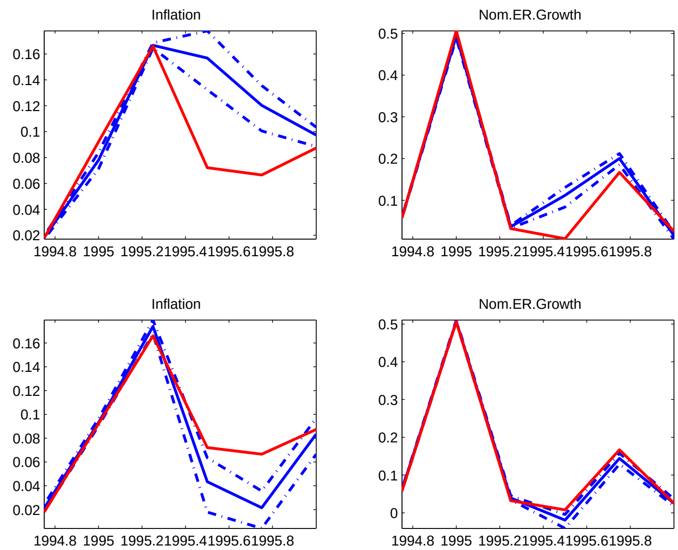

FIGURE 2.16: Stabilization Program Credibility 1995

Note: Top panel presents counterfactual series obtained by assuming private sector perceives the policy change as temporary, whereas bottom panel assumes the perception is permanent. Red line are actual series, blue line are counterfactual series and 68% confidence bands are represented by dashed lines.

I find that if agents perceive the policy as completely transitory, the stabilization effect in terms of inflation and nominal exchange rate growth are diminished, both for the cases of the 1988 and 1995 stabilization programs.

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 small effects 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.

The previous figures present two extreme cases, when agents believe policy change is not persistent and when agents perceive it is permanent. We find that credibility matters for stabilization. However, do we need to assume complete lack of credibility in order to find a failure of a stabilization program? Figure 2.17 describes how the persistence probability of the active monetary policy regime affects average inflation and growth rate of nominal exchange rate in both 1988 and 1995 stabilization episodes,

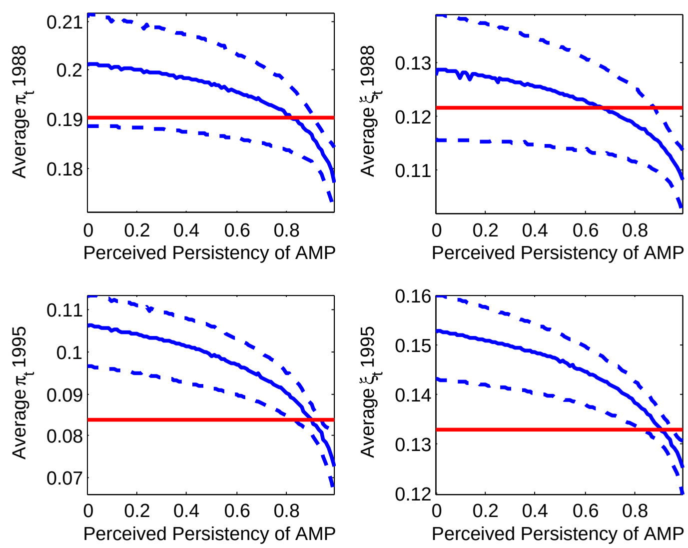

FIGURE 2.17: Credibility

Note: Average inflation and growth rate of nominal exchange rate and 68% confidence bands. The red lines indicate the sample averages for the same period.

As can be seen in the picture, a large perceived persistence probability, i.e. credibility, is required to lower the average inflation and growth rate of nominal exchange rate. However, these stabilization episodes do not need to be perceived as permanent in order to stabilize the economy, as can be seen significant differences are obtained for transition probabilities of 0.8 or larger.

2.9 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 et al. (2008) that modified Gelfand and Dey (1994) and Geweke (1999) approach to efficiently handle time-varying parameters model.

Following notation from previous references, the marginal density function is defined as

$$P(Y_T) = \int p(Y_T|\Upsilon)p(\Upsilon)d\Upsilon.$$

This function can be expressed as

$$P(Y_T)^{-1} = \int \frac{h(\Upsilon)}{p(Y_T|\Upsilon)p(\Upsilon)} p(\Upsilon|Y_T)d\Upsilon,$$

and approximated by

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

Gelfand and Dey (1994) and Geweke (1999) propose a normal distribution to approximate $h(\Upsilon)$. 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.

Authors suggest to center the distribution in the posterior mode, $\hat{\Upsilon}$, and for scaling they propose,

$$\hat{\Omega} = \frac{1}{M}\sum_{j=1}^{M}(\Upsilon^{(j)} - \hat{\Upsilon})(\Upsilon^{(j)} - \hat{\Upsilon})'.$$

Finally, the elliptical distribution that is centered in $\hat{\Upsilon}$ with scaling $\sqrt{\hat{\Omega}}$ has the following form,

$$g(\Upsilon) = \frac{\Gamma(k/2)f(r)}{2\pi^{k/2}|det(\sqrt{\hat{\Omega}})|r^{k-1}}$$

where k stands for Υ's dimension $r = \sqrt{(\Upsilon^{(j)} - \hat{\Upsilon})'\hat{\Omega}^{-1}(\Upsilon^{(j)} - \hat{\Upsilon})}$ and $f(r)$ stands for a one-dimensional density that is defined in $\mathbb{R}_+$.

Following this approach, Table 2.9 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 2.9: 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

Note: Log marginal data density, where p is the fraction of draws used for the approximation.

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.

2.10 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; and that in this environment, these economies implemented several stabilization programs which encompassed a mix of changes in the fiscal and monetary policies.

Motivated by these facts, I develop a dynamic stochastic general equilibrium model that allows fiscal and monetary policy rule coefficients to change accordingly to a Markov-Switching process. The model also allows for volatility changes. Using this model, I 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 assumption 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, and find that during a large part of the sample, we observe the opposite, i.e. fiscal policy is conducted independently of government debt and monetary policy accommodates to fiscal policy requirements.

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 from 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.

I study these findings for the stabilizations of 1988 and 1995 and provide evidence that policy changes played a major role in the observed dynamics of inflation and nominal exchange rate growth in both episodes.

Appendix A

Appendix to Chapter 1

A.1 Impulse Responses

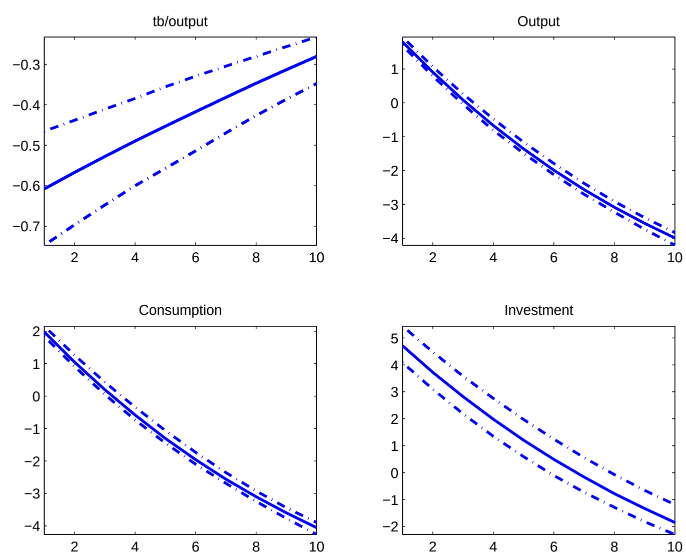

FIGURE A.1: Impulse Response to Trend Shock

Note: 68% confidence bands is dashed lines.

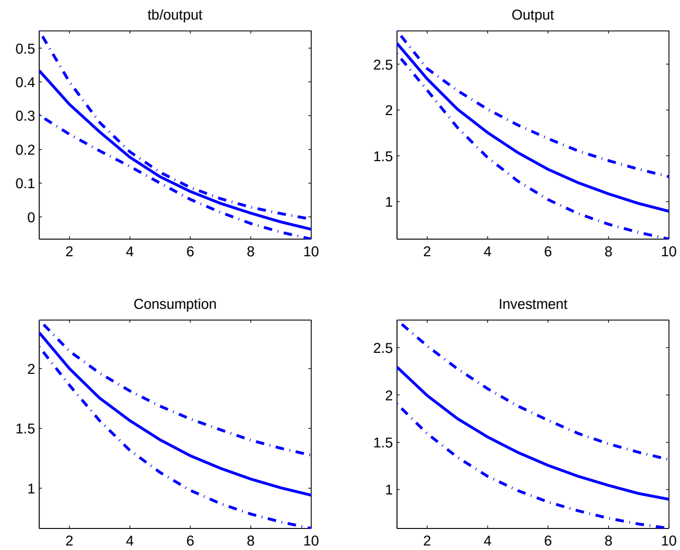

FIGURE A.2: Impulse Response to Stationary Technology Shock

Note: 68% confidence bands is dashed lines.

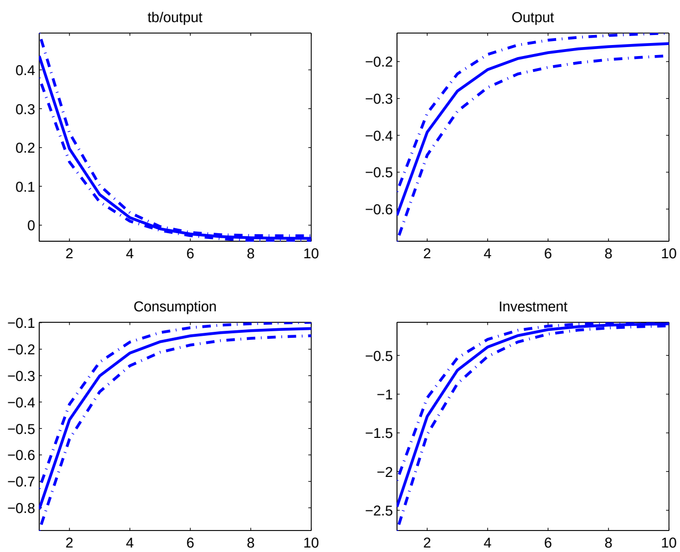

FIGURE A.3: Impulse Response to Interest Rate Shock

Note: 68% confidence bands is dashed lines.

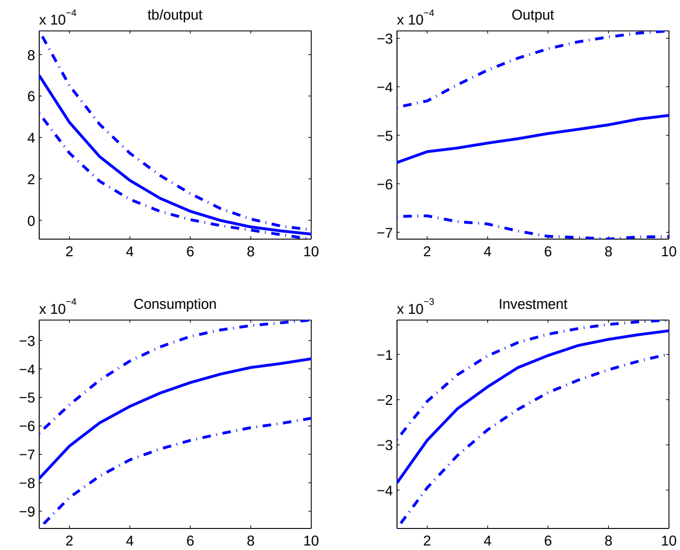

FIGURE A.4: Impulse Response to ψ_t shock

Note: 68% confidence bands is dashed lines.

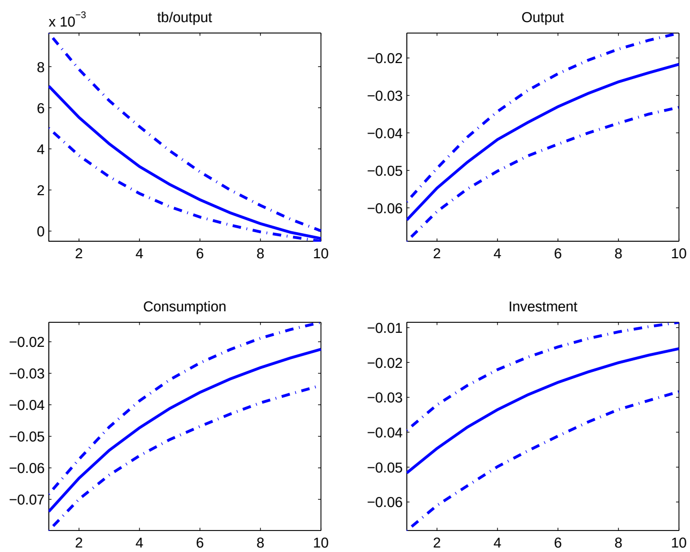

FIGURE A.5: Impulse Response to κ_t shock

Note: 68% confidence bands is dashed lines.

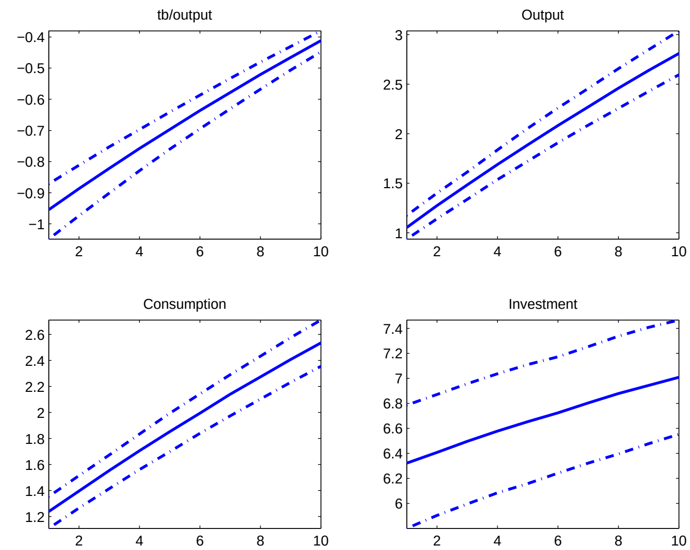

FIGURE A.6: Impulse Response to α_t shock

Note: 68% confidence bands is dashed lines.

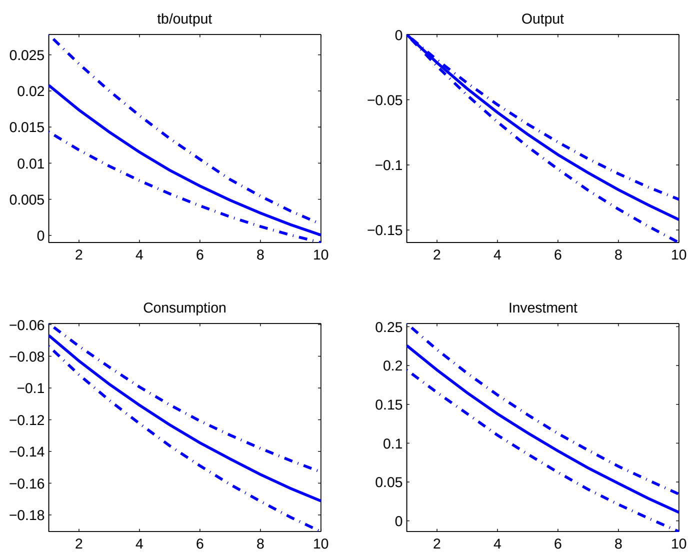

FIGURE A.7: Impulse Response to δ_t shock

Note: 68% confidence bands is dashed lines.

A.2 Data

A.2.1 Emerging Markets data

Data from Ecuador, Korea, Philippines, South Africa, Slovak Republic and Turkey is from IMF at fixed prices 2005, except for Korea which is at fixed prices 2000. Data is at quarterly frequencies.

Brazilian data is from IBGE, at quarterly frequency and fixed prices 1995. The sample is from 1995 to 2008.

Mexican data is from Bank of Mexico, at constant prices 1993. The sample is from 1980 to 2008 at quarterly frequency.

A.2.2 Developed Countries data

Data for Developed Countries in Table A.1 is from OECD at domestic currency constant prices for a national base year.

A.2.3 Argentina

We use quarterly data for the period 1983:1 to 2008:2. Real GDP, aggregate consumption, investment and trade balance are from MECON (Ministry of Economics and Public Finances). Private consumption is available for the period 1993:1 to 2008:2. In order to construct private consumption for the period 1983:1 to 1992:4 we use growth rates from INDEC (National Institute of Statistics and Censuses). In order to seasonally adjust the data we use X-11 filter. Data on GDP, consumption, investment and trade balance is in per capital terms.

Data on real interest rate from 1983 to 2001 is from Neumeyer and Perri (2005) and from 2001 to 2008.2 it is extended using 3 months T-bill plus the J.P. Morgan

EMBI[1]

The definition of real GDP in the model includes no government, so we removed government consumption from GDP in the data.

A.3 Stability of Emerging Markets Data

This section provides strong evidence that emerging markets' time series suffered multiples structural breaks during the last 25 years. I study stability properties of aggregate data for a set of emerging economies: Argentina, Brazil, Korea, Philippines, Malaysia, Ecuador, and Mexico using multiple break tests and rolling window second order moments.[2] We start by testing for structural breaks in GDP and then we study the behavior of statistical moments of interest, such as volatilities and cross correlations.

Tests for one time breaks have larger power than tests for multiple break testing. In Table A.1, we present Andrew's Break test's results under the assumption of a one time break in GDP series of emerging markets.

[1] See Neumeyer and Perri (2005) for details.

[2] Emerging markets data is compiled from multiple sources. See Data Appendix

Table A.1: One time Break Test

Country	p-value	Date	Country	p-value	Date
Argentina	0.08	2003Q1	Australia	0.99	1993Q4
Brazil	0.55	2005Q4	Austria	0.98	1992Q3
Ecuador	0.31	1999Q1	Canada	0.85	1990Q2
Korea	0.09	1998Q1	Norway	0.27	2002Q3
Mexico	0.10	1995Q3	Sweden	0.42	1990Q2
Malaysia	0.03	1998Q1	Switzerland	0.86	1990Q2
Philippines	0.08	2002Q2			

Note: This table test for one time break with unknown date in real GDP. Data sets are heterogeneous, as well as data sources, specifications are found in data appendix.

As can be seen, emerging markets supports the hypothesis of structural breaks. For Brazil and Ecuador Andrews' test cannot reject the null of stability, however in these cases the data spawn is very short. The second block of same table shows this is not the case of developed small open economies.

However, it is important to detect the number of breaks occurred, if any. In order to do that, we implement Bai and Perron (1998) test. Table A.2 presents the number of breaks and the break dates,[3]

[3] For a description of the test, the reader is referred to Bai and Perron (1998)

Table A.2: Multiple breaks test

Country	Number of breaks	UDMax	Dates
Argentina	3	72.83	1990Q3 &1998Q4 & 2003Q2
Brazil	-	-	-
Ecuador	-	-	-
Korea	3	39.02	1986Q3 & 1990Q4 & 2008Q1
Mexico	2	598.9	1984Q4 & 1995Q1
Philippines	4	24.32	1985Q2 & 1989Q3 & 1993Q2 & 2001Q4
Malaysia	2	53.41	1993Q3 & 1997Q2

Note: Multiple break testing using Bai and Perron (1998) UDMax procedure. Trimming of .15, assuming a maximum of 5 breaks and controlling for heteroskedasticity and autocorrelation of the error term. We allow for different variance of the error term across subsamples.

As can be seen, we find evidence of multiple breaks in many emerging economies. In most of the cases, break dates can be directly associated with macroeconomic crises, such as Tequila crisis in Mexico, Asian crisis in Malaysia, Argentina's 2nd hyperinflation crisis in 1990. In other cases, breaks are associated to events that took place in larger periods, such as the large recession suffered in Argentina since Russian crisis until the beginning of the recovery in 2003 (this crisis includes the large macroeconomic crisis and default but is actually a well larger event starting at the end of the nineties).

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Biography

Hernán Daniel Seoane was born in Buenos Aires, Argentina on September 26th, 1979. He got his bachelor's degree in Economics, with Cum Laude Honors, in Universidad de Buenos Aires, Buenos Aires, Argentina in October 2003 and his Masters in Economics in Universidad de San Andrés, Buenos Aires, Argentina in September 2006. Before joining the graduate program in the Economics Department of Duke University, he worked as research assistant in the Centro de Estudios del Estado y Sociedad (CEDES) and Centro de Investigaciones para la Transformación (CENIT). He received his Masters of Arts in Economics from Duke University in May 2007.

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