Did the Introduction of Inflation Targeting Represent a Regime Switch of Monetary Policy in Latin America?

Sebastián Cadavid Sánchez
Alberto Ortiz Bolaños

Abstract

In the 1990s, after experiencing high levels of inflation, several countries in Latin America passed constitutional amendments providing greater autonomy to their central banks. A few years later, many central banks increased their exchange rate flexibility and later adopted inflation targeting frameworks. These institutional changes coincided with sharp reductions in inflation and its variability. In this paper, we ask if the observed reduction of inflation is possibly related to changes in monetary policy. To answer this question, we build and estimate a Markov-Switching DSGE model for an open economy with monetary factors for Brazil, Chile, Colombia, Mexico, and Peru, all of whom formally adopted inflation targeting regimes between 1999 and 2002. Regimes are classified according to their relative weights of inflation in an interest rate reaction function. Although ex-ante these regimes need not be associated with the introduction of the inflation targeting framework, the coincidence of a regime switch with a more responsive interest rate - inflation relationship is striking. Furthermore, the Markov-Switching DSGE model allows us to generate counterfactuals of what could have happened if the observed change towards a more aggressive fight against inflation had not taken place. In general, we observe that if monetary policy had remained dovish, these countries would have experienced higher and more variable levels of inflation and more pronounced variations in GDP with small gains in average economic growth. Therefore, we conclude that

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

the introduction of inflation targeting represented a favorable regime switch in the implementation of monetary policy in Latin America.

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

JEL: E31, E37, E52, E58, C11.

1. INTRODUCTION

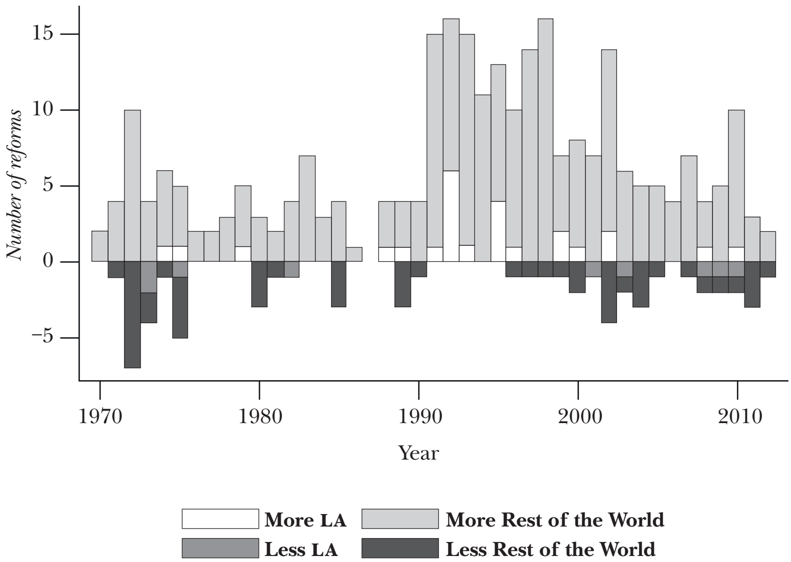
Beginning in the late 1980s, many countries around the world enacted new central banking legislation to grant more autonomy to their monetary authorities. For example, see Figure 1, which uses a sample of indexes of central bank independence from 182 countries since 1970, produced by Garriga (2016). Figure 1 shows a sharp increase in the number of reforms toward increased central bank independence in the 1990s. This shift came in response to the traumatic inflationary and hyper-inflationary episodes experienced in the previous decades, and it was reinforced by evidence showing that "central bank independence promotes price stability" without "measurable impact on real economic performance" (e.g., Alesina and Summers (1993)).

In Latin America, starting with Venezuela in 1974, several countries had reforms to strengthen the independence of their central banks[1]. In some countries, and for different reasons (from depletion of reserves to the desire to gain greater control of monetary policy), many central banks increased their exchange rate flexibility. The process continued with the adoption of inflation targeting frameworks to direct monetary policy. These institutional changes coincided with

[1] According to Garriga (2016), since 1970, countries that took positive reforms towards independence were the following: Venezuela in 1974; Chile in 1975; Haiti in 1979; Mexico in 1985; Brazil in 1988; Chile in 1989; El Salvador in 1991; Argentina, Colombia, Ecuador, Nicaragua, Peru, and Venezuela in 1992; Mexico in 1993; Bolivia, Costa Rica, Paraguay, and Uruguay in 1995; Honduras in 1996; Cuba in 1997; Nicaragua and Venezuela in 1999; El Salvador in 2000; Guatemala and the Dominican Republic in 2002; and Uruguay in 2008 and 2010. Meanwhile, negative reforms hindering Central Bank independence include the following: Argentina and El Salvador in 1973, Panama in 1975, El Salvador in 1982, Uruguay in 1997, Venezuela in 2001, Argentina in 2003, Ecuador in 2008, Venezuela in 2009, Nicaragua in 2010, and Argentina in 2012.

Figure 1

REFORMS TO THE INDEPENDENCE OF CENTRAL BANKS AROUND THE WORLD



sharp reductions of inflation and its variability. Table 1 summarizes the average inflation for each decade together with the years when positive reforms toward central bank independence were enacted, greater exchange rate flexibility was pursued, and inflation targeting was introduced. The selected countries for this analysis are Brazil, Chile, Colombia, Mexico, and Peru, which were early adopters of inflation targeting in Latin America between 1999 and 2002.

Although common sense provides a reason to believe that there could be a relation between institutional changes and inflation reduction, to the best of our knowledge, there is no quantitative evidence measuring if and how these changes determined inflation. In this paper, we provide this evidence by analyzing a Markov-Switching Dynamic Stochastic General Equilibrium (MS-DSGE) model for an open economy with monetary factors estimated for Brazil, Chile, Colombia, Mexico, and Peru. Regimes are classified according to their

Table 1

INFLATION AND CENTRAL BANKS CHANGES IN SELECTED COUNTRIES OF LATIN AMERICA

Average inflation	*1980-1989*	*1990-1999*	*2000-2009*	*2010-2015*	*Positive reforms towards independence*	*Exchange rate flexibility*	*Year of Inflation Targeting introduction*
Brazil	121.7	147.1	6.6	6.2	1988	1999	1999
Chile	19.9	11.8	3.5	3	1975 and 1989	1999	1999
Colombia	20.8	19.9	6.1	3.1	1992	1999	1999
Mexico	53.1	18.3	5.1	3.6	1985 and 1993	1995	2001
Peru	111	78.5	2.6	3	1992	2002	2002

relative weights of inflation in an interest rate reaction function. Although ex-ante these regimes need not be associated with the introduction of the inflation targeting framework, the coincidence of a more responsive monetary policy with inflation targeting is striking. Furthermore, the model allows us to generate counterfactuals of what could have happened if the observed change toward a more aggressive fight against inflation would not have taken place. In general, we observe that if monetary policy had remained dovish, these countries would have experienced higher and more variable levels of inflation and more pronounced variations in GDP with small gains in average economic growth. Therefore, we conclude that the introduction of inflation targeting represented a favorable regime switch in the regulation of monetary policy in Latin America.

The rest of the paper is organized as follows. Section 2 presents a Markov-Switching open-economy DSGE model with monetary factors that will serve as the theoretical basis used to perform our analysis. Section 3 describes the tools used to solve and estimate the Markov-switching DSGE model. Section 4 presents results for the five countries discussed. Specifically, (4.1) displays the probabilities of the high inflation responses and high volatility regimes;

(4.2) reports the parameter estimates; (4.3) shows the model's impulse response functions for the high and low inflation response regimes to analyze the mechanisms; and (4.4) counterfactual simulated variables under the high and low inflation response regimes to analyze what could have happened during the sample period if monetary policy had been conducted differently, together with tables summarizing the average standard deviation and coefficient of variation of the observed variables and the hypothetical series generated in the counterfactuals. Section 5 concludes.

2. MODEL

Our model is based on the monetary open economy model presented by Gali and Monacelli (2005) and later estimated for the Commonwealth countries by Lubik and Schorfheide (2007) and for a large set of emerging market countries by Ortiz and Sturzenegger (2007). In essence the economy is summarized by the following three equations: an open economy Investment-Savings (IS) curve, an open economy Phillips curve and an interest rate rule.

To capture potential regime changes, we specify a Markov-switching DSGE model where we allow for changes in the parameters associated with the monetary authority reaction function and the price formation process, and use a state variable ξ^{sp} to denote the structural parameters *sp* regime at time *t*. To allow for regime changes in the stochastic volatilities we model a second, independent, Markov-Switching process and use a state variable ξ^{vo} to distinguish the volatility *vo* regime at time *t*.

In log linearized form, the open economy IS-curve is:

$$y_t = E_t y_{t+1} - \left[\tau + \alpha(2-\alpha)(1-\tau)\right]\left(R_t - E_t\pi_{t+1} - \rho_a a_t + \alpha E_t \Delta q_{t+1}\right) + \alpha(2-\alpha)\frac{1-\tau}{\tau} E_t \Delta y^*_{t+1} \quad (2.1)$$

where y_t denotes aggregate output, R_t nominal interest rate, π_t CPI inflation, a_t is the growth rate of a non-stationary technology process A_t, q_t terms of trade, defined as the relative price of exports in terms of imports, and y^*_t world output. E_t denotes the conditional expectation operator. The parameter τ represents the elasticity of inter-temporal substitution and α is the import share.[2] Technology follows an exogenous process: $ln\left(A_t / A_{t-1}\right) = \bar{a} + a_t, a_t = \rho_a a_{t-1} + \sigma_{a,\xi^{vo}} \varepsilon_{a,t}$, where ρ_a is the autoregressive coefficient and $\sigma_{a,\xi^{vo}}$ is the standard deviation of the stochastic volatility of the technology innovations $\varepsilon_{a,t}$, whose ξ^{vo} subscript denotes that it is allowed to change across regimes at time t. The same convention in notation follows for the other exogenous processes as world output y_t^* that is treated as an unobservable and is assumed to follow the process $y_t^* = \rho_{y^*} y_{t-1}^* + \sigma_{y^*,\xi_t^{vo}} \varepsilon_{y^*,t}, \varepsilon_{y^*,t} \sim N\left(0,1\right)$. In order to guarantee stationarity of the model, all real variables are expressed in terms of percentage deviations from A_t.

The log-linear version of the open economy Phillips curve is:

2.2
$$\pi_t = \frac{\beta}{1+\beta\chi_{p,\xi_t^{sp}}} E_t \pi_{t+1} + \frac{\chi_{p,\xi_t^{sp}}}{1+\beta\chi_{p,\xi_t^{sp}}} \pi_{t-1} + \beta\alpha\Delta q_{t+1} - \alpha\Delta q_t + \frac{\kappa_{\xi_t^{sp}}}{\tau + \alpha\left(2-\alpha\right)\left(1-\tau\right)}\left(y_t - \bar{y}_t\right)$$

where $\bar{y}_t = -\alpha\left(2-\alpha\right)\frac{1-\tau}{\tau} y_t^*$ is potential output in the absence of nominal rigidities. β represents the discount factor, χ_p is the degree of lagged price inflation, κ is the structural parameter associated to the Phillips curve and the ξ^{sp} subscript indicates that these parameters are allowed to change across regimes at time t.

The log-linear version of the interest rate rule is given by:

2.3
$$R_t = \rho_{R,\xi_t^{sp}} R_{t-1} + \left(1-\rho_{R,\xi_t^{sp}}\right)\left[\psi_{\pi,\xi_t^{sp}} \pi_t + \psi_{y,\xi_t^{sp}} y_t + \psi_{\Delta e,\xi_t^{sp}} \Delta e_t\right] + \sigma_{R,\xi_t^{vo}} \varepsilon_{R,t}$$

where e_t is the nominal effective exchange rate, defined as the price of domestic currency in terms of foreign currency. The parameter ρ_R captures the degree of interest rate smoothing, while ψ_π, ψ_y and $\psi_{\Delta e}$ capture the sensitivity of the interest rate with respect to inflation, output deviation from its steady-state and nominal exchange rate

---

2 The equation reduces to the closed economy variant when $\alpha = 0$.

depreciation, Δe_t, respectively. The ξ^{sp} subscript indicates that these parameters are allowed to change across regimes at time t. $\sigma_{R,\xi^{vo}}$ is the standard deviation of the stochastic volatility of the interest rate $\varepsilon_{R,t} \sim N(0,1)$, whose ξ^{vo} subscript denotes that it is allowed to change across regimes at time t.

The exchange rate is introduced via CPI inflation according to:

$$\pi_t = \Delta e_t + (1-\alpha)\Delta q_t + \pi_t^* \tag{2.4}$$

where π_t^* is a world inflation shock which is treated as an unobservable and is assumed to follow an exogenous process: $\pi_t^* = \rho_{\pi^*}\pi_{t-1}^* + \sigma_{\pi^*,\xi_t^{vo}}\varepsilon_{\pi^*,t}, \varepsilon_{\pi^*,t} \sim N(0,1)$. Terms of trade, in turn, are assumed to follow a law of motion for their growth rate:

$$\Delta q_t = \rho_q \Delta q_{t-1} + \sigma_{q,\xi_t^{vo}}\varepsilon_{q,t} \tag{2.5}$$

with $\varepsilon_{q,t} \sim N(0,1)$. Equations (2.1) to (2.5), plus the exogenous processes for technology, world output and world inflation, constitute the whole model.

3. SOLUTION AND ESTIMATION OF THE MARKOV-SWITCHING DSGE MODEL

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

$$\Gamma_o X_{t+1} = \Gamma_1 X_t + \Theta Z_t + \varphi\varepsilon_t \tag{3.1}$$

where Γ_o, Γ_1, Θ and φ matrices contain the model's parameters. x_t stands for the $(n\times 1)$ vector of endogenous variables,[3] Z_t is the $(k\times 1)$ vector of exogenous processes and η_t corresponds to the $(\ell\times 1)$

[3] with $X_t = \left[y_t \pi_t R_t \Delta q_t \Delta e_t \pi_t^* y_t^* a_t\right]'$.

disturbances vector. The conditions for existence and uniqueness of the solution (3.1) depend on the generalized eigenvalues of the system's matrices (Farmer *et al.*, 2008).

Using the solution algorithm proposed by Sims (2002) or Schmitt-Grohé and Uribe (2003) the unique solution for the system (3.2) is combined with an observation equation:

3.2 $$X_t = G(\Lambda)x_{t-1} + AZ_t$$

3.3 $$Y_t^{obs} = MX_t$$

where Λ stands for the parameters of the model, Y_t^{obs} are the observed variables,[4] and M provides the policy function for the observables. Following Bianchi and Ilut (2017), we introduce the possibility of regime change for the structural parameters and the volatilities through two Markov chains, ξ^{sp} and ξ^{vo}. The former denotes the unobserved regime associated with the monetary parameters subject to regime shifts and takes on discrete values $sp \in \{1,2\}$,[5] and the latter stands for the shock volatilities, assumes discrete values, $vo \in \{1,2\}$,[6] and evolves independently of *sp*.

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

3.4 $$H = \begin{pmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{pmatrix} \text{ and } \begin{pmatrix} Q_{11} & Q_{12} \\ Q_{21} & Q_{22} \end{pmatrix}$$

---

4 GDP growth, inflation rate, interest rate, change in the terms of trade and nominal depreciation.

5 Where 1 and 2 are the high and low response to inflation regimes $\left(\text{i.e } \psi_{\pi,\xi_t^{sp=1}} > \psi_{\pi,\xi_t^{sp=2}}\right)$, respectively.

6 Where 1 and 2 are the low and high volatility regimes. In order to define the high volatility regime, we included into the model the following restriction: $\sigma_{a,\xi^{vol=1}} < \sigma_{a,\xi^{vol=2}}$.

where $H_{ij}=p\,(sp_t=j|sp_{t-1}=i)$, for $i, j=1, 2$, and $Q_{ij}=p(vo_t=j\mid vo_{t-1}=i)$ for $i, j=1, 2$. Then, H_{ij} stands for the probability of being in regime j at t given that one was in regime i. The analysis is symmetric for Q_{ij}.

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

3.5
$$B_1\left(\xi_t^{sp}\right)X_t = E_t\left\{A_1\left(\xi_t^{sp},\xi_{t+1}^{sp}\right)X_{t+1}\right\} + B_2\left(\xi_t^{sp}\right)X_{t-1} + C_1\left(\xi_t^{sp}\right)Z_t$$

3.6
$$Z_t = S\left(\xi_t^{sp}\right)Z_{t-1} + \varepsilon_t \quad \text{with} \quad \varepsilon_t \sim N\left(0,\Sigma\left(\xi^{vo}\right)\right)$$

where the matrices $A_1\left(\xi_t^{sp}\right), B_1\left(\xi_t^{sp}\right), B_2\left(\xi_t^{sp}\right), C_1\left(\xi_t^{sp}\right)$ and $S\left(\xi_t^{sp}\right)$ are functions of the model parameters. $\Sigma\left(\xi^{vo}\right)$ is the covariance matrix of the shocks,[7] which depends on the unobserved state ξ^{vo}, controlled by the transition matrix Q. Therefore, note that, in contrast with (3.1), (3.5) has a presence of unobserved variables and unobserved Markov states of the Markov chains.

There are several studies in the MS-DSGE literature that analyze the technical aspects of solving this state-space system (Farmer *et al.* (2008, 2011); Foerster *et al.* (2014); Maih (2015)[8] and Cho (2016)), in the sense that solution algorithms developed for solving DSGE models with fixed parameters (e.g. Sims (2002) and Schmitt-Grohé and Uribe (2003)) are unsuitable. To solve the system we use the Newton methods developed in Maih (2015), which expand on the method proposed by Farmer *et al.* (2011) and concentrates on minimum state variable solutions (MSV) of the form:

7 Where: $\Sigma\left(\xi^{vo}\right) = diag\left(\sigma_{q,\xi_t^{vo}}, \sigma_{a,\xi_t^{vo}}, \sigma_{R,\xi_t^{vo}}, \sigma_{y^*,\xi_t^{vo}}, \sigma_{\pi^*,\xi_t^{vo}}\right)$.

8 The routines used for the computations were implemented using RISE, an object-oriented Matlab toolbox for solving and estimating Markov switching rational expectation models, developed by Junior Maih.

$$X_t = \Omega^*\left(\xi^{sp},\theta^{sp},H\right)X_{t-1} + \Gamma^*\left(\xi^{sp},\theta^{sp},H\right)Z_t\left(\xi^{vo},\theta^{vo}\right) \quad (3.7)$$

Where θ^{sp} and θ^{vo} are the switching parameters controlled by ξ_t^{sp} and ξ_t^{sp}, respectively.

The complete state form of the model combines (3.7) with the measurement equations (3.8):

$$Y_t^{obs} = L\left(\theta^{ss}\right) + MX_t \quad (3.8)$$

where:

$$Y_t^{obs} = \begin{bmatrix} \Delta GDP_t \\ Inflation \\ Interest\ rate_t \\ \Delta Terms\ of\ trade \\ \Delta Exchange\ rate \end{bmatrix}, L\left(\theta^{ss}\right) = \begin{bmatrix} 0 \\ 4\pi^{ss} \\ 4\left(\pi^{ss} + r^{ss}\right) \\ 0 \\ 0 \end{bmatrix}, M \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 4 & 0 & 0 & 0 \\ 0 & 0 & 4 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

The presence of unobserved DSGE states X_t and unobserved parameters (controlled by the Markov chains), implies that the standard Kalman filter cannot be used to compute the likelihood. So, in correspondence with Bianchi and Ilut (2017) we use the Kim *et al.* (1999) filter.

We use the Bayesian approach to estimate the model:

- Using Kim *et al.* (1999) algorithm, we compute the likelihood introducing non-linearities and unobserved chains employing the filter with prior distribution of the parameters.
- We construct the posterior kernel with our results from the Bee_gate[9] optimizer routine.
- We use the posterior mode as the initial value for the Metropolis Hasting algorithm, with 100.000 iterations.
- We compute moments utilizing the mean and variance of the last 50.000 iterations.

9 RISE toolbox optimization routine.

3.1 Counterfactuals

To explore the characteristics of the MS-DSGE model with multiple regimes, we generate a counterfactual series based on conditional forecast simulations. Specifically, this analysis allows us to get an idea of what would have happened if the monetary policy had not changed, given the smoothed shocks estimated by the model. The model is resolved introducing a law of motion consistent with the fact that no other regime would have been observed. In this section the algorithm to generate the simulated series is briefly explained.

Once the model is estimated, we generate forecasts from the ms-dsge model conditional on the realized path of the five model shocks: terms of trade, technology, monetary, world output, and world inflation. Our conditional forecasts are generated over the full sample period for each of the five countries. The data from the first quarter in every sample are used as initial conditions. The parameters utilized are the estimated posterior distribution of the coefficients for each regime.

We trace out the counterfactuals' paths by generating a new data vector for Z_t in (3.7), which includes the smoothed shocks. As different paths for the endogenous variables (one for each regime) are obtained for this regime switching model, we utilize the "expected smoothed series of the shocks, correspond to the weighted average paths of the exogenous variables.

Once the system is integrated, as in the previous subsection, the data are filtered and the counterfactual paths for the unobserved and observable variables are generated.

4. RESULTS

4.1 Regime probabilities

Figures 2 to 6 show the smoothed probabilities for the two Markov-switching processes. The top panel of each figure shows the probability that monetary policy is conducted under a high interest rate response to inflation regime based on the structural parameters of the interest rate rule. The bottom panel presents the probability of being on a high volatility regime based on the relative volatility of the non-stationary technology process. The first thing one must notice is that high interest rate response regimes have been the most prevalent forms of regime during the sample periods. The percentage of periods where our estimation assigns a probability higher than 50% of Brazil, Chile, Colombia, Mexico, and Peru being in a high response regime are 77%, 90%, 77%, 65% and 69%, respectively. Regarding the transition matrix, the mean (and 10%-90% confidence interval in parenthesis) parameter estimates for the probability of going from a high response to a low response regime, $H_{1,2}^{coef=1}$, are 0.1603 (0.039, 0.4719), 0.0808 (0.0141, 0.21), 0.0863 (0.0239, 0.2236), 0.1161 (0.0707, 0.1842) and 0.0721 (0.0276, 0.1129), respectively, while the probability of moving from a low response to a high response regime $H_{2,1}^{coef=2}$, are 0.2257 (0.0997, 0.4375), 0.0521 (0.0225, 0.0942), 0.1566 (0.048, 0.3472), 0.2108 (0.097, 0.3049) and 0.0565 (0.0191, 0.101), respectively.

4.1.1 High interest rate response regimes

With the introduction of inflation targeting and greater exchange rate flexibility, after a 35% real depreciation in 1999, Brazil experienced a regime switch to high response in 1999Q3. Our analysis captures the 2002 depreciation and the Cardoso-da Silva government transition as a transitory change of the monetary policy regime from 2002Q4 to 2003Q4. From 2004Q1 onwards, the probability of being under a high response monetary policy is close to 1.

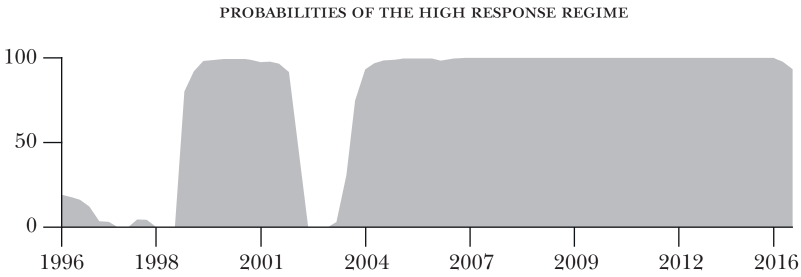
Chile fully adopted inflation targeting in 1999, but as stated in Corbo *et al.* (2002) the scheme began to be implemented in the 1990s. Our estimation captures a high response to inflation from the beginning of the sample in 1996 until 2007Q4. In 2008Q1 and until 2009Q4, there was a marked shift in policy with smaller weight on inflation and larger weight on output during a stagflationary period. From 2010Q1 onwards, the interest response of interest rates to inflation is estimated to be strong with high probability.

Colombia experienced a strong shift in monetary policy during 2000Q1 shortly after the introduction of inflation targeting and greater exchange rate flexibility.

Mexico has three periods during which our estimation assigns a high probability to a high response regime: from 1988Q2 to 1988Q3, from 1992Q1 to 1994Q4 and from 1997Q2 onwards. The first period coincides with Pacto de Solidaridad y Estabilidad Económica, signed in December 1987, which was a heterodox plan committing labor unions and public and private sectors to limit their price revisions

Figure 2

SMOOTHED PROBABILITIES FOR BRAZIL



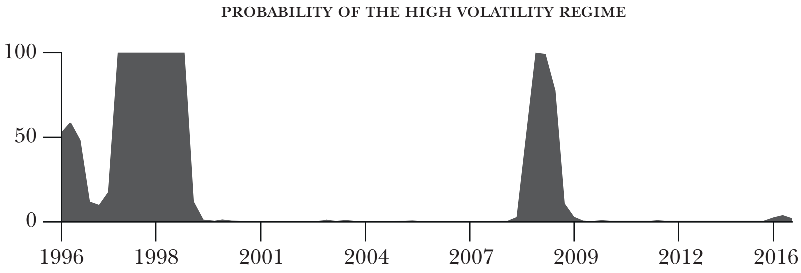
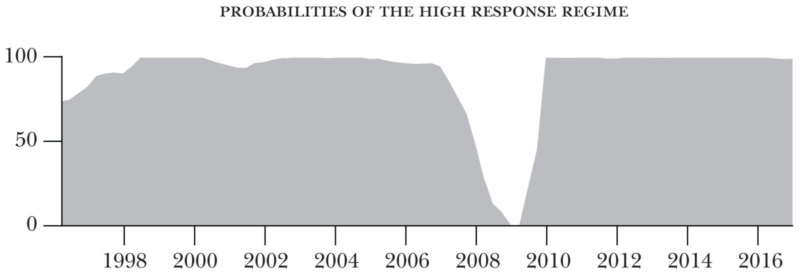


Figure 3

SMOOTHED PROBABILITIES FOR CHILE



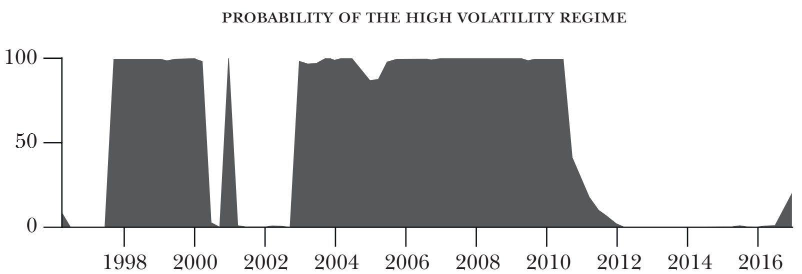


Figure 4

SMOOTHED PROBABILITIES FOR COLOMBIA

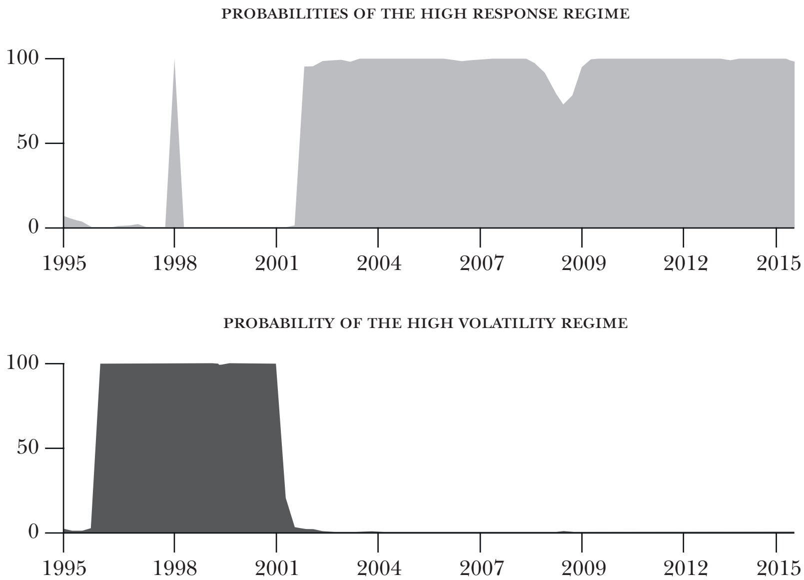


Figure 5

SMOOTHED PROBABILITIES FOR MEXICO

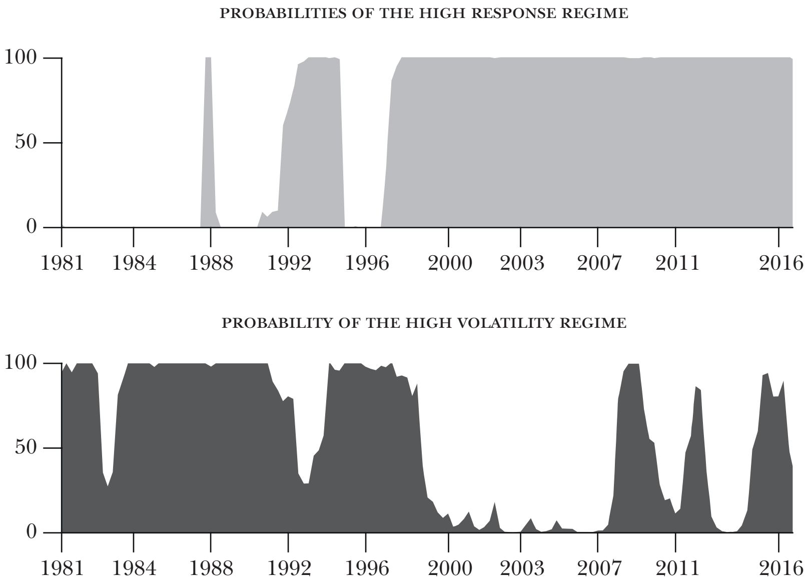
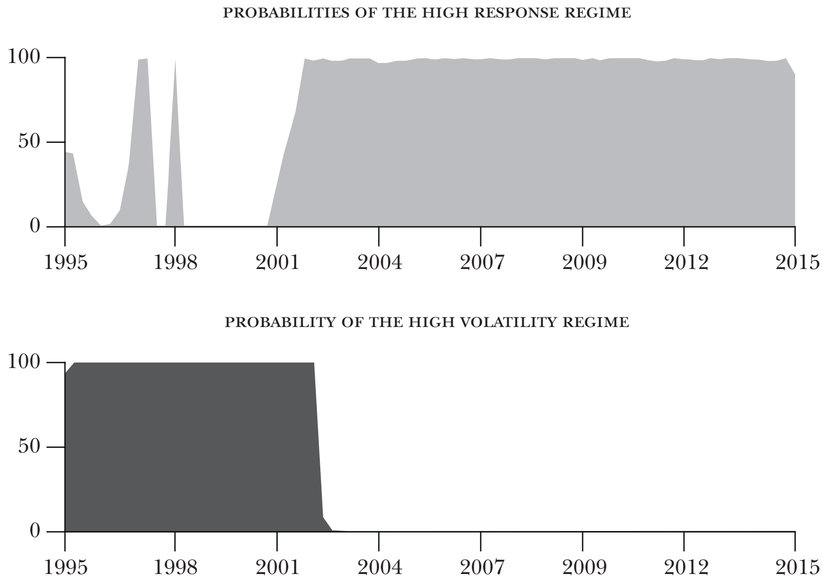


Figure 6

SMOOTHED PROBABILITIES FOR PERU



to anchor inflation expectations. The second period was shortly after the exchange rate policy changed from fixed exchange rate to a band system with a floor and a ceiling both adjustable over time. It includes the 1993 Constitutional reform granting legal autonomy to the Central Bank and the establishment of the price stability objective while it recognized that no government authority could force the Central Bank to grant financing. The December 1994 Tequila crisis forced the Central Bank to adopt a floating exchange rate regime. The crisis required balancing nominal pressures with an output contraction which required postponing the adoption of a high response regime until 1997Q2 consolidated in 2001 with the introduction of inflation targeting.

In addition, our analysis estimates Peru had three periods with a high probability of high response regime: from 1997Q4 to 1998Q1, in 1998Q4, and from 2002Q1 onwards. Therefore, after brief episodes of monetary tightening in 1997/1998, monetary policy switched towards greater responsiveness to inflation in 2002 which coincides with the adoption of the inflation targeting regime.

4.1.2 High volatility shock regimes

Cogley and Sargent (2005), Sims and Zha (2006) and Bianchi (2012) highlight the importance of accounting for stochastic volatility of exogenous shocks when a regime switch in monetary policy is analyzed. Additionally, Liu and Mumtaz (2011) and Goncalves *et al.* (2016) show that the fit of the model is improved when a Markov-Switching process for regime volatilities is introduced. In our estimation, we classify a regime as one of high volatility if the standard deviation of the stochastic volatility of the non-stationary technology shock is large. Given that in order to guarantee stationarity of the model, all real variables must be expressed in terms of percentage deviations from A_t, the growth rate of the non-stationary technology process enters the IS-curve. Organizing countries alphabetically, the percentage of periods where the estimation assigns a probability higher than 50% of being in a high volatility regime are 18%, 51%, 22%, 56% and 35%, respectively. Regarding the transition matrix, the mean (and 10%-90% confidence interval in parenthesis) parameter estimates for the probability of going from a low volatility to a high volatility regime, $H_{1,2}^{vol=1}$, are 0.3071 (0.1241, 0.5589), 0.0307 (0.0107, 0.0589), 0.0607 (0.0089, 0.2931), 0.1922 (0.0958, 0.339) and 0.0849 (0.0103, 0.4463), respectively, while the probability of moving from a low response to a high response regime $H_{2,1}^{coef=2}$, are 0.1458 (0.0278, 0.4982), 0.182 (0.1096, 0.2873), 0.1023 (0.0257, 0.2056), 0.109 (0.0577, 0.1836) and 0.1719 (0.0427, 0.4136), respectively. High volatility periods for Brazil are 1996Q2-1996Q3, 1997Q4-1999Q3, and 2008Q3-2009Q2; while for Chile they are 1997Q4-2000Q2, 2001Q1, and 2003Q1-2010Q3; for Colombia they are 1995Q4-1996Q3, 1998Q2-2000Q2, 2002Q3-2003Q1, and 2008Q4-2009Q1; for Mexico they are 1981Q1-1983Q1, 1984Q1-1992Q2, 1994Q1-1998Q3, 2008Q2-2010Q1, 2011Q4-2012Q2, and 2015Q1-2016Q3; and for Peru it is 1995Q4-2002Q3.

4.2 Estimation results

Table 2, below, reports the mean for the estimated parameters of the model for each country, while the appendix has individual tables for each country with the mean, mode, standard deviation

Table 2

MEAN FOR THE ESTIMATED PARAMETERS FOR BRAZIL, CHILE, COLOMBIA, MEXICO AND PERU

		Country				
Parameter	*Distribution*	*Brazil*	*Chile*	*Colombia*	*Mexico*	*Peru*
$\chi_{p,\xi^{coef=1}}$	Beta	0.1738	0.2053	0.7092	0.8564	0.1318
$\chi_{p,\xi^{coef=2}}$	Beta	0.4471	0.5124	0.313	0.6134	0.1471
$\kappa_{p,\xi^{coef=1}}$	Gamma	1.1362	0.0765	0.5845	2.1643	0.5011
$\kappa_{p,\xi^{coef=2}}$	Gamma	0.6296	0.0631	1.9982	2.3736	0.0565
$\rho_{R,\xi^{coef=1}}$	Beta	0.7629	0.9215	0.7298	0.458	0.697
$\rho_{R,\xi^{coef=2}}$	Beta	0.6113	0.4912	0.7065	0.6279	0.6254
$\psi_{\pi,\xi^{coef=1}}$	Gamma	3.4901	2.7337	3.2941	1.8458	1.9066
$\psi_{\pi,\xi^{coef=2}}$	Gamma	1.0417	0.8692	0.9746	0.6154	0.9226
$\psi_{y,\xi^{coef=1}}$	Gamma	0.3013	0.5594	0.3849	0.7265	0.4092
$\psi_{y,\xi^{coef=2}}$	Gamma	0.8799	0.434	0.7379	0.8310	0.5639
$\psi_{\Delta,\xi^{coef=1}}$	Gamma	0.0435	0.0816	0.137	0.1108	0.1725
$\psi_{\Delta,\xi^{coef=2}}$	Gamma	0.0422	0.0662	0.0463	0.3408	0.1506
α	Beta	0.076	0.0539	0.1132	0.2689	0.0393
r	Gamma	3.6731	2.2813	6.8509	2.1004	8.8041
τ	Beta	0.2792	0.16	0.2445	0.3256	0.1306
ρ_a	Beta	0.3014	0.1599	0.1291	0.2007	0.3924

Parameter	*Distribution*	*Country*				
		Brazil	*Chile*	*Colombia*	*Mexico*	*Peru*
ρ_q	Beta	0.424	0.1553	0.1628	0.4305	0.3605
ρ_{y*}	Beta	0.9818	0.9579	0.9659	0.9042	0.9682
$\rho_{\pi*}$	Beta	0.3715	0.3129	0.2303	0.7824	0.416
$H_{1,2}^{coef=1}$	Beta	0.1603	0.0808	0.0863	0.1161	0.0721
$H_{2,1}^{coef=2}$	Beta	0.2257	0.0521	0.1566	0.2108	0.0565
$\sigma_{R,\xi^{vol=1}}$	Inv.Gamma	5.3145	0.5788	0.8134	4.5438	2.4271
$\sigma_{R,\xi^{vol=2}}$	Inv.Gamma	3.3642	3.3239	6.8695	5.8216	7.6316
$\sigma_{q,\xi^{vol=1}}$	Inv.Gamma	5.791	6.4758	5.5065	3.121	4.1378
$\sigma_{q,\xi^{vol=2}}$	Inv.Gamma	4.2554	5.3403	7.2084	4.4066	5.1138
$\sigma_{a,\xi^{vol=1}}$	Inv.Gamma	4.6972	3.9563	5.0036	3.2222	2.7075
$\sigma_{a,\xi^{vol=2}}$	Inv.Gamma	4.7999	6.1979	6.0725	7.4444	6.0456
$\sigma_{y^*,\xi^{vol=1}}$	Inv.Gamma	3.5522	3.4781	1.6996	6.7571	2.1448
$\sigma_{y^*,\xi^{vol=2}}$	Inv.Gamma	6.9291	5.4652	3.0673	7.3328	3.5942
$\sigma_{\pi^*,\xi^{vol=1}}$	Inv.Gamma	4.8214	7.2118	5.0864	5.09	5.0435
$\sigma_{\pi^*,\xi^{vol=2}}$	Inv.Gamma	6.1201	4.6023	2.4292	9.5155	5.0472
$H_{1,2}^{vol=1}$	Beta	0.3071	0.0307	0.0607	0.1922	0.0849
$H_{2,1}^{vol=2}$	Beta	0.1458	0.182	0.1023	0.109	0.1719

and confidence intervals. When describing the parameter estimates, we follow the convention of reporting values of countries ordered as Brazil, Chile, Colombia, Mexico, and Peru. First, we describe the values for the high interest rates responses to inflation regimes and then for the low response regimes, followed by a comparison. We report the mean for the estimated parameters and, in parenthesis, the estimated values for the 10% and 90% confidence intervals. Here, we focus on talking about the parameters related to the inflation formation process of the Phillips curve and the interest rate reaction function.

The persistence of inflation is captured by the parameter χ_p in the Phillips Curve. The parameter estimates for the high interest rate response regime, $\chi_{p,\xi_{coef=1}}$, are 0.1738 (0.0319, 0.4303), 0.2053 (0.1027, 0.3366), 0.7092 (0.4474, 0.8981), 0.8564 (0.6316, 0.9739) and 0.1318 (0.0321, 0.2885), respectively, while for the low interest rate response regimes, $\chi_{p,\xi_{coef=2}}$, they are 0.4471 (0.1352, 0.8285), 0.5124 (0.1913, 0.8204), 0.313 (0.1498, 0.5307), 0.6134 (0.496, 0.7669), and 0.1471 (0.0352, 0.286), respectively. Therefore, average inflation persistence has been lower for the high interest rate response regimes in Brazil and Chile, while it has been higher in Colombia and Mexico, and has remained almost unchanged in Peru. The counterpart to this persistence of inflation is the relative weight that expectations have in the inflation formation process.

The sensitivity of inflation to the output gap is partially captured by the parameter κ in the Phillips Curve. The parameter estimates for the high interest rate response regime, $\kappa\xi_{coef=1}$, are 1.1362 (0.8484, 1.6328), 0.0765 (0.0368, 0.1346), 0.5845 (0.3863, 0.8068), 2.1643 (1.9357,2.3318) and 0.5011(0.3481,0.6833), respectively, while for the low interest rate response regimes, $\kappa\xi_{coef=2}$, they are 0.6296 (0.27, 1.2559), 0.0631 (0.0331, 0.1008), 1.9982 (1.6591,2.3484), 2.3736 (1.7729,3.3246) and 0.0565 (0.0294,0.0863), respectively. Therefore, average sensitivity of inflation to the output gap has been lower for the high interest rate response regime in Colombia, higher in Brazil and Peru, and it has remained almost unchanged at a fairly low value in Chile and a high value in Mexico.

Therefore, in the context of the inflation formation process, going from a low interest response to a high one, as happened chronologically in all countries except Chile, Brazil experienced a drop in inflation inertia and a more responsive trade-off between output gap and inflation, Colombia has higher inflation inertia and a less responsive trade-off, Mexico has higher inflation inertia and moderate decrease in the responsiveness of the trade-off, and Peru has the same level of inertia and a more responsive trade-off. Meanwhile, as stated before, Chile started the sample with a high interest rate response to inflation and loosened the policy from 2008Q1 to 2009Q4. Then, when moving from a high interest rate response to a low one, Chile had an increase in inflation inertia without changes in the slope of its Phillips curve.

Turning to the interest rate reaction function, the persistence of interest rates is captured by the parameter ρ_R. The parameter estimates for the high interest rate response regime, $\rho R,\xi_{coef=1}$, are 0.7629 (0.6917,0.8144), 0.9215 (0.8525,0.9788), 0.7298 (0.6633, 0.8071), 0.458 (0.3897,0.5541) and 0.697 (0.6211,0.753), respectively, while for the low interest rate response regime, $\rho R,\xi_{coef=2}$, they are 0.6113 (0.2252,0.813),0.4912 (0.4328, 0.5514), 0.7065 (0.6491, 0.7621), 0.6279 (0.3992, 0.7734) and 0.6254 (0.5227, 0.7344), respectively.

Therefore, average persistence of interest rates has been higher for the high interest rate response regime in Brazil, Chile and Peru, it has decreased in Mexico and it has remained relatively unchanged in Colombia.

The sensitivity of interest rates to inflation is captured by the parameter ψ_π. The parameter estimates for the high interest rate response regime, $\psi\pi,\xi_{coef=1}$, are 3.4901 (2.733, 3.8618), 2.7337 (1.079, 5.4875), 3.2941 (1.8292, 4.9853), 1.8458 (1.7431, 1.9526) and 1.9066 (1.3059,3.309), respectively, while for the low interest rate response regime, $\psi\pi,\xi_{coef=2}$, are 1.0417 (0.6815,1.4375),0.8692 (0.7058,1.0166),0.9746 (0.7722, 1.1641), 0.6154 (0.4424, 0.823) and 0.9226 (0.444, 1.7992), respectively.

The sensitivity of interest rates to output deviations is captured by the parameter ψ_y. The parameter estimates for the high interest rate response regime, $\psi y,\xi_{coef=1}$, are 0.3013 (0.075, 0.9818), 0.5594 (0.3015, 0.8963), 0.3849 (0.1969, 0.6058), 0.7265 (0.602, 0.8016) and 0.4092 (0.1659,0.859), respectively, while for the low interest rate response regime, $\psi y,\xi_{coef=2}$, are 0.8799 (0.2204, 2.0191), 0.434 (0.2317, 0.7397), 0.7379(0.3355, 1.2305), 0.831 (0.8039, 0.8562) and 0.5639 (0.3263, 1.0481), respectively. Therefore, average sensitivity of interest rates to output deviations has been lower for the high interest rate response regime in Brazil, Colombia, Mexico and Peru, while it has been higher in Chile.

The sensitivity of interest rates to exchange rate depreciations is captured by the parameter $\psi_{\Delta e}$. The parameter estimates for the high interest rate response regime, $\psi_{\Delta e,\xi^{coef=1}}$, are 0.0435 (0.0156,0.098), 0.0816 (0.0229,0.2694), 0.137 (0.1068,0.1752), 0.1108 (0.0961,0.1254) and 0.1725 (0.1215,0.2283), respectively, while for the low interest rate response regimes, $\psi_{\Delta e,\xi^{coef=2}}$, are 0.0422 (0.0139,0.1547), 0.0662 (0.026,0.1325), 0.0463 (0.0148,0.0844), 0.3408 (0.0775,0.6386) and 0.1506 (0.1139,0.1925), respectively. Therefore, average sensitivity of interest rates to exchange rate depreciations has been higher for the high interest rate response regime in Colombia, it has decreased in Mexico and it has remained almost unchanged for Brazil, Chile and Peru.

Therefore, in terms of the interest rate reaction function, going from a low interest response to a high one as happened chronologically in all countries except Chile, Brazil exhibited a greater persistence of interest rates, less sensitivity to output deviations, and no change in the response to exchange rate fluctuations. Colombia exhibited similar persistence of interest rates, decreased sensitivity to output deviations and larger sensitivity to exchange rate fluctuations. Mexico exhibited less persistence of interest rates, and smaller sensitivity to output deviations and exchange rate fluctuations. Peru exhibited larger persistence of interest rates, diminished sensitivity to output deviations, and similar response to exchange rate fluctuations. Finally, for Chile, when moving from a high interest rate response to a low one, interest rates exhibited less persistence and the weight on output deviations was larger, as expected from the countercyclical stance of their monetary policy.

4.3 Impulse response functions

Figures 7 to 11 show the impulse response functions regarding monetary policy, non-stationary technology, terms of trade, world output, and world inflation shocks, respectively. Each graph compares the responses under the high and low interest rate response to inflation regimes. Inspecting the different mechanisms prevalent in each country under each policy stance will allow us to understand the counterfactuals that are presented later where we ask what may have happened if another regime had been in place for the entire sample.

An unexpected expansion of monetary policy appreciates the currency, while it lowers inflation and output. Under the high policy response regime, appreciations are larger in Chile and Peru, where real interest rates increase by more and inflation drops are larger. Only in the case of Chile has the observed output contraction been larger under the high policy response regime, which could be due to the fact that the low response regime was implemented for countercyclical motives only once the inflation targeting regime was consolidated.

Technology is assumed to be difference stationary, so innovations in productivity have permanent effects on output. On average, output increases, inflation is positive, currency depreciates, and real interest rates decrease. These movements are slightly smaller under the high policy response regime.

An unexpected improvement in terms of trade raises output, appreciates the currency, and lowers inflation (except for the high policy response regime in Peru, where prices increase). On average, these movements prompt the central banks to loosen policy (except for the high policy response of Chile). Appreciations are of similar magnitude under both policy response regimes. Under the high policy response regime, output expansions are larger in Colombia and Mexico, the reduction of inflation is smaller in Brazil, Chile and Mexico, and the real interest rate drops by more in all countries except Chile.

World demand shocks lower domestic output, increase inflation, and potentially cause an exchange rate depreciation. These results arise because, under the estimated elasticities of intertemporal substitution, world output shocks lower domestic potential output in all countries. Despite the fact that nominal interest rates increase, real interest rates decrease. Under high policy response regimes output contractions are larger, inflation increases less, nominal exchange rate depreciation is smaller, and the central banks cut real interest rates by less.

Shocks to import price inflation appreciate the currency, but raise inflation because, in addition to the inherent foreign price inflation, the central bank reacts to movements in the exchange rate, and lowers real interest rates. Under high policy response regimes output increases by less, except in the case of Colombia, inflation increases by less, except in the case of Peru and the nominal exchange rate depreciation is of similar magnitude, except for Mexico where it is larger under high response.

Figure 7

MONETARY POLICY SHOCK IRFs

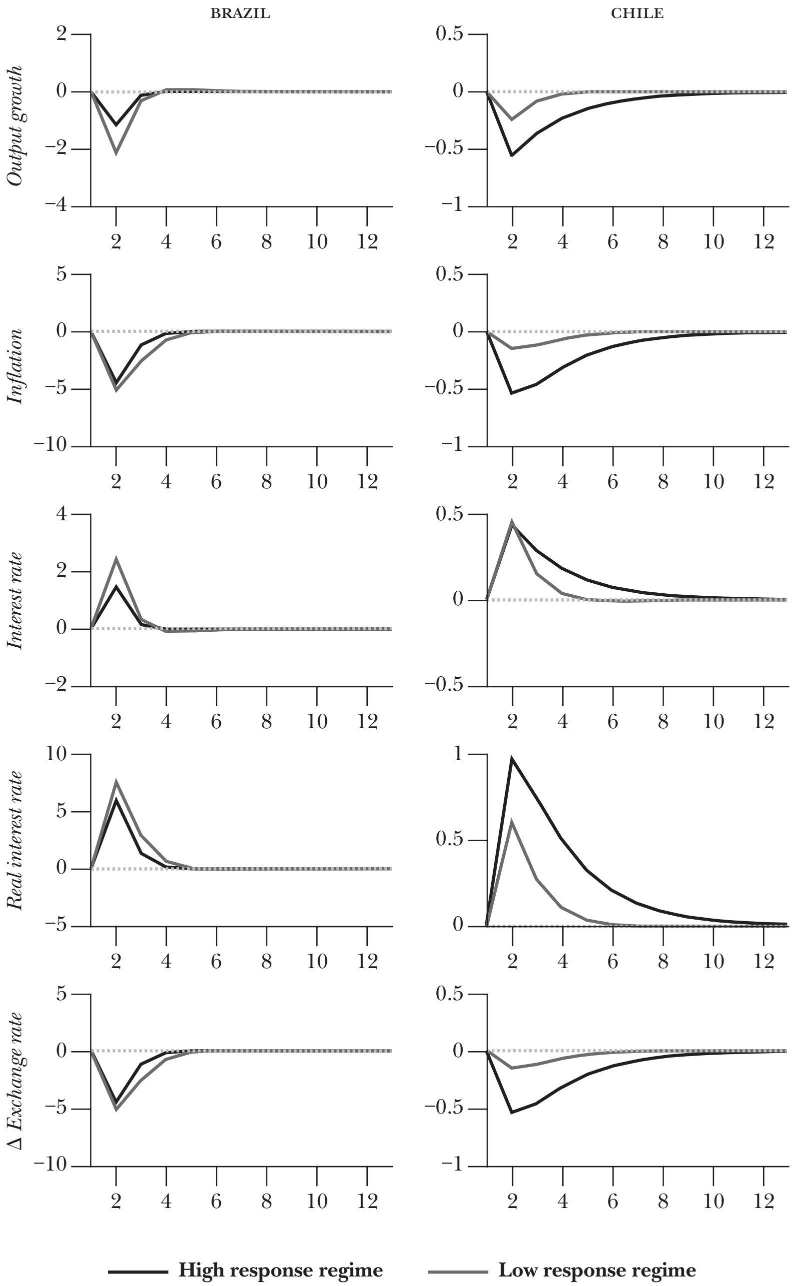


Figure 7 (cont.)

MONETARY POLICY SHOCK IRFs

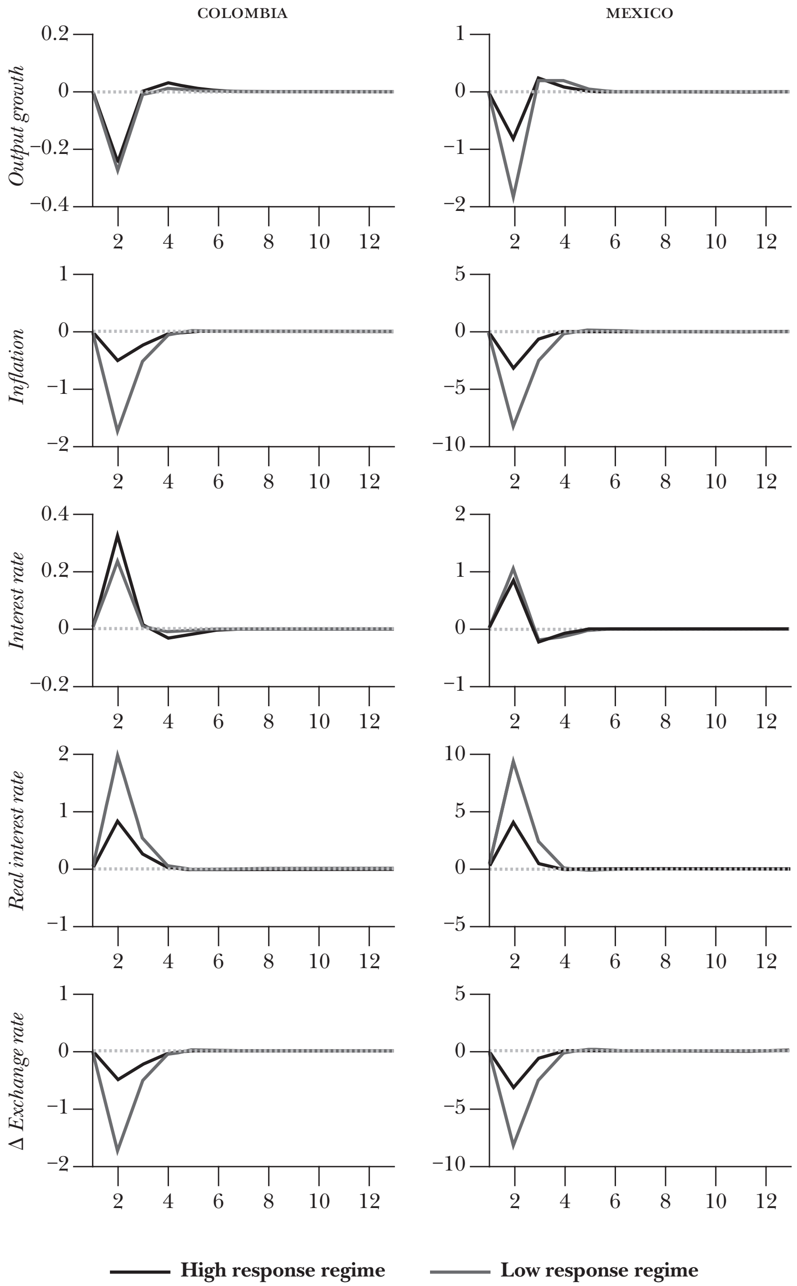


Figure 7 (cont.)

MONETARY POLICY SHOCK IRFs

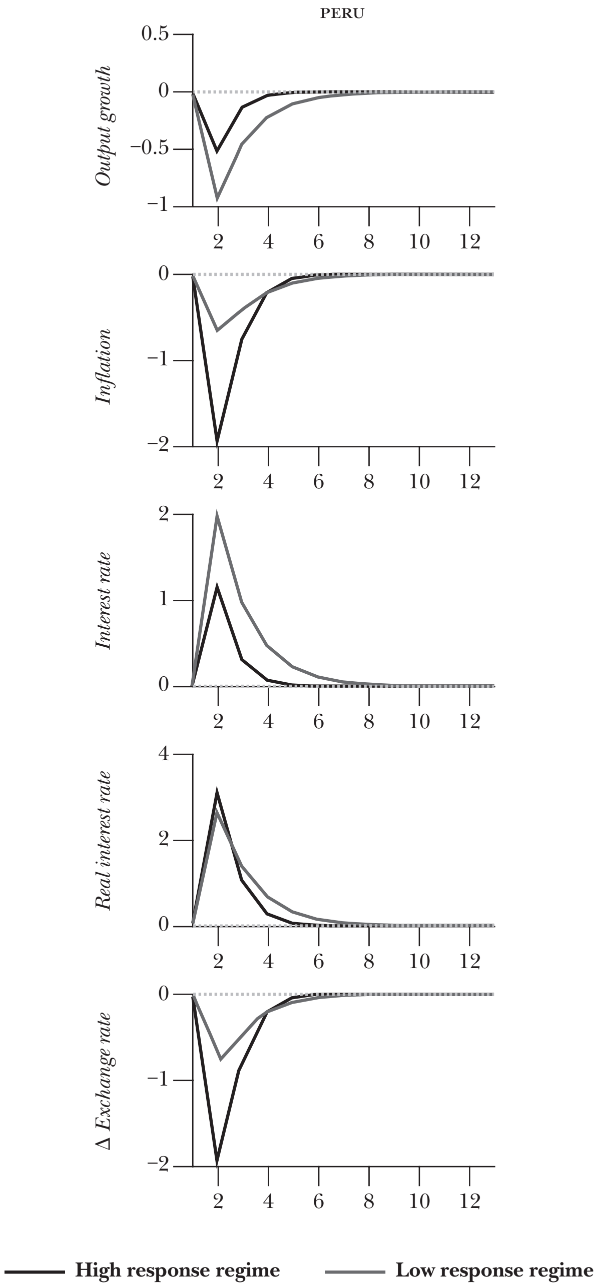


Figure 8

TECHNOLOGY SHOCK IRFs

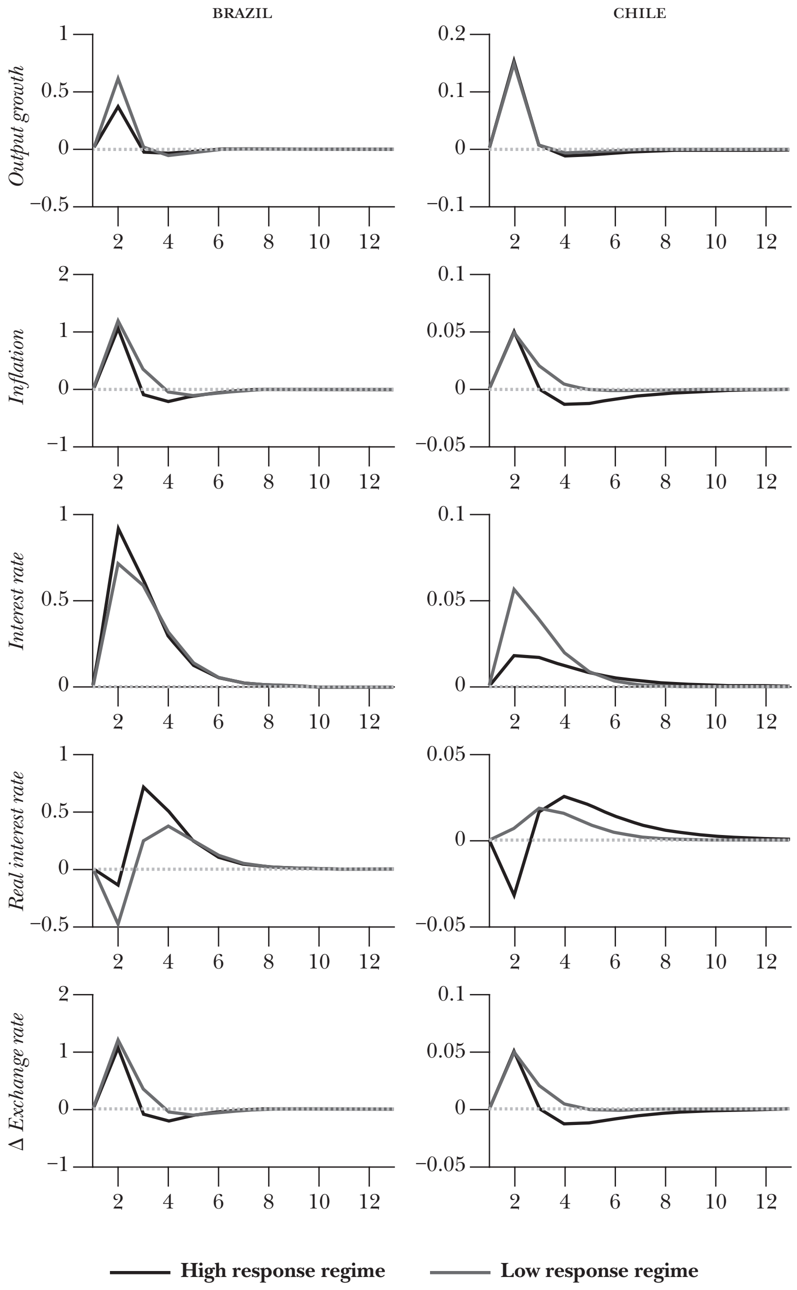


Figure 8 (cont.)

TECHNOLOGY SHOCK IRFs

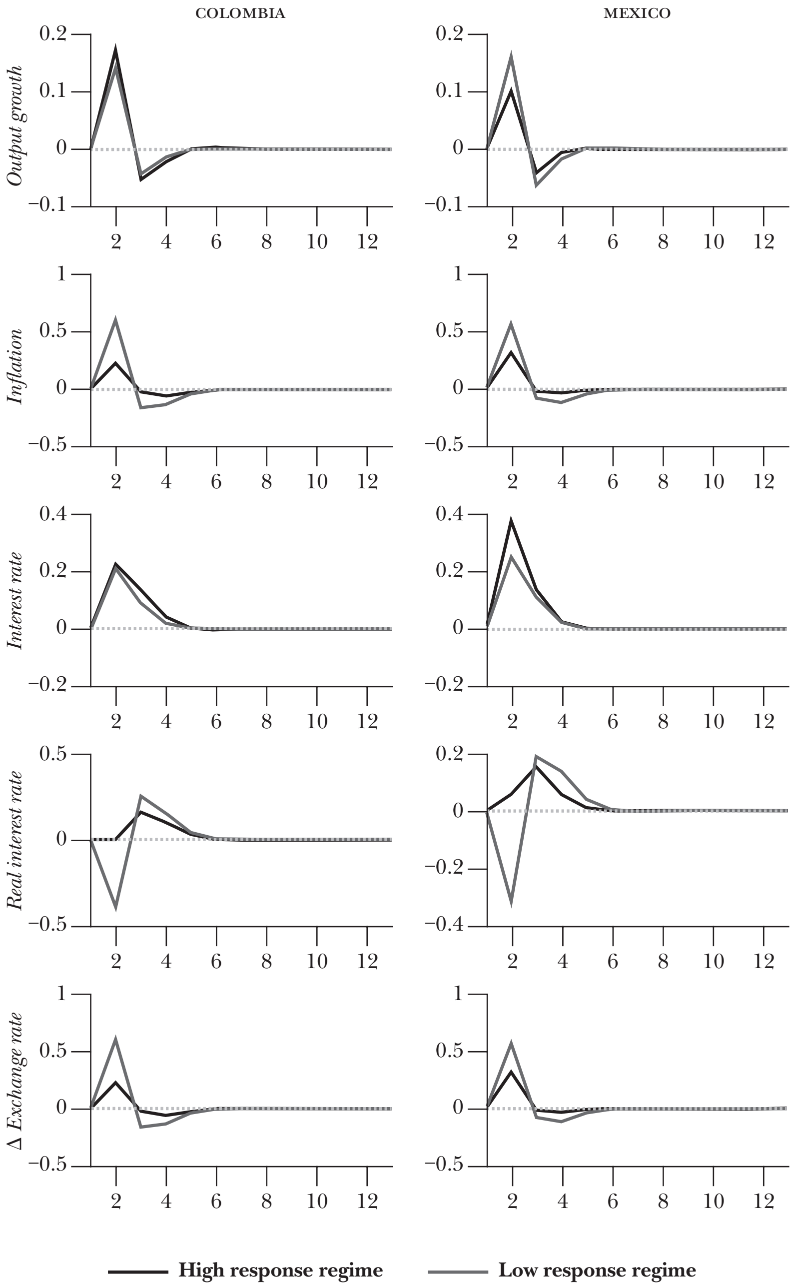


Figure 8 (cont.)

TECHNOLOGY SHOCK IRFs

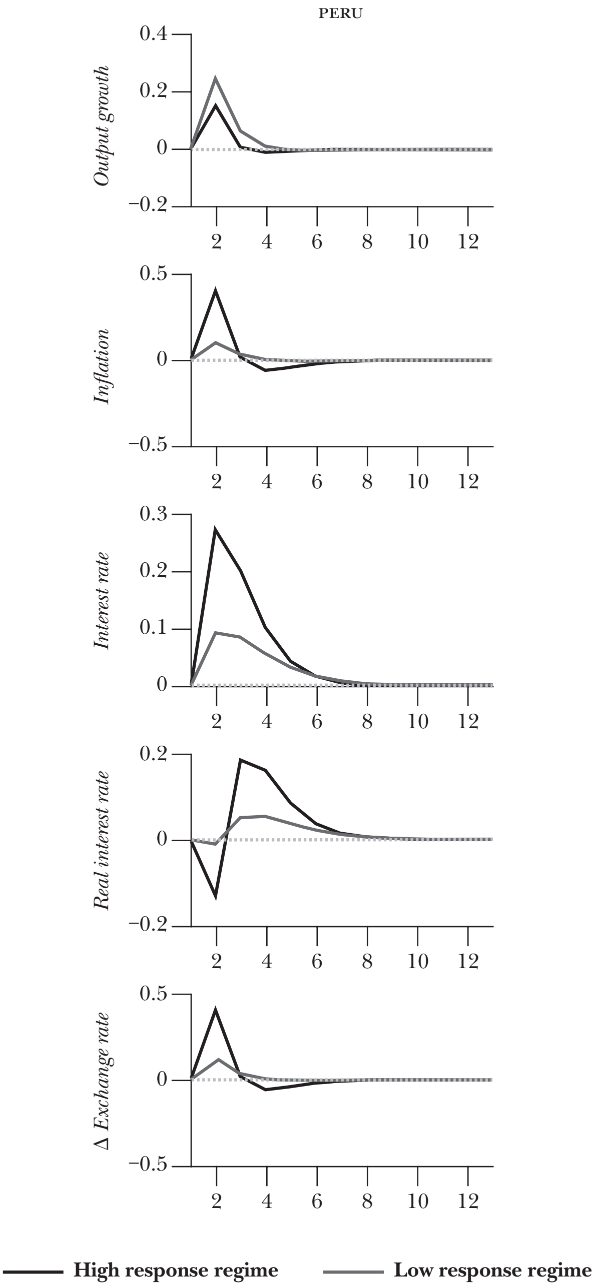


Figure 9

TERMS OF TRADE SHOCK IRFs

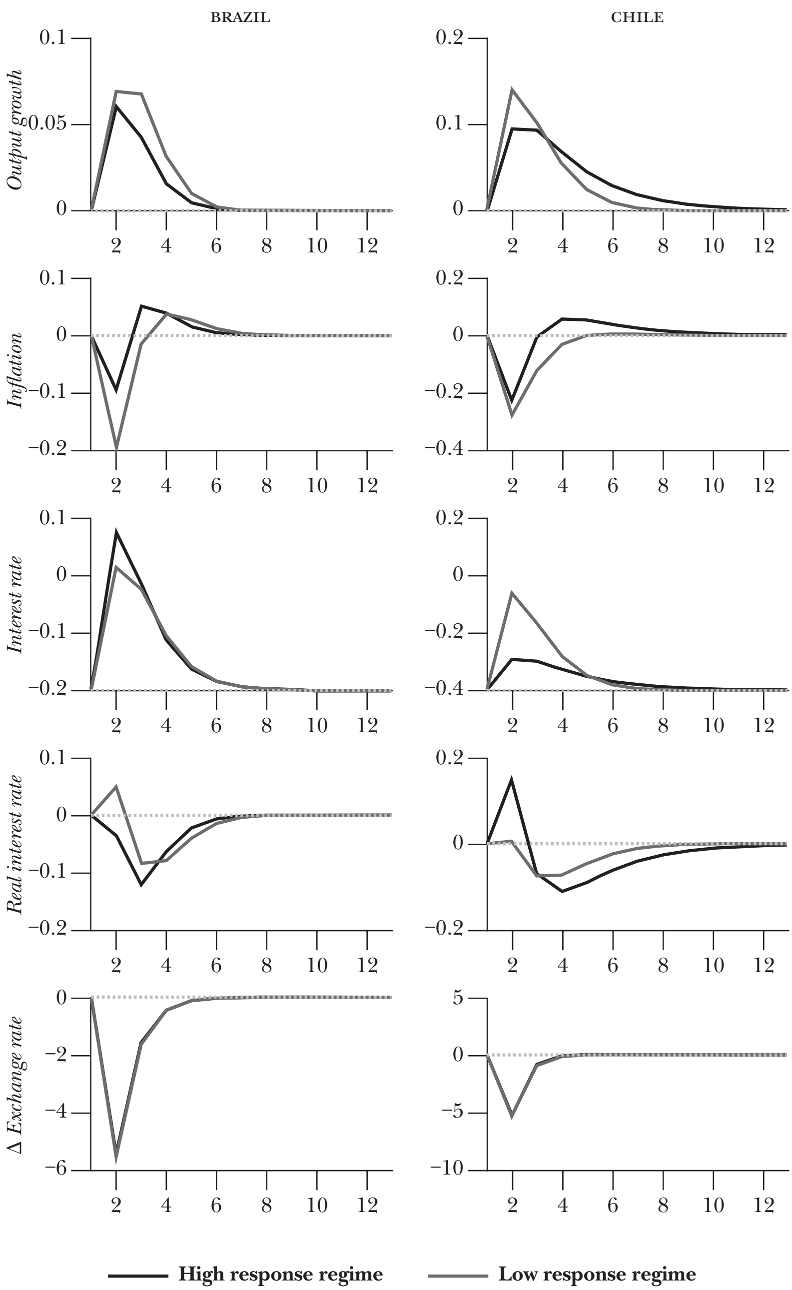


Figure 9 (cont.)

TERMS OF TRADE SHOCK IRFs

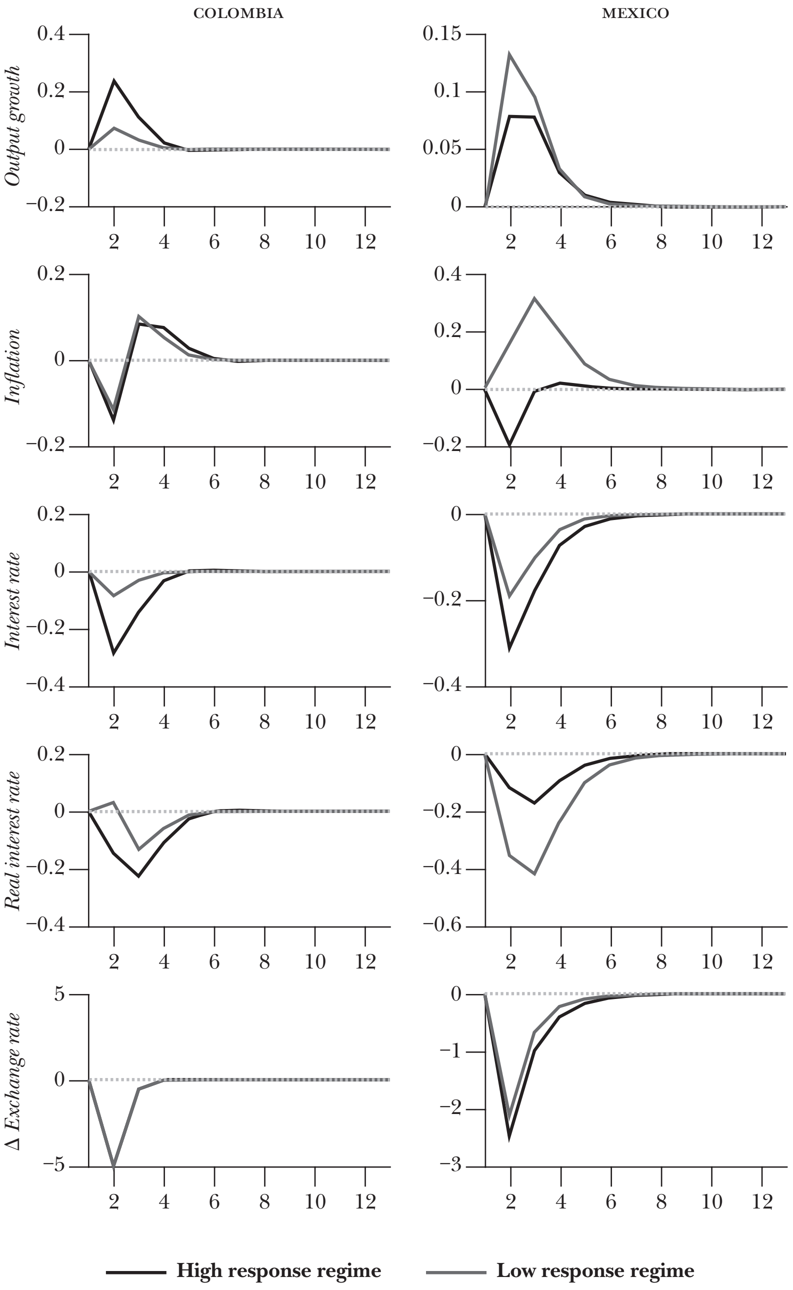


Figure 9 (cont.)

TERMS OF TRADE SHOCK IRFs

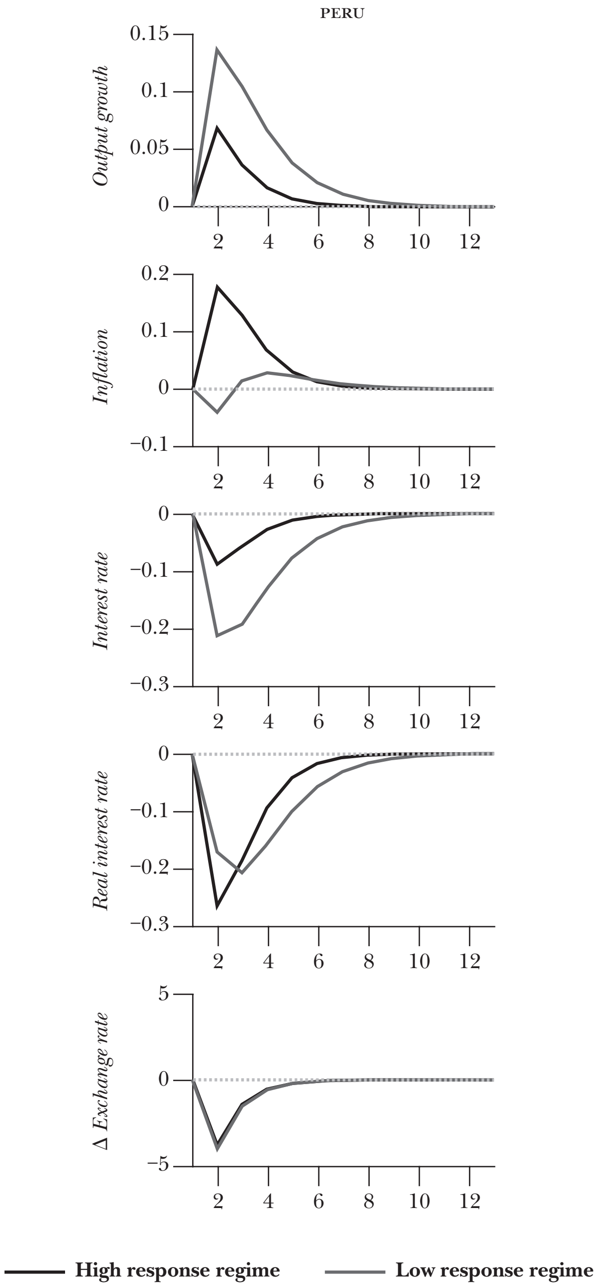


Figure 10

WORLD OUTPUT SHOCK IRFs

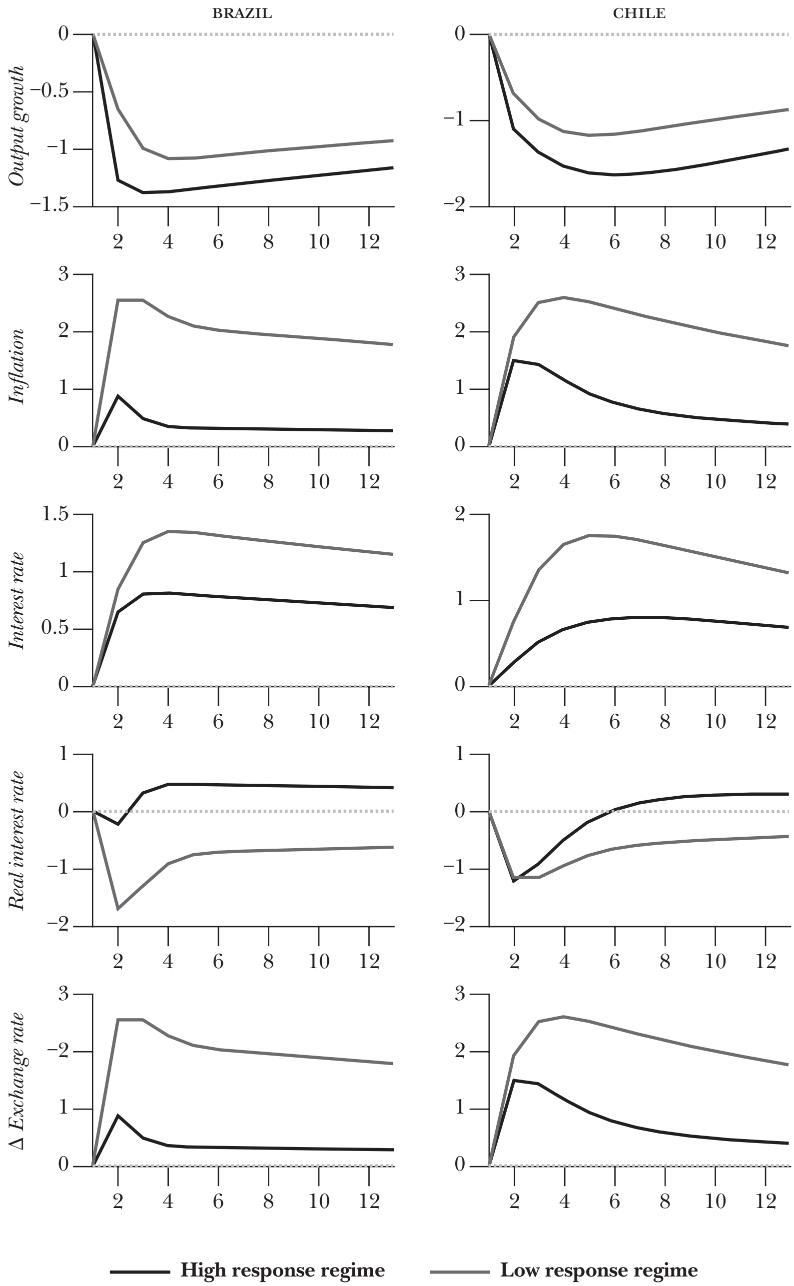


Figure 10 (cont.)

WORLD OUTPUT SHOCK IRFs

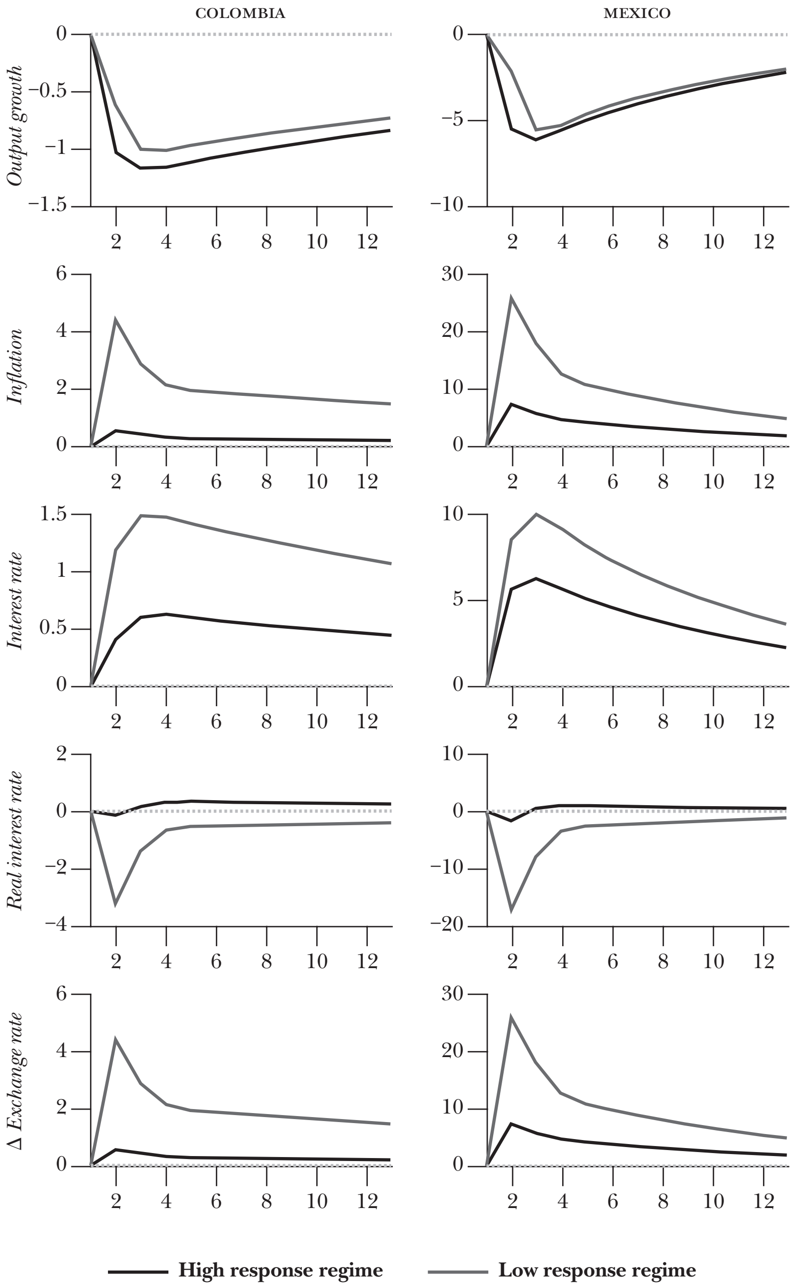
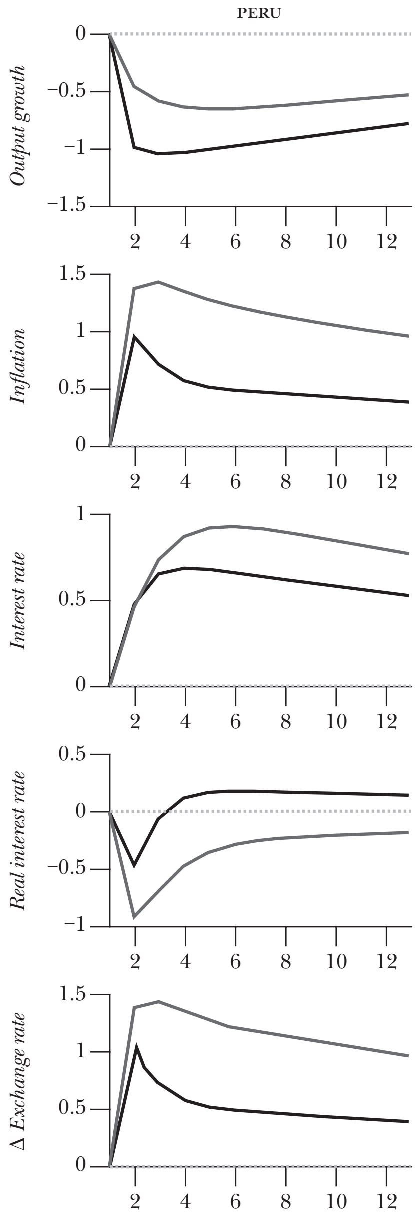


Figure 10 (cont.)

WORLD OUTPUT SHOCK IRFs



High response regime — Low response regime

Figure 11

WORLD INFLATION SHOCK IRFs

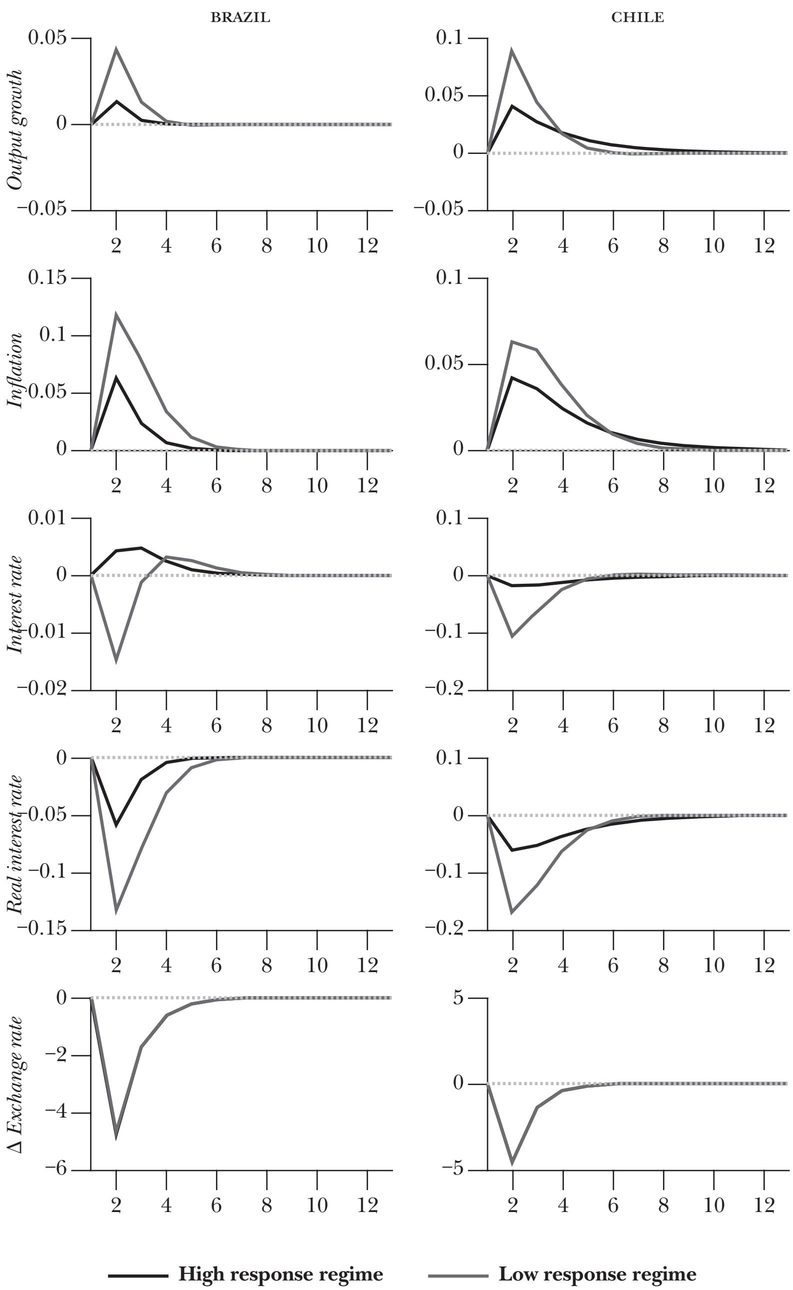


Figure 11 (cont.)

WORLD INFLATION SHOCK IRFs

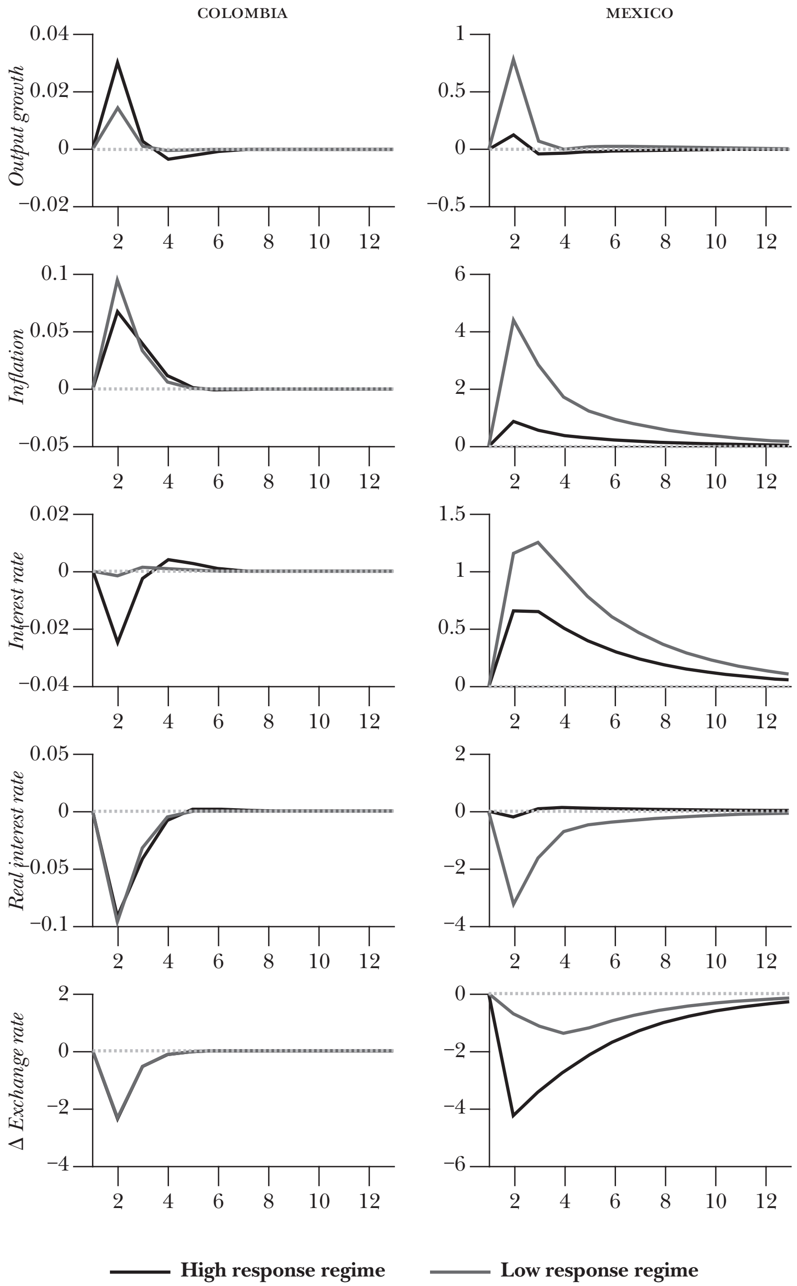
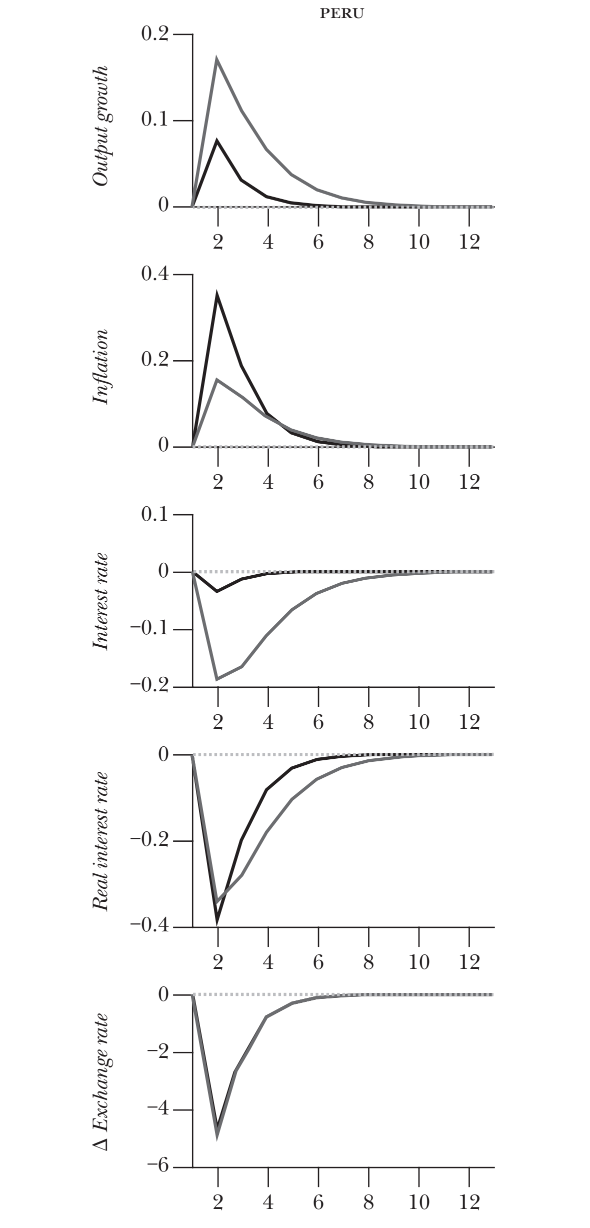


Figure 11 (cont.)

WORLD INFLATION SHOCK IRFs



4.4 Counterfactuals

As shown by the impulse response functions, there are differences in the magnitudes and even signs of the responses under the different regimes. Our estimated model allows one to perform counterfactual analysis of what could have happened if policies had been different. In Figures 12 to 16, we show the actual behavior of five observables: GDP growth, inflation, nominal interest rate, ex-post real interest rate, and nominal depreciation, and compare them with the hypothetical behavior that may have been observed under a constant high interest rate response regime and a constant low response regime. Table 3 reports the average, standard deviation and coefficient of variation of the actual observables and their simulated counterfactuals.

Looking at the figures one realizes that the regime switches that occurred throughout Latin America towards more responsive interest rate reaction functions helped to prevent many inflationary runs, several large nominal exchange rate depreciations, and large volatility of the nominal variables. Table 3 confirms that there would have been less average inflation under the high interest rate response regime than the observed average inflation, which is lower than the average inflation under the low interest rate response regime. Not only would average inflation have been lower, but the standard deviation of inflation would also have been lower under the counterfactual high response regime than in the observed one, which is lower than the counterfactual low response regime. The high response regime does not imply higher average nominal interest rates or higher average real interest rates, while their variability under that high response regime would have been less than the observed ones. Average nominal depreciation under the high response regime turned out to be smaller and less volatile. The reduction in the level and volatility of the nominal variables under the high response regime does not imply a sacrifice in terms of output growth, or on its volatility.

Table3

SUMMARY STATISTICS

Variable	*Series*	*Brazil*			*Chile*			*Colombia*			*Mexico*			*Peru*		
		Average	*SD*	*CV*	*Average*	*SD*	*CV*	*Average*	*SD*	*CV*	*Average*	*SD*	*CV*	*Average*	*SD*	*CV*
	Observed	0.64	1.26	1.97	3.85	4.21	1.09	3.44	4.27	1.11	2.26	5.73	2.53	4.65	3.31	0.71
Output growth	High response	0.99	3.28	3.30	3.75	2.78	0.74	3.42	4.11	1.22	1.77	4.84	2.73	4.97	2.74	0.55
	Low response	1.00	3.63	3.62	3.65	4.75	1.30	3.37	4.47	1.31	3.46	8.85	2.56	5.38	5.71	1.06
	Observed	6.31	3.72	0.59	3.06	2.51	0.82	9.84	7.43	1.12	20.15	24.78	1.23	3.62	3.18	0.88
Inflation	High response	3.89	2.73	0.70	2.93	1.90	0.65	7.13	4.93	1.04	11.08	7.65	0.69	3.34	2.12	0.64
	Low response	15.73	5.80	0.37	3.14	3.88	1.23	17.13	12.26	0.89	26.83	23.69	0.88	6.89	8.68	1.26
	Observed	16.49	7.00	0.42	4.59	2.04	0.44	12.56	10.50	2.33	25.38	26.36	1.04	6.91	6.03	0.87

Variable	*Series*	*Brazil*			*Chile*			*Colombia*			*Mexico*			*Peru*		
		Average	*SD*	*CV*	*Average*	*SD*	*CV*	*Average*	*SD*	*CV*	*Average*	*SD*	*CV*	*Average*	*SD*	*CV*
Interest rate	High response	10.69	3.84	0.36	4.76	1.44	0.30	9.01	6.41	1.61	18.90	13.06	0.69	5.43	2.61	0.48
	Low response	12.59	4.17	0.33	4.76	3.02	0.63	12.58	8.48	1.57	30.81	27.84	0.90	4.42	5.26	1.19
	Observed	10.18	7.58	0.74	1.53	2.15	1.40	2.72	5.13	2.43	5.23	9.08	1.74	3.29	5.73	1.74
Real interest rate	High response	6.80	3.49	0.51	1.83	2.04	1.11	1.89	2.80	3.64	7.82	7.94	1.01	2.09	2.61	1.25
	Low response	−3.14	7.36	2.34	1.63	1.48	0.91	−4.56	8.94	1.07	3.98	15.61	3.92	−2.47	13.33	5.40
	Observed	1.64	9.13	5.58	0.67	4.87	7.25	1.36	6.60	0.89	−0.59	4.81	8.10	0.45	2.70	6.02
Nominal depreciation	High response	−0.60	8.61	14.26	0.72	2.86	4.00	−3.15	8.44	1.34	−5.59	9.92	1.77	0.25	3.29	13.40
	Low response	11.24	9.23	0.82	1.28	7.50	5.88	6.33	9.15	0.77	5.74	14.88	2.59	3.77	8.15	2.16

Figure 12

COUNTERFACTUAL FOR HIGH AND LOW RESPONSE REGIMES FOR BRAZIL

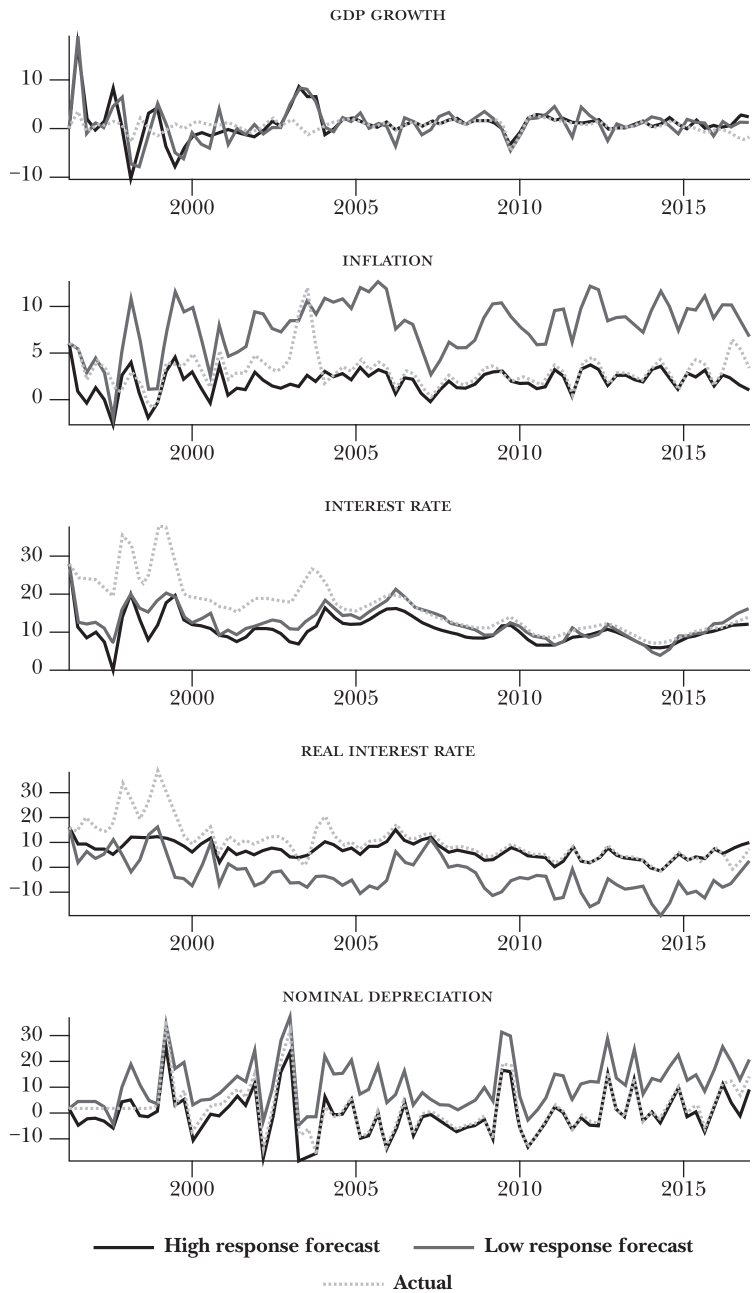


Figure 13

COUNTERFACTUAL FOR HIGH AND LOW RESPONSE REGIMES FOR CHILE

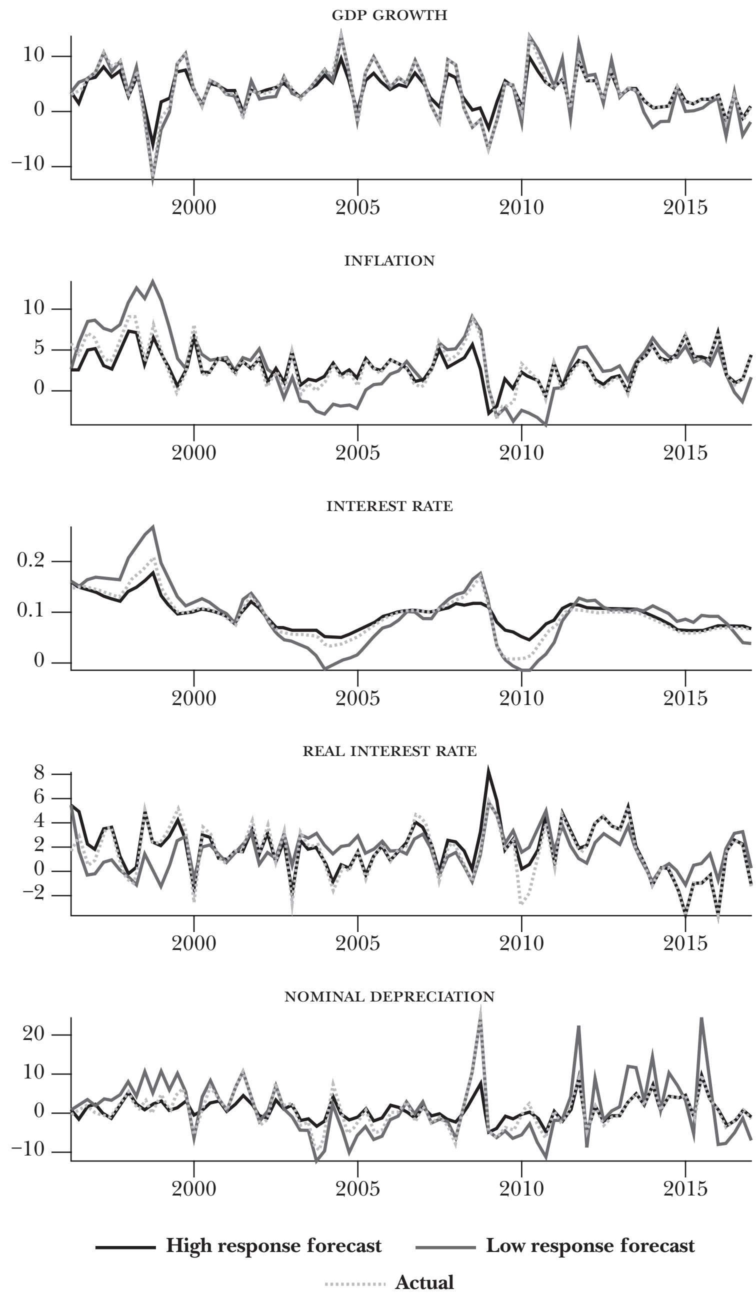


Figure 14

COUNTERFACTUAL FOR HIGH AND LOW RESPONSE REGIMES FOR COLOMBIA

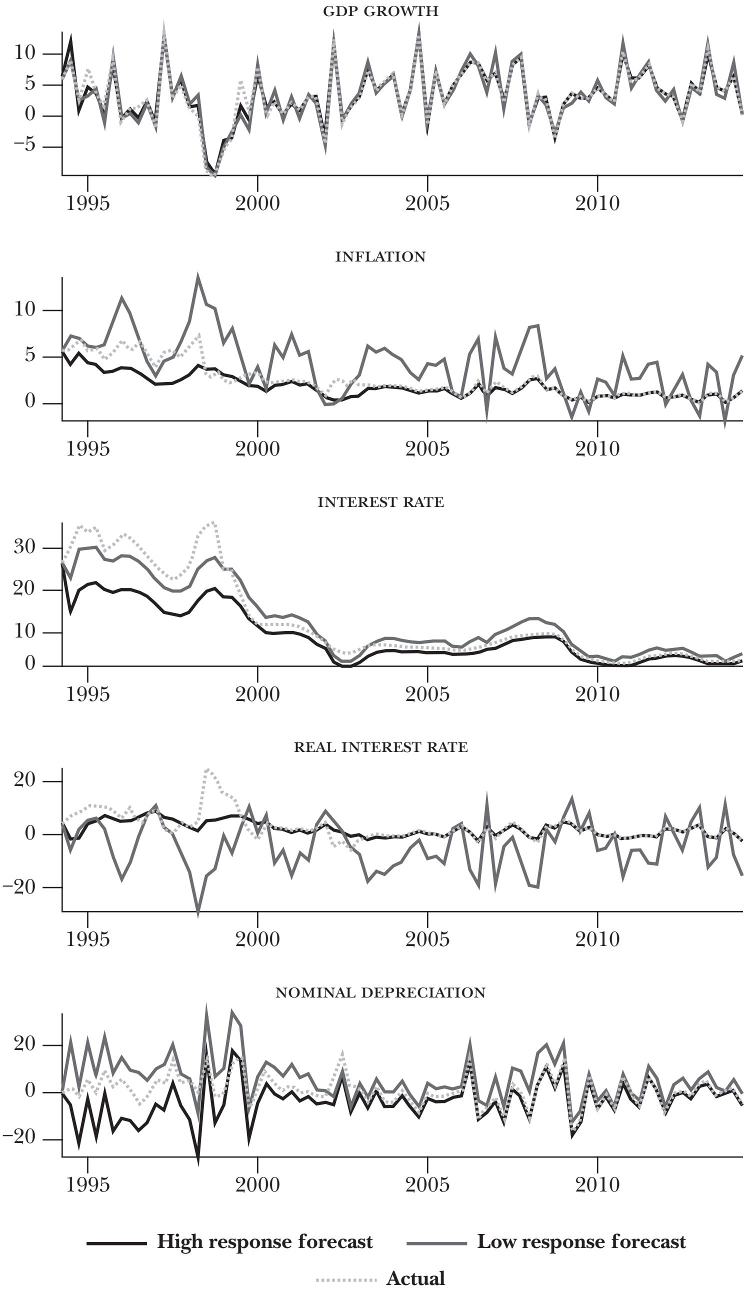


Figure 15

COUNTERFACTUAL FOR HIGH AND LOW RESPONSE REGIMES FOR MEXICO

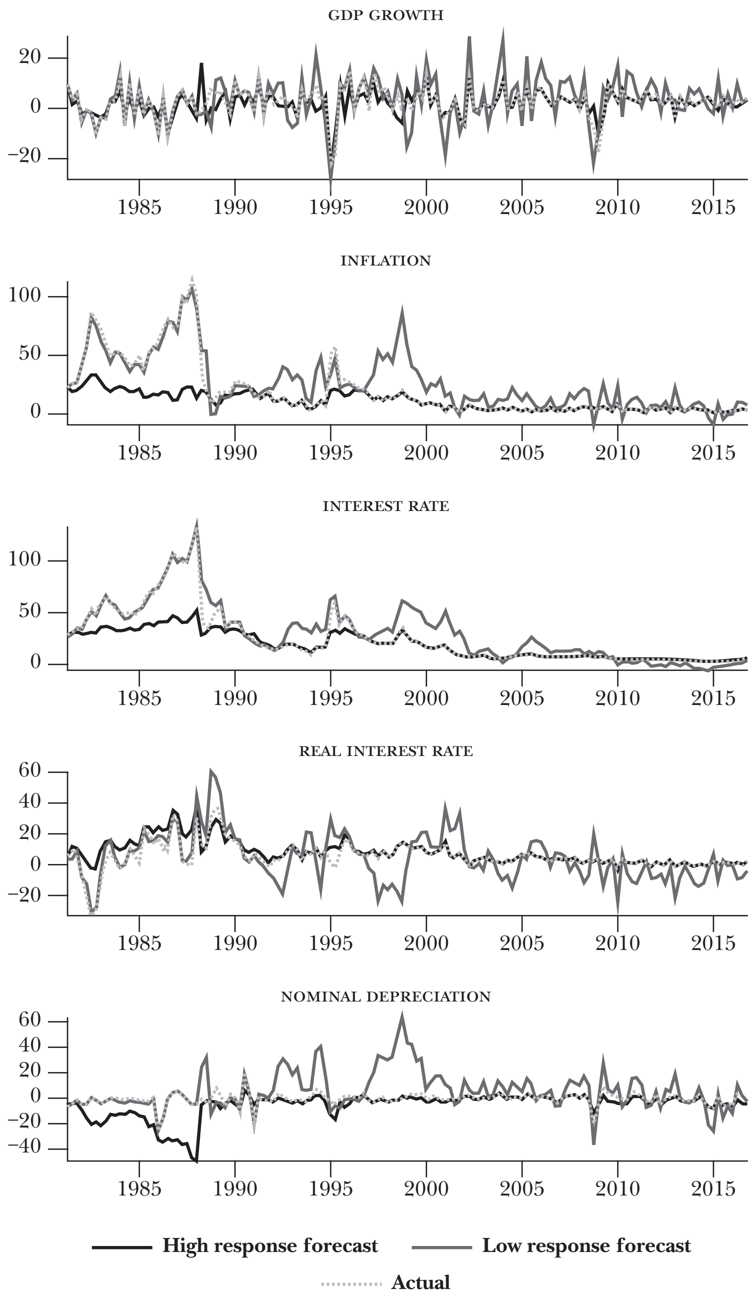
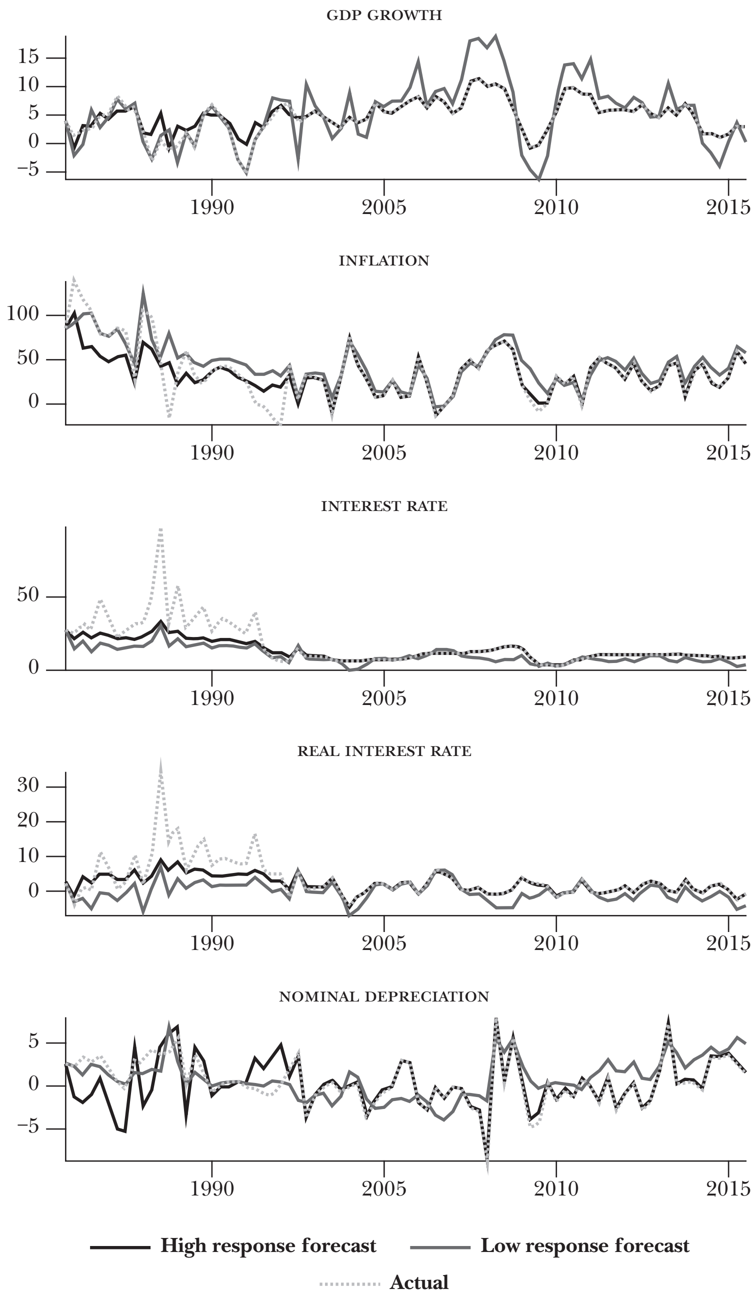


Figure 16

COUNTERFACTUAL FOR HIGH AND LOW RESPONSE REGIMES FOR PERU



5. CONCLUSIONS

In this paper we explore whether the central bank reforms implemented in the 1990s in Brazil, Chile, Colombia, Mexico and Peru, which lead to an inflation targeting framework, represented a regime switch in their monetary policies. The estimation of a Markov-switching DSGE open economy monetary model allows us to identify regime shifts of an interest rate reaction function together with the inflation determination process of a hybrid New Keynesian open economy Phillips curve. Our estimation identifies the following periods as having high interest rate responses to inflation: from 1999Q3 to 2002Q3 and from 2004Q1 onwards for Brazil; from the beginning of the sample in 1996Q2 to 2007Q4 and from 2010Q1 onwards for Chile; from 2000Q1 onwards for Colombia; from 1988Q2 to 1988Q3, from 1992Q1 to 1994Q4, and from 1997Q2 onwards for Mexico; 1997Q4 to 1998Q1, in 1998Q4, and from 2002Q1 onwards for Peru. The introduction of inflation targeting is associated with a marked regime switch towards a more reactive interest rate policy.

The estimation of the structural parameters associated with the hybrid New Keynesian open economy Phillips curve indicates that when changing from a low interest response to a high one as it happened chronologically in all countries (except Chile), Brazil experienced a drop in inflation inertia and a more responsive trade-off between output gap and inflation, Colombia experienced a higher inflation inertia and a reduction in the slope of the Phillips curve, Mexico also experienced higher inflation inertia and a slightly reduction in the large slope of the Phillips curve, and Peru experienced the same level of inertia and a more responsive trade-off. Meanwhile, as stated before, Chile began our sample with a high interest rate response to inflation and loosened the policy from 2008Q1 to 2009Q4. Then, when moving from a high interest rate response to a low one, Chile had an increase in inflation inertia without changes in the small slope of the Phillips curve.

The estimation of the structural parameters associated with the interest rate reaction function indicates that when going from a low interest response to a high one as it happened chronologically in all countries (except Chile), Brazil exhibited increased persistence of interest rates, decreased sensitivity to output deviations, and no change in response to exchange rate fluctuations. Colombia exhibited similar persistence of interest rates, less sensitivity to output deviations, and more sensitivity to exchange rate fluctuations. Mexico exhibited smaller persistence of interest rates and smaller sensitivity to output deviations and exchange rate fluctuations. Peru exhibited higher persistence of interest rates, lower sensitivity to output deviations and similar responses to exchange rate fluctuations. Finally, for Chile, when moving from a high interest rate response to a low one, interest rates exhibited less persistence and the weight on output deviations was larger, as expected from the countercyclical stance of their monetary policy.

When comparing the impulse response functions under the two regimes, we notice some differences in magnitude and sign. An unexpected increase in monetary policy, appreciates the currency, while it lowers inflation and output. Under high policy response regimes appreciations are larger in Chile and Peru, where real interest rates increase by more and inflation drops are larger. Only in the case of Chile has the observed output contraction been larger under the high policy response regime. This may be explained by the fact that the Chile's low response regime was implemented with countercyclical motives only once the inflation targeting regime was consolidated.

Our counterfactual analysis allows us to argue that the regime switches towards more responsive interest rate reaction functions helped to avoid many inflationary runs, several large nominal exchange rate depreciations and large volatility of the nominal variables. This reduction of nominal volatility did not come at the cost of smaller output growth or the need of larger output fluctuations. Therefore, we conclude that the introduction of inflation targeting represented a favorable regime switch in the conduct of monetary policy in Latin America.

ANNEX

A. Estimated Parameters

Table 4

ESTIMATED PARAMETERS OF BRAZIL

Parameter	*Distribution*	*Mean*	*Mode*	*Standard dev.*	*10%*	*90%*
$\chi_{p,\xi^{coef=1}}$	Beta	0.1738	0.0482	0.1299	0.0319	0.4303
$\chi_{p,\xi^{coef=2}}$	Beta	0.4471	0.3213	0.2214	0.1352	0.8285
$\kappa_{p,\xi^{coef=1}}$	Gamma	1.1362	0.9582	0.2401	0.8484	1.6328
$\kappa_{p,\xi^{coef=2}}$	Gamma	0.6296	0.4708	0.3204	0.27	1.2559
$\rho_{R,\xi^{coef=1}}$	Beta	0.7629	0.7847	0.048	0.6917	0.8144
$\rho_{R,\xi^{coef=2}}$	Beta	0.6113	0.7513	0.1814	0.2252	0.813
$\psi_{\pi,\xi^{coef=1}}$	Gamma	3.4901	3.6914	0.3406	2.733	3.8618
$\psi_{\pi,\xi^{coef=2}}$	Gamma	1.0417	0.7656	0.296	0.6815	1.4375
$\psi_{y,\xi^{coef=1}}$	Gamma	0.3013	0.1377	0.3081	0.075	0.9818
$\psi_{y,\xi^{coef=2}}$	Gamma	0.8799	0.378	0.6633	0.2204	2.0191
$\psi_{\Delta,\xi^{coef=1}}$	Gamma	0.0435	0.0323	0.025	0.0156	0.098
$\psi_{\Delta,\xi^{coef=2}}$	Gamma	0.0422	0.0268	0.0391	0.0139	0.1547
α	Beta	0.076	0.0436	0.0454	0.0291	0.1778
r	Gamma	3.6731	3.0345	0.7512	2.6661	4.8276
τ	Beta	0.2792	0.2896	0.1012	0.147	0.4755
ρ_a	Beta	0.424	0.0606	0.2548	0.0349	0.7505

Parameter	*Distribution*	*Mean*	*Mode*	*Standard dev.*	*10%*	*90%*
ρ_q	Beta	0.3014	0.1127	0.2563	0.0512	0.8563
ρ_{y*}	Beta	0.9818	0.999	0.0356	0.9387	0.9992
$\rho_{\pi*}$	Beta	0.3715	0.3471	0.0892	0.2455	0.535
$H_{1,2}^{coef=1}$	Beta	0.1603	0.0428	0.1461	0.039	0.4719
$H_{2,1}^{coef=2}$	Beta	0.2257	0.1262	0.1173	0.0997	0.4375
$\sigma_{R,\xi^{vol=1}}$	Inv.Gamma	5.3145	6.0774	0.704	4.0033	6.2124
$\sigma_{R,\xi^{vol=2}}$	Inv.Gamma	3.3642	2.3893	1.0409	2.262	5.2165
$\sigma_{q,\xi^{vol=1}}$	Inv.Gamma	5.791	6.202	0.342	5.2568	6.2795
$\sigma_{q,\xi^{vol=2}}$	Inv.Gamma	4.2554	3.7875	0.9045	3.1056	5.8516
$\sigma_{a,\xi^{vol=1}}$	Inv.Gamma	4.6972	4.5965	0.1259	4.5092	4.9424
$\sigma_{a,\xi^{vol=2}}$	Inv.Gamma	4.7999	4.6046	0.2162	4.5204	5.188
$\sigma_{y^*,\xi^{vol=1}}$	Inv.Gamma	3.5522	2.4173	0.9944	2.3191	5.2352
$\sigma_{y^*,\xi^{vol=2}}$	Inv.Gamma	6.9291	7.8618	1.0058	5.0694	8.0384
$\sigma_{\pi^*,\xi^{vol=1}}$	Inv.Gamma	4.8214	4.0789	0.6289	4.002	5.8516
$\sigma_{\pi^*,\xi^{vol=2}}$	Inv.Gamma	6.1201	6.72	0.7868	4.811	7.1394
$H_{1,2}^{vol=1}$	Beta	0.3071	0.2284	0.1399	0.1241	0.5589
$H_{2,1}^{vol=2}$	Beta	0.1458	0.0487	0.1472	0.0278	0.4982

Table 5

ESTIMATED PARAMETERS OF CHILE

Parameter	*Distribution*	*Mean*	*Mode*	*Standard dev.*	*10%*	*90%*
$\chi_{p,\xi^{coef=1}}$	Beta	0.2053	0.1535	0.0715	0.1027	0.3366
$\chi_{p,\xi^{coef=2}}$	Beta	0.5124	0.7801	0.1992	0.1913	0.8204
$\kappa_{p,\xi^{coef=1}}$	Gamma	0.0765	0.0648	0.03	0.0368	0.1346
$\kappa_{p,\xi^{coef=2}}$	Gamma	0.0631	0.0363	0.0208	0.0331	0.1008
$\rho_{R,\xi^{coef=1}}$	Beta	0.9215	0.8787	0.0462	0.8525	0.9788
$\rho_{R,\xi^{coef=2}}$	Beta	0.4912	0.4859	0.0359	0.4328	0.5514
$\psi_{\pi,\xi^{coef=1}}$	Gamma	2.7337	1.2134	1.6982	1.079	5.4875
$\psi_{\pi,\xi^{coef=2}}$	Gamma	0.8692	0.8601	0.0915	0.7058	1.0166
$\psi_{y,\xi^{coef=1}}$	Gamma	0.5594	0.3792	0.2495	0.3015	0.8963
$\psi_{y,\xi^{coef=2}}$	Gamma	0.434	0.4119	0.1508	0.2317	0.7397
$\psi_{\Delta,\xi^{coef=1}}$	Gamma	0.0816	0.0441	0.0774	0.0229	0.2694
$\psi_{\Delta,\xi^{coef=2}}$	Gamma	0.0662	0.0561	0.0334	0.026	0.1325
α	Beta	0.0539	0.0526	0.0144	0.0331	0.0798
r	Gamma	2.2813	1.6134	0.9063	0.9927	3.9223
τ	Beta	0.16	0.1537	0.0389	0.1068	0.2349
ρ_a	Beta	0.1553	0.1155	0.0403	0.0925	0.224
ρ_q	Beta	0.1599	0.173	0.0632	0.0639	0.2696

Parameter	*Distribution*	*Mean*	*Mode*	*Standard dev.*	*10%*	*90%*
ρ_{y^*}	Beta	0.9579	0.9601	0.0134	0.9344	0.9784
ρ_{π^*}	Beta	0.3129	0.2894	0.0601	0.2253	0.4259
$H_{1,2}^{coef=1}$	Beta	0.0808	0.0234	0.0633	0.0141	0.21
$H_{2,1}^{coef=2}$	Beta	0.0521	0.0288	0.0222	0.0225	0.0942
$\sigma_{R,\xi^{vol=1}}$	Inv.Gamma	0.5788	0.708	0.0994	0.3924	0.7324
$\sigma_{R,\xi^{vol=2}}$	Inv.Gamma	3.3239	0.5593	1.72	0.5233	5.5594
$\sigma_{q,\xi^{vol=1}}$	Inv.Gamma	6.4758	8.2896	0.9905	5.2872	8.4767
$\sigma_{q,\xi^{vol=2}}$	Inv.Gamma	5.3403	2.6141	1.7776	2.2494	7.698
$\sigma_{a,\xi^{vol=1}}$	Inv.Gamma	3.9563	3.8918	0.3844	3.4115	4.7018
$\sigma_{a,\xi^{vol=2}}$	Inv.Gamma	6.1979	3.9948	1.5389	3.8555	8.1539
$\sigma_{y^*,\xi^{vol=1}}$	Inv.Gamma	3.4781	3.5359	0.5735	2.7111	4.5585
$\sigma_{y^*,\xi^{vol=2}}$	Inv.Gamma	5.4652	3.8204	1.2679	3.5727	7.7182
$\sigma_{\pi^*,\xi^{vol=1}}$	Inv.Gamma	7.2118	8.1589	0.9146	5.7006	8.754
$\sigma_{\pi^*,\xi^{vol=2}}$	Inv.Gamma	4.6023	2.8905	1.2114	2.8584	6.702
$H_{1,2}^{vol=1}$	Beta	0.0307	0.0275	0.0149	0.0107	0.0589
$H_{2,1}^{vol=2}$	Beta	0.182	0.1298	0.0535	0.1096	0.2873

Table 6

ESTIMATED PARAMETERS OF COLOMBIA

Parameter	*Distribution*	*Mean*	*Mode*	*Standard dev.*	*10%*	*90%*
$\chi_{p,\xi^{coef=1}}$	Beta	0.7092	0.3151	0.1375	0.4474	0.8981
$\chi_{p,\xi^{coef=2}}$	Beta	0.313	0.592	0.1163	0.1498	0.5307
$\kappa_{p,\xi^{coef=1}}$	Gamma	0.5845	0.6924	0.1267	0.3863	0.8068
$\kappa_{p,\xi^{coef=2}}$	Gamma	1.9982	1.6185	0.2196	1.6591	2.3484
$\rho_{R,\xi^{coef=1}}$	Beta	0.7298	0.8046	0.0436	0.6633	0.8071
$\rho_{R,\xi^{coef=2}}$	Beta	0.7065	0.6574	0.0349	0.6491	0.7621
$\psi_{\pi,\xi^{coef=1}}$	Gamma	3.2941	1.8019	1.1685	1.8292	4.9853
$\psi_{\pi,\xi^{coef=2}}$	Gamma	0.9746	0.8772	0.1204	0.7722	1.1641
$\psi_{y,\xi^{coef=1}}$	Gamma	0.3849	0.2018	0.1315	0.1969	0.6058
$\psi_{y,\xi^{coef=2}}$	Gamma	0.7379	0.5394	0.3263	0.3355	1.2305
$\psi_{\Delta,\xi^{coef=1}}$	Gamma	0.137	0.1147	0.0206	0.1068	0.1752
$\psi_{\Delta,\xi^{coef=2}}$	Gamma	0.0463	0.0296	0.042	0.0148	0.0844
α	Beta	0.1132	0.084	0.0292	0.0722	0.1641
r	Gamma	6.8509	5.4332	0.5786	5.8481	7.6151
τ	Beta	0.2445	0.1537	0.0852	0.1398	0.4253
ρ_a	Beta	0.1628	0.1377	0.0336	0.1122	0.2207
ρ_q	Beta	0.1291	0.1212	0.0685	0.0355	0.2556

Parameter	*Distribution*	*Mean*	*Mode*	*Standard dev.*	*10%*	*90%*
ρ_{y^*}	Beta	0.9659	0.9619	0.015	0.9391	0.9864
ρ_{π^*}	Beta	0.2303	0.2119	0.0575	0.1442	0.3319
$H_{1,2}^{coef=1}$	Beta	0.0863	0.0163	0.0566	0.0239	0.2236
$H_{2,1}^{coef=2}$	Beta	0.1566	0.0367	0.0871	0.048	0.3472
$\sigma_{R,\xi^{vol=1}}$	Inv.Gamma	0.8134	0.3186	0.4212	0.3368	1.5494
$\sigma_{R,\xi^{vol=2}}$	Inv.Gamma	6.8695	5.962	0.4012	6.2046	7.4314
$\sigma_{q,\xi^{vol=1}}$	Inv.Gamma	5.5065	5.5265	0.7479	4.3785	6.5215
$\sigma_{q,\xi^{vol=2}}$	Inv.Gamma	7.2084	6.3208	0.5752	6.3062	8.2431
$\sigma_{a,\xi^{vol=1}}$	Inv.Gamma	5.0036	5.7915	0.6898	3.9735	5.8133
$\sigma_{a,\xi^{vol=2}}$	Inv.Gamma	6.0725	8.2629	1.1733	4.3541	7.8001
$\sigma_{y^*,\xi^{vol=1}}$	Inv.Gamma	1.6996	0.6976	0.8043	0.5943	2.9033
$\sigma_{y^*,\xi^{vol=2}}$	Inv.Gamma	3.0673	2.673	0.3084	2.6163	3.5536
$\sigma_{\pi^*,\xi^{vol=1}}$	Inv.Gamma	5.0864	5.0467	0.3212	4.3974	5.4164
$\sigma_{\pi^*,\xi^{vol=2}}$	Inv.Gamma	2.4292	2.907	0.4745	1.6841	3.073
$H_{1,2}^{vol=1}$	Beta	0.0607	0.0553	0.0809	0.0089	0.2931
$H_{2,1}^{vol=2}$	Beta	0.1023	0.136	0.0601	0.0257	0.2056

Table 7

ESTIMATED PARAMETERS OF MEXICO

Parameter	*Distribution*	*Mean*	*Mode*	*Standard dev.*	*10%*	*90%*
$\chi_{p,\xi^{coef=1}}$	Beta	0.8564	0.9444	0.1206	0.6316	0.9739
$\chi_{p,\xi^{coef=2}}$	Beta	0.6134	0.7351	0.0816	0.496	0.7669
$\kappa_{p,\xi^{coef=1}}$	Gamma	2.1643	2.2281	0.1162	1.9357	2.3318
$\kappa_{p,\xi^{coef=2}}$	Gamma	2.3736	2.0484	0.4645	1.7729	3.3246
$\rho_{R,\xi^{coef=1}}$	Beta	0.458	0.4138	0.0551	0.3897	0.5541
$\rho_{R,\xi^{coef=2}}$	Beta	0.6279	0.735	0.142	0.3992	0.7734
$\psi_{\pi,\xi^{coef=1}}$	Gamma	1.8458	1.7333	0.0627	1.7431	1.9526
$\psi_{\pi,\xi^{coef=2}}$	Gamma	0.6154	0.8004	0.1313	0.4424	0.823
$\psi_{y,\xi^{coef=1}}$	Gamma	0.7265	0.7031	0.0629	0.602	0.8016
$\psi_{y,\xi^{coef=2}}$	Gamma	0.8310	0.8491	0.1824	0.8039	0.8562
$\psi_{\Delta,\xi^{coef=1}}$	Gamma	0.1108	0.1093	0.0335	0.0961	0.1254
$\psi_{\Delta,\xi^{coef=2}}$	Gamma	0.3408	0.0899	0.2613	0.0775	0.6386
α	Beta	0.2689	0.238	0.0362	0.2123	0.3289
r	Gamma	2.1004	1.7134	0.2971	1.6491	2.5185
τ	Beta	0.3256	0.3347	0.0216	0.2756	0.3478
ρ_a	Beta	0.2007	0.2273	0.0444	0.1302	0.2724
ρ_q	Beta	0.4305	0.3102	0.0879	0.2889	0.5608

Parameter	*Distribution*	*Mean*	*Mode*	*Standard dev.*	*10%*	*90%*
ρ_{y^*}	Beta	0.9042	0.9236	0.0217	0.8646	0.9359
ρ_{π^*}	Beta	0.7824	0.8252	0.0428	0.7059	0.8408
$H_{1,2}^{coef=1}$	Beta	0.1161	0.1094	0.0361	0.0707	0.1842
$H_{2,1}^{coef=2}$	Beta	0.2108	0.2528	0.061	0.097	0.3049
$\sigma_{R,\xi^{vol=1}}$	Inv.Gamma	4.5438	4.5083	0.1139	4.3641	4.7386
$\sigma_{R,\xi^{vol=2}}$	Inv.Gamma	5.8216	5.8513	0.038	5.7552	5.8765
$\sigma_{q,\xi^{vol=1}}$	Inv.Gamma	3.121	3.0513	0.0634	3.012	3.2223
$\sigma_{q,\xi^{vol=2}}$	Inv.Gamma	4.4066	4.3941	0.0598	4.3069	4.5035
$\sigma_{a,\xi^{vol=1}}$	Inv.Gamma	3.2222	3.2116	0.0709	3.101	3.3199
$\sigma_{a,\xi^{vol=2}}$	Inv.Gamma	7.4444	7.3618	0.1203	7.2862	7.6952
$\sigma_{y^*,\xi^{vol=1}}$	Inv.Gamma	6.7571	6.7489	0.0777	6.6572	6.9247
$\sigma_{y^*,\xi^{vol=2}}$	Inv.Gamma	7.3328	7.3367	0.0746	7.2085	7.4538
$\sigma_{\pi^*,\xi^{vol=1}}$	Inv.Gamma	5.09	5.0717	0.0477	5.0186	5.1741
$\sigma_{\pi^*,\xi^{vol=2}}$	Inv.Gamma	9.5155	9.4522	0.0774	9.3967	9.6475
$H_{1,2}^{vol=1}$	Beta	0.1922	0.1021	0.0825	0.0958	0.339
$H_{2,1}^{vol=2}$	Beta	0.109	0.0925	0.0397	0.0577	0.1836

Table 8

ESTIMATED PARAMETERS OF PERU

Parameter	*Distribution*	*Mean*	*Mode*	*Standard dev.*	*10%*	*90%*
$\chi_{p,\xi^{coef=1}}$	Beta	0.1318	0.0928	0.0787	0.0321	0.2885
$\chi_{p,\xi^{coef=2}}$	Beta	0.1471	0.1609	0.0779	0.0352	0.286
$\kappa_{p,\xi^{coef=1}}$	Gamma	0.5011	0.3816	0.1019	0.3481	0.6833
$\kappa_{p,\xi^{coef=2}}$	Gamma	0.0565	0.0672	0.0171	0.0294	0.0863
$\rho_{R,\xi^{coef=1}}$	Beta	0.697	0.7132	0.0412	0.6211	0.753
$\rho_{R,\xi^{coef=2}}$	Beta	0.6254	0.6094	0.0656	0.5227	0.7344
$\psi_{\pi,\xi^{coef=1}}$	Gamma	1.9066	1.4844	0.5911	1.3059	3.309
$\psi_{\pi,\xi^{coef=2}}$	Gamma	0.9226	0.5921	0.5032	0.444	1.7992
$\psi_{y,\xi^{coef=1}}$	Gamma	0.4092	0.2172	0.2179	0.1659	0.859
$\psi_{y,\xi^{coef=2}}$	Gamma	0.5639	0.4629	0.2286	0.3263	1.0481
$\psi_{\Delta,\xi^{coef=1}}$	Gamma	0.1725	0.1612	0.0326	0.1215	0.2283
$\psi_{\Delta,\xi^{coef=2}}$	Gamma	0.1506	0.1693	0.0247	0.1139	0.1925
α	Beta	0.0393	0.0389	0.0166	0.0201	0.0757
r	Gamma	8.8041	1.8227	4.3353	1.4432	13.308
τ	Beta	0.1306	0.0582	0.0516	0.0522	0.2153
ρ_a	Beta	0.3605	0.3714	0.0521	0.2759	0.4462
ρ_q	Beta	0.3924	0.3134	0.0721	0.2687	0.5028

Parameter	*Distribution*	*Mean*	*Mode*	*Standard dev.*	*10%*	*90%*
ρ_{y*}	Beta	0.9682	0.9756	0.0133	0.9445	0.9877
$\rho_{\pi*}$	Beta	0.416	0.3717	0.0559	0.3277	0.5085
$H_{1,2}^{coef=1}$	Beta	0.0721	0.0662	0.0257	0.0276	0.1129
$H_{2,1}^{coef=2}$	Beta	0.0565	0.0615	0.0265	0.0191	0.101
$\sigma_{R,\xi^{vol=1}}$	Inv.Gamma	2.4271	1.0314	1.8471	0.9785	6.2415
$\sigma_{R,\xi^{vol=2}}$	Inv.Gamma	7.6316	7.4037	1.2162	5.286	9.3854
$\sigma_{q,\xi^{vol=1}}$	Inv.Gamma	4.1378	3.6176	0.7587	3.5144	6.1017
$\sigma_{q,\xi^{vol=2}}$	Inv.Gamma	5.1138	3.2364	2.213	2.7457	8.9518
$\sigma_{a,\xi^{vol=1}}$	Inv.Gamma	2.7075	2.2299	0.8397	2.0503	4.9969
$\sigma_{a,\xi^{vol=2}}$	Inv.Gamma	6.0456	3.837	1.7465	3.4937	8.618
$\sigma_{y^*,\xi^{vol=1}}$	Inv.Gamma	2.1448	0.2633	1.2789	0.2842	4.4775
$\sigma_{y^*,\xi^{vol=2}}$	Inv.Gamma	3.5942	0.2823	2.6484	0.3459	8.0066
$\sigma_{\pi^*,\xi^{vol=1}}$	Inv.Gamma	5.0435	4.6914	0.5071	4.3391	6.001
$\sigma_{\pi^*,\xi^{vol=2}}$	Inv.Gamma	5.0472	4.5065	1.3062	3.1803	7.6507
$H_{1,2}^{vol=1}$	Beta	0.0849	0.0213	0.1287	0.0103	0.4463
$H_{2,1}^{vol=2}$	Beta	0.1719	0.0582	0.1171	0.0427	0.4136

References

Alesina, A. and Summers, L. H. (1993). Central Bank Independence and Macroeconomic Performance: Some Comparative Evidence. *Journal of Money Credit and Banking*, 25(2):151- 162.

Bianchi, F. (2012). Regime Switches, Agents' Beliefs, and Post-World War II US Macroeconomic Dynamics. *Review of Economic* Studies, 80(2):463-490.

Bianchi, F. and Ilut, C. (2017). Monetary/Fiscal Policy Mix and Agents Beliefs. *Review of Economic Dynamics (forthcoming).*

Cho, S. (2016). Sufficient Conditions For Determinacy in a Class of Markov-Switching Rational Expectations Models. *Review of Economic Dynamics*, 21:182-200.

Cogley, T. and Sargent, T. J. (2005). Drifts and Volatilities: Monetary Policies and Outcomes in the Post WWII US. *Review of Economic Dynamics*, 8(2):262-302.

Corbo, V., Landerretche, O., Schmidt-Hebbel, K., *et al.* (2002). Does Inflation Targeting Make a Difference? *Inflation Targeting: Design Performance Challenges*, 5:221-69.

Farmer, R. E., Waggoner, D. F., and Zha, T. (2008). *Minimal State Variable Solutions to Markov-Switching Rational Expectations models*, Working Paper, No. 2008-23a, Federal Reserve Bank of Atlanta.

Farmer,R. E.,Waggoner,D. F.,and Zha,T. (2011).Minimal State Variable Solutions to Markov-Switching Rational Expectations models. *Journal of Economic Dynamics and Control*, 35(12):2150-2166.

Foerster, A., Rubio-Ramirez, J., Waggoner, D. F., and Zha, T. (2014). *Perturbation Methods for Markov-Switching DSGE Models.* Technical Report, National Bureau of Economic Research.

Gali, J. and Monacelli, T. (2005). Monetary Policy and Exchange Rate Volatility in a Small Open Economy. *The Review of Economic Studies*, 72(3):707-734.

Garriga, A. C. (2016). Central Bank Independence in the World: A New Data Set. *International Interactions*, 42(5):849-868.

Goncalves, C. C. S., Portugal, M. S., and Aragón, E. K. d. S. B. (2016). Assessing Brazilian Macroeconomic Dynamics Using a Markov-Switching DSGE Model. *EconomiA*, 17(1):23-42.

Kim, C.-J., Nelson, C. R., *et al.* (1999). *State-Space Models with Regime Switching: Classical and Gibbs-Sampling Approaches with Applications.* MIT Press Books, 1.

Liu, P. and Mumtaz, H. (2011). Evolving Macroeconomic Dynamics in a Small Open Economy: An estimated Markov Switching DSGE Model for the UK. *Journal of Money Credit and Banking*, 43(7):1443-1474.

Lubik, T. A. and Schorfheide, F. (2007). Do Central Banks Respond to Exchange Rate Movements? A Structural Investigation. *Journal of Monetary Economics*, 54(4):1069-1087.

Maih, J. (2015). *Efficient Perturbation Methods for Solving Regime-Switching DSGE Models.* Working Paper 2015/01, Norges Bank.

Ortiz, A. and Sturzenegger, F. (2007). Estimating Sarb's Policy Reaction Rule. *South African Journal of Economics*, 75(4):659-680.

Schmitt-Grohé, S. and Uribe, M. (2003). Closing Small Open Economy Models. *Journal of International Economics*, 61(1):163-185.

Sims, C. A. (2002). Solving Linear Rational Expectations Models. *Computational Economics*, 20(1):1-20.

Sims, C. A. and Zha, T. (2006). Were There Regime Switches in US Monetary Policy?, *The American Economic Review*, 96(1):54-81.