Fear of Floating or Monetary Policy as Usual? A Structural Analysis of Mexico's Monetary Policy

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Abstract

This paper estimates a small open economy DSGE model for the period after the financial and balance of payments crisis of 1994 using Bayesian methods. I consider a Taylor rule as the expression of the evolution of monetary policy in order to gauge its response to the exchange rate in the post crisis period. The estimation results favor a consistent response of the nominal interest rate to the short-run nominal exchange rate post 1994. This period is often described as the floating regime. This evidence provides some empirical support that responding to the exchange rate is as important to the Mexican central bank as responding to inflation. The results show that although fear of floating is present, Mexico's monetary policy has taken steps towards having a credible free floating exchange rate that targets inflation.

Keywords: Small Open Economy Models, Monetary Rules, Inflation Targeting, Fear of Floating.

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1. Introduction

Fear of floating[1] has been an endemic problem in emerging market countries for the past decades. This issue developed after the contagion of financial and balance of payments crises around the emerging markets such as in Mexico in 1994. Before the crises, most of these countries had as a common characteristic pegged or managed exchange rate policies. As part of their recovery, several of these countries allowed the exchange rate to float. In Mexico's case, low international reserves, a large current account deficit, and lack of credibility drove the policy authorities to have a floating exchange rate regime. However, Calvo and Reinhart (2002) concluded that most emerging markets are not true floaters. Instead, they are characterized by fear of floating. This paper looks at the Mexican economy experience after the financial and balance of payments crisis. I estimate a structural model that includes a Taylor rule as the expression of the evolution of monetary policy. The monetary policy rule evaluates to what extent the interest rate is responding to inflation or to the exchange rate in the post crisis period. This allows me to evaluate the Mexican central bank's claim that post 1994 monetary policy targeted inflation or if it reflected fear of floating.

Policy was characterized by a significant regime change after the financial and balance of payments crisis of 1994. Policy shifted from having a predetermined exchange rate to a floating exchange rate making monetary policy the nominal anchor of the economy after the crisis. There are several reasons why emerging markets, and in this case Mexico, have sought a predetermined exchange rate apart from the desire to stabilize inflation through the exchange rate, as addressed by Calvo and Reinhart (2002). Predetermined exchange rates have been adopted by emerging markets due in part to the association of devaluations with recessions. In addition, a large portion of these countries' debt is denominated in dollars, which make defaults and general debt servicing more pervasive if there are large swings in the exchange rate. If large depreciations occur, adjustments in the current account are more pronounced in emerging markets. Moreover, large swings in the exchange rate have a larger impact on trade mostly because trade is invoiced in U.S. dollars in these countries.

I estimate a Taylor rule to study if the central bank of Mexico is still respond-

[1] By fear of floating I mean that policy authorities take "deliberate policy actions to stabilize the exchange rate," Calvo and Reinhart (2002)

ing to changes in the exchange rate, behaving in accordance with fear of floating, or if it is targeting inflation after the crisis in order to corroborate if monetary policy has become the nominal anchor of the economy. Calvo and Reinhart (2002) compare the behavior of the volatility of the interest rate, the exchange rate, and the international reserves from different countries, including Mexico, that are suspected of fear of floating to the behavior of such variables in true floater countries such as Japan and the U.S. Ball and Reyes (2004) use the same analytical approach as Calvo and Reinhart (2002), as well as a VAR analysis in order to unravel if Mexico exhibits fear of floating or if it is an inflation targeter, and if the two are empirically distinguishable. Ball and Reyes (2004) find that indeed Mexico suffers from fear of floating by standard measures. Their results also suggest that a rise in the exchange rate today signals the coming of higher inflation tomorrow. Therefore, they find evidence of both, inflation targeting and fear of floating with more weight on inflation targeting. The contribution of this study is to estimate of a small open economy model for the Mexican economy under two different regimes, one that stands for a control that is known for having a managed exchange rate, and the second one that targets inflation but where fear of floating might be present.

In order to attain my goal I estimate a New Keynesian small open economy model using Bayesian methods. The small open economy model framework, derived from micro-foundations, offers a structural channel for the study of monetary policy. The model is derived from the optimization problems of the households and monopolistically competitive firms. The New Keynesian dynamic stochastic general equilibrium (DSGE) model has become a widely used tool for the study of monetary policy by researchers and policy makers. Large New Keynesian DSGE models have been estimated for the U.S. and Europe and small open economy models have been estimated for countries such as Australia, Canada, and New Zealand. In this paper I estimate a small open economy DSGE model for Mexico's emerging market economy. The estimated model is based on a simplification of the Galí and Monacelli (2005) small open economy model carried by Lubik and Schorfheide (2007) using likelihood based Bayesian methods. Within the small open economy framework most countries must be analyzed using the rest of the world and its effect on the small open economy; however, Mexico may be analyzed by simply using the influence of the U.S. economy. This is because the shocks that emanate from the U.S. business cycle have the greatest impact on the Mexican economy according to Del Negro and Obiols-Homs (2001). This conclusion was reached after computing the forecast variance decomposition for Mexican output and prices. The authors further state that the percentage of the forecast errors explained by the U.S. business cycles varies between $30 - 97\%$.

The estimatimation of a DSGE model for Mexico is performed for two subsamples, the period before and after the 1994 crisis. Within this framework this paper builds on Kamin and Rogers (1996) and Martinez, Sanchez and Werner (2000), who estimate a Taylor type of policy rule for the periods before and after the crisis respectively. Furthermore, multiple equation models have been estimated in Santaella and Vela (1996) before the crisis, in Martinez, Sanchez and Werner (2000) for the period after the crisis, and Del Negro and Obiols-Homs (2000) for the periods before and after the crisis, that portray the characteristics of a small open economy. However, the purpose of Kamin and Rogers (1996), and Santaella and Vela (1996), is to pin down whether the monetary authorities used an exchange rate stabilization program (ERBS) or a money based stabilization program (MBS) to contain inflation before the crisis, while the purpose of this paper is to evaluate if Mexico's monetary policy suffers from fear of floating after the crisis. The estimating procedure used in Martinez, Sanchez, and Werner (2000), and in Del Negro and Obiols-Homs (2000) is a VAR that has as its objective the study of the mechanisms of monetary policy transmission in Mexico. My estimation is closer to the model structure approximated by the VAR used by Martinez, Sanchez and Werner; however, I estimate a small open economy structural model. Del-Negro and Obiols-Homs use a money supply equation as a monetary policy reaction function, while my estimation utilizes a Taylor type rule.

The empirical analysis shows that the central bank of Mexico favors a consistent response to movements in the exchange rate during the floating exchange rate regime. Although the estimated positive response to exchange rate movements can be attributed to interventions by the central bank to relieve inflationary pressures, the response to the exchange rates in Mexico is higher than in other small open economies such as New Zealand, U.K., and Canada. Moreover, when the exchange rate and inflation policy parameters are normalized using their respective standard deviations, we still observe a comparable response to both variables by the central bank. Thus, there is some evidence that monetary policy in Mexico is conducted in accordance with fear of floating. In addition, I find that responding to inflation has become important in the years after the 1994 crisis. In the monetary policy rule analysis, the response of the interest rate to inflation in the floating exchange rate regime is more than one to one which compares to the reaction behavior addressed by the Taylor principle. I find much less concern by the monetary policy authorities to control inflation during the managed exchange rate regime. The estimation of impulse response functions for the pre-crisis and post-crisis subperiod also suggest that the Mexican central bank has improved its ability to insulate the economy against real shocks after the crisis. This is a relevant feature of the dynamics experienced by a country that has a flexible exchange rate regime. Therefore, Mexico's central bank is inflation targeting but suffering from some degree of fear of floating.

1.1. Brief History of Mexico's Monetary Policy (1976-2006)

From September 1976 to February 1982, there was a fixed exchange rate regime in place in Mexico, with the peso pegged to the U.S. dollar at almost a constant rate. By February 1982, Mexico suffered an inflation rate growing at 31% and dangerously low reserves. In addition, the country experienced a 28% overvaluation of the peso. All these factors led to a large devaluation in February 1982.

On February 17th, 1982 the peso was devalued by 85% after which Mexico adopted a flexible exchange rate regime that lasted until August of the same year. The economy was suffering from inflationary pressures that came from a large deficit financed by money creation and foreign borrowing, and an emergency wage increase. Moreover, Mexico was unable to meet its foreign obligations due to a critical currency shortage. The shortage was caused by the outflow of foreign capital, the coming to term of loans acquired in 1981, and the fall in oil prices. These events unleashed the August 1982 debt crisis that resulted in the nationalization of the banking system and the adoption of tighter capital controls. In addition, the monetary policy authorities adopted a pegged rate of depreciation of the peso to the dollar that lasted until 1988. By the end of this monetary policy regime yearly inflation was at an all time high of 150% caused in part by constant wage revision. Mexico underwent a devaluation of its currency in September and October of 1988.

The devaluations of September and October 1988 indicate the beginning of a new monetary policy regime that would gradually liberalize the exchange rate. The purpose of this regime was to abandon the exchange rate as the nominal anchor of the economy. In December 1987 Mexico adopted an anti-inflationary program that put an end to the constant wage revisions, privatized the banking system and fixed the exchange rate to the dollar. The fixed exchange rate regime lasted from March to December 1988 changing into a "Tablita" type regime that prevailed until October 1991. The "Tablita" regime let the peso's exchange rate adjust at a slow fixed pace that went from a daily devaluation of 1 peso per dollar, to .40 peso per dollar. The exchange rate was further liberalized into a "limited flexibility" regime that used a "widening exchange rate band" to control the depreciation of the currency. From October 1992 to the balance of payment crisis of December 1994, the band width reached 15% of the peso exchange rate with the dollar. The predetermined exchange rate bands helped to anchor inflation expectations in the economy during this regime. In December 22nd, 1994, the beginning of the Tequila crises, the monetary authorities adopted a floating exchange rate regime.

After the adoption of a flexible exchange rate, the economy experienced two regimes that intended to target inflation in the economy. The tool used as the anchor in the economy shifted from a controlled exchange rate in the previous regimes to a regime that controls monetary policy. In recent years, monetary policy oriented to target inflation has used the interest rate as the policy instrument. Policy has evolved from a borrowed reserves regime to a regime that used "discretionary actions of monetary policy" as Martinez, Sanchez and Werner (2000) concluded. Monetary policy authorities in Mexico have taken into consideration the output gap, expected inflation and shocks originating in the foreign sector to formulate a discretionary monetary rule. The evolution of monetary policy led to a rule that uses explicit inflation targeting as a preemptive source of stability.

2. A Simple Small Open Economy Model

The New Keynesian model has been extended to include the characteristics of small open economies (Galí and Monacelli (2005)). The small open economy model differs from the closed economy model in that the former assumes that the economy observes a higher degree of trade openness, higher substitutability across foreign goods, and a higher response of their main macroeconomic variables to outside shocks. The model essentially consists of a dynamic IS-type equation and a New Keynesian Phillips curve. The dynamic IS-type equation is derived from the "conventional" Euler equation that includes the consumption of goods produced at home and in the foreign economy taking into consideration the effective terms of trade. As described by Galí and Monacelli (2005) the wedge between consumption and output, and domestic and consumer prices changes the specifications of the New Keynesian Phillips curve. In this setting, the terms of trade and foreign output affect the wage through their effects on consumption[2]. The New Keynesian Phillips curve is also modified by the effects that trade openness has in the slope of the curve. In particular, a higher degree of trade openness affects the Phillips curve by dampening the impact that a change in domestic output exerts on inflation. A smaller change in the terms of trade is needed to accommodate a change in domestic output. In addition, in the IS-type equation, a higher degree of trade openness causes a stronger effect on the induced terms of trade on demand, making the output gap more sensitive to changes in the interest rate. An additional assumption of this model is that the economy observes complete international financial markets, which is admittedly a shortcoming of the model used for the Mexican economy setting.

The model specification follows Lubik and Schorfheide (2007) developed through a simplification of Galí and Monacelli (2005). The small economy model is log-linearized around a steady state and is composed by a New Keynesian Phillips curve (1), a dynamic IS-type equation (2), a CPI equation that introduces the exchange rate in the model (3), a policy rule(4), and a terms of trade equation. For a detailed discussion on the specification and derivation of the model see Lubik and Schorfheide (2007) and Galí and Monacelli (2005). The open economy

[2]For a more detailed explanation on the transmission mechanism of terms of trade and foreign output on marginal cost and the real wage see Galí and Monacelli 2005.

Phillips curve is given by:

$$\pi_t = \beta\ E_t\pi_{t+1} + \alpha\beta\ E_t\Delta q_{t+1} - \alpha\Delta q_t + \frac{\kappa}{[\tau + \alpha(2-\alpha)(1-\tau)]}(y_t - \bar{y}_t) + u_t \quad (1)$$

where $\bar{y}_t = -\alpha(2-\alpha)\frac{1-\tau}{\tau}{y_t}^*$ "is potential output in the absence of nominal rigidities" Lubik and Schorfheide (2007). The structural parameters present in the model are $\alpha \in [0,1]$ is the import share and it represents a natural index of trade openness, τ that is the intertemporal elasticity of substitution, and $\kappa > 0$ that is a function of price stickiness. The endogenous variables are the output gap y_t, CPI inflation rate π_t, first difference of the terms of trade Δq_t, and the U.S. output y_t*. The dynamic IS-type equation is described by:

$$y_t = E_t y_{t+1} - [\tau + \alpha(2-\alpha)(1-\tau)]\,(R_t - E_t\pi_{t+1}) \quad (2)$$

$$-\alpha[\tau + \alpha(2-\alpha)(1-\tau)]E_t\Delta q_{t+1} + \alpha(2-\alpha)\frac{1-\tau}{\tau}E_t\Delta y^*_{t+1} + g_t$$

Assuming relative purchasing power parity, the nominal exchange rate enters the model as:

$$\pi_t = \Delta e_t + (1-\alpha)\Delta q_t + {\pi_t}^* \quad (3)$$

Monetary policy is represented by a Taylor-type rule that responds to inflation, the output gap, and the exchange rate. The monetary policy parameters are denoted by ψ_π, ψ_y and ψ_e. The utilization of a Taylor type of rule for the study of the inflation targeting regime after the 1994 balance of payments crisis has been widely justified in previous literature for Mexico. Moreover, for the first regime[3] I follow Adolfson, Laseén, Lindé and Villani (2005) and Cúrdia and Finocchiaro (2005). They further explain the relevance of using a Taylor type of rule that includes the exchange rate in a open economy DSGE model for the study of monetary policy. Adolfson, Laseén, Lindé and Villani (2005) use an instrument rule where the central bank responds to deviations from an inflation target, the output gap, and the exchange rate. These authors claim that, although this rule is not based on optimization behavior, it performs well from an empirical view point[4]. Moreover, Cúrdia and Finocchiaro (2005) estimate a small economy

[3]The fixed exchange peg as observed in the first monetary regime is a special case of the observed Taylor rule. The Taylor rule with zero coefficients on all the state variables leads to the same rational expectations equilibrium as a pure exchange rate peg.

[4]In addition the authors conclude that the welfare loss from utilizing this instrument rule is not substan-

model for Sweden with a monetary regime change. The monetary regime changed from an exchange rate target zone to having flexible exchange rates with explicit inflation targeting. Cúrdia and Finocchiaro (2005) describe monetary policy by an interest rate rule, through which "the monetary authority reacts to exchange rate deviations from central parity." Sweden observed a target zone regime instead of a fully fixed exchange rate that allowed monetary authorities to have a more flexible management of monetary policy. Monetary policy could be used to stabilize other variables in the economy such as output and inflation. I observe this flexibility characteristic during Mexico's first monetary regime. An alternative specification would be to estimate a Taylor type rule where the interest rate responds only to movements in the exchange rate. However, in this paper I will let the data speak and I will estimate the same monetary policy rule for both periods.

$$R_t = \rho_R R_{t-1} + (1-\rho_R)[\psi_\pi \pi_t + \psi_y y_t + \psi_e \Delta e_t] + \epsilon_t^R \quad (4)$$

The terms of trade equation is represented by "the relative price that clears the international goods market" Lubik and Schorfheide (2007), which implies that prices of internationally traded goods are affected when there are changes in the economy even if the economy is relatively small. This equation also implies that when the rest of the world's output (in this case U.S. output) increases, the demand for domestically produced goods raise as well, which improves the terms of trade. The terms of trade relation is reproduced below:

$$[\tau + \alpha(2-\alpha)(1-\tau)]\Delta q_t = \Delta {y_t}^* - \Delta y_t + \epsilon_t^q$$

In this paper I follow Lubik and Schorfheide (2007) and I estimate a law of motion for the growth rate of the terms of trade given by equation (5) instead of the structural equation described above. This is done in order to make a more consistent comparison of the estimates obtained for Mexico in this paper and the coefficients previously estimated for New Zealand, U.K., and Canada. The law of motion is given by:

$$\Delta q_t = \rho_q \Delta q_{t-1} + \epsilon_t^q \quad (5)$$

The structural model composed of equations (1)-(5) is a linear Rational Expectations model[5]. I assume that ${y_t}^*$, and the disturbances u_t, g_t, ${\pi_t}^*$, ϵ_t^q follow

tially greater than when using optimal rules

[5]The rational expectations model was solved using Sims (2002).

an AR(1) processes with coefficients ρ_{y*}, ρ_u, ρ_g, $\rho_{\pi*}$, and ρ_q. I estimated the full set of structural, non-structural and policy parameters along with the standard deviations of the shocks. A unique and stationary equilibrium exists in this model as long as $\psi_e > 1$ or $\psi_\pi > 1$ which is referred to as the Taylor principle condition. In order to deal with the non-existent or multiple equilibria solution to the linear rational expectations model estimated, I discarded the parameter values that fall into the indeterminacy region of the parameter space. Thus, the parameter values reported are within the determinacy region. Although the issue of determinacy for the Mexican economy is beyond the scope of this paper, a plot of the determinacy region of the parameter space is reported in Figures 1 of the Appendix.

3. Bayesian Estimation Strategy

The estimation performed for this model is a Bayesian estimation following An and Schorfheide (2005). I estimate the set of structural and non-structural parameters, policy parameters, and corresponding standard deviations of the shocks jointly in the model and these are represented in a vector of 18 x 1 parameters denoted θ. The vector θ is composed by:

$$\theta = [\tau, \alpha, \kappa, \rho, \psi_\pi, \psi_y, \psi_e, \rho_{y^*}, \rho_g, \rho_u, \rho_{\pi^*}, \rho_q, \sigma_R, \sigma_{y*}, \sigma_g, \sigma_u, \sigma_{\pi*}, \sigma_q]' \quad (6)$$

The vector of observed variables consists of the CPI inflation rate, the output gap, the depreciation rate, nominal interest rate, first difference of the terms of trade, and U.S. output gap, and can be written as: Y_T=[π_t, y_t, Δe_t, R_t, Δq_t, y_t*].

A prior distribution is assigned to the parameters of the model and is represented by $p(\theta)$. The Kalman filter is used to evaluate the likelihood function given by $p(Y^T|\theta)$, where $Y^T = [Y_1, ..., Y_T]$. Lastly, the posterior distribution is obtained by updating prior beliefs through Bayes' rule taking into consideration the data reflected in the likelihood. Bayes' rule is represented by:

$$p(\theta|Y^T) = \frac{p(Y^T|\theta)p(\theta)}{p(Y^T)} \quad (7)$$

I estimate the posterior distribution through a Metropolis Hastings algorithm[6]. The specific simulation method that I use is random walk Metropolis Hastings for which I ran 300,000 iterations, discarding the initial 20% as burn-in.

3.1. Data

The estimation for Mexico was done using quarterly data from the second quarter of 1981 to the fourth quarter of 2005. The first monetary policy regime includes observations from 1981:2 to 1994:4, which marked the beginning of the financial and balance of payments crisis. The estimation for the second regime used data from 1995:1, when the monetary policy authorities were forced to let the exchange rate to float, to 2005:4[7]. The inflation measure was measured using log differences of the CPI or INPC (Indice Nacional de Precios as Consumidor) multiplied by 100 to yield quarterly percentage rates of change. Detrended output was used in the estimation and it was derived by the log difference between the GDP or or PIB (Producto Interno Bruto), seasonally adjusted, and its trend, scaled by a 100 to transform them into quarter-to-quarter percentages. As a measure of the interest rate I used the 91 days cetes, which is considered the Mexican equivalent of the federal funds rate. The nominal exchange rates of the peso to the dollar, and the terms of trade changes are also measured in log differences scaled by a 100 to transform them into depreciation rates, and percentage changes in the terms of trade. Lastly, I use U.S. output gap as the the log difference between GDP and potential GDP (CBO estimate). The CPI series, nominal exchange rate of the peso to the dollar, and terms of trade were obtained from DRI Webstract, while the values for GDP and cetes were obtained from the Banco de Mexico website in the section of Indicadores Economicos y Financieros. The U.S. output gap was obtained from the database of the Federal Reserve Bank of St. Louis.

3.2. Priors

The prior for the Bayesian estimation of the small open economy model for Mexico for the periods before and after the crisis, along with 95% prior probability

[6]For details on the specification of the Metropolis Hastings algorithm see Chib and Greenberg (1995).

[7]The data end in the beginning of 2006 in order to leave out the peak of the U.S. housing bubble and the financial crisis. This is important since the shocks that emanate from the U.S. business cycle have the greatest impact on the Mexican economy.

intervals can be found in Table 1. The choice of priors for the estimation of the model takes into consideration estimations of small open economy models for different countries and estimates from the previous literature for Mexico. The priors for the monetary policy rules ψ_π and ψ_y are centered at values estimated in Taylor (1993). I choose a non informative prior for the exchange rate policy coefficient ψ_e given by a uniform prior distribution with support [-2,2], which I consider to be the benchmark model. Moreover, as a robustness check, the model was re-estimated with an alternative prior for the exchange rate response in order to confirm that the data are in fact informative and that the results are not completely influenced by the prior. The alternative prior, centered at 1, is allowed to vary widely. The prior means for the interest rate smoothing parameter ρ, and κ, take values chosen by Lubik and Schorfheide (2007) for Canada, New Zeeland, Australia and Great Britain that are set at 0.5. However, the choice of prior for the measure of trade openness α has a higher mean than has been found in the previous literature for Australia, for example. This is because the proportion of total trade to GDP has increased from 15% in 1990 to 58% in 1999 in Mexico, while the same measure in Australia has increased from 26% to 31%. Thus, I center the prior for α at 0.5, as opposed to the estimate used by the Lubik and Schorfheide (2007) centered at 0.2. The prior means for the standard deviations to the shocks are not too informative, and they are allowed to vary widely.

Table 1: Prior Distributions

Name	Density	Mean	Standard Deviation	95% Prior Prob. Interval
τ	Gamma	1.00	0.50	[0.27,2.19]
α	Beta	0.50	0.20	[0.13,0.87]
κ	Gamma	0.50	0.20	[0.19,0.96]
ρ_R	Beta	0.80	0.10	[0.57,0.95]
ψ_π	Normal	1.50	0.25	[1.01,1.99]
ψ_y	Normal	0.50	0.25	[0.01,0.99]
ψ_e	Uniform	0.00	1.15	[-1.90,1.90]
ρ_{y^*}	Beta	0.80	0.10	[0.57,0.95]
ρ_g	Beta	0.80	0.10	[0.57,0.95]
ρ_u	Beta	0.80	0.10	[0.57,0.95]
ρ_{π^*}	Beta	0.80	0.10	[0.57,0.95]
ρ_q	Beta	0.80	0.10	[0.57,0.95]
σ_R	InvGamma	8.00	6.00	[0.80,23.37]
σ_y*	InvGamma	1.00	0.70	[0.12,2.78]
σ_g	InvGamma	7.00	4.89	[0.86,19.51]
σ_u	InvGamma	7.00	4.89	[0.86,19.51]
$\sigma_\pi*$	InvGamma	10.00	6.00	[1.88,24.68]
σ_q	InvGamma	7.00	4.89	[0.85,19.48]

4. Results

Parameter estimates for the post-crisis period can be found in Table 2. I report posterior means as point estimates and 95% posterior probability intervals. For the analysis of the results I will refer to the period after the balance of payment's crisis as the floating exchange rate regime. The post-crisis coefficients were estimated using data from 1995:1 to 2005:4. The parameters of interest in this model are the Taylor rule coeffients that describe the conduction of monetary policy.

The benchmark estimation for the floating exchange rate regime, (located on the left hand side of Table 2) show that the central bank of Mexico was concerned with stabilizing inflation ($\psi_\pi = 1.24$), was moderately concerned with output gap stabilization ($\psi_y = 0.37$), and was, in fact, reacting to changes in the exchange rate ($\psi_e = 0.40$). The estimation for the exchange rate coefficient takes on a value that is different from 0 as reflected in the 95% posterior probability interval ([0.13, 0.79]). Furthermore, this paper compares the estimated response to the exchange rate in Mexico for the floating exchange rate regime with previous estimates for other small open economies. The results for the New Zealand, U.K., and Canada from Lubik and Schorfheide (2007) are reproduced in Table 4 for convenience. The response that the short term interest rate prescribes to exchange rate movements is unequivocally higher in Mexico than in New Zealand, U.K. and Canada ($\psi_e = 0.04, 0.13, 0.26$). Moreover, the response to inflation is higher in these countries than in Mexico ($\psi_\pi = 1.69, 1.30, 1.80$.) Thus, evidence is found that fear of floating is stronger in Mexico than in New Zealand, U.K. and Canada.

In order to gauge the importance of inflation stabilization in comparison to exchange rate stabilization to the central bank of Mexico, the policy rule coefficients were standardized using the sample standard deviations of inflation and nominal exchange rate. The standardized coefficient on the exchange rate depreciation becomes $\psi_e = 3.36$ and the standardized coefficient on inflation is now $\psi_\pi = 3.85$. Therefore, based on a DSGE model estimation we can conclude that responding to inflation is roughly as important to the central bank of Mexico as responding to the exchange rate. The parameter coefficients for the floating exchange rate regime model estimated with the alternative prior (normal centered at 1 and with higher standard deviation) yield similar results to the results obtained for the benchmark model.

Although the focus of this paper is to analyze if Mexico responded to exchange rate movements after the balance of payments crisis, I estimate the model for the period before the crisis as well. During the period leading to the crisis the Mexican central bank had as objective to conduct policy in accordance with a managed or pegged exchange rate. The coefficients estimated for the pre-crisis period use data from 1981:2 to 1994:4, and are reported in Table 3. The Taylor type rule shows that the response to output did not change much during the floating exchange rate regime and the pre-crisis period, for the first regime ψ_y=0.37 and for the second regime ψ_y=0.38. These measures confirm that the central bank of Mexico was concerned with targeting output in their determination of the interest rates during both regimes and these values are similar to the response suggested in Taylor (1993) for the U.S. This is contrary to what is reported in Kamin and Rogers (1996). The authors conclude that the central bank of Mexico was not concerned with controlling output as part of their monetary policy in the pre-crisis regime, while their purpose was to control the exchange rate. Martinez Sanchez and Werner (2000), moreover, estimate that during the floating exchange rate regime monetary authorities were interested mostly in controlling the output gap and inflation in their conduction of monetary policy, that is consistent with what is found in this paper.

Table 2: Parameter Estimation Results

	Regime 2 (Benchmark model)		**Regime 2 (Forward looking policy)**	
Name	Mean	95% Post. Prob. Int.	Mean	95 % Post. Prob. Int.
τ	0.77	[0.41, 1.27]	0.59	[0.33, 0.97]
α	0.28	[0.08, 0.54]	0.21	[0.06, 0.42]
κ	0.43	[0.14, 0.83]	0.29	[0.10, 0.58]
ρ_R	0.64	[0.48, 0.77]	0.61	[0.44, 0.75]
ψ_π	1.24	[0.93, 1.60]	1.57	[1.20, 1.96]
ψ_y	0.37	[0.14, 0.68]	0.53	[0.23, 0.88]
ψ_e	0.40	[0.13, 0.79]	0.45	[0.20, 0.83]
ρ_{y^*}	0.91	[0.83, 0.97]	0.90	[0.83 0.96]
ρ_g	0.79	[0.64, 0.91]	0.73	[0.57, 0.86]
ρ_u	0.85	[0.73, 0.95]	0.85	[0.72, 0.95]
ρ_{π^*}	0.46	[0.30, 0.65]	0.45	[0.29, 0.62]
ρ_q	0.54	[0.34, 0.75]	0.56	[0.36, 0.77]
σ_R	0.80	[0.58, 1.11]	0.62	[0.48, 0.80]
σ_y*	0.55	[0.44, 0.70]	0.55	[0.44, 0.69]
σ_g	0.90	[0.50, 1.47]	0.88	[0.52, 1.38]
σ_u	0.80	[0.41, 1.39]	0.67	[0.36, 1.15]
$\sigma_\pi*$	3.49	[2.80, 4.34]	3.48	[2.81, 4.32]
σ_q	1.98	[1.56, 2.49]	1.99	[1.58, 2.50]

The parameter value for inflation in the pre-crisis regime is ψ_π=0.74, which supports the notion that monetary authorities did not use inflation targeting as the nominal anchor of the economy. The inflation parameter in the floating exchange rate regime is ψ_π=1.24 which implies that the response of interest rates to inflation is greater than 1. This estimate is consistent with the Taylor principle condition; however, it is still a more moderate anti-inflationary policy than what is observed for the U.S. economy where the same measure is close to 1.5.

In order to complete my analysis, and determine if Mexican policymakers respond to exchange rate movements in the policy reaction function, I take a closer look at the exchange rate coefficient. I observe a strong concern among the monetary policy authorities to target the exchange rate in the conduction of monetary policy during the pre-crisis regime (ψ_e=1.87). This measure is consistent with Mexico's history of managed exchange rate policies during the first regime and with parameter values reported by the previous literature. For the floating exchange rate regime I conjecture that Mexican authorities are much less concerned with targeting the exchange rate in their conduction of monetary policy. The measure for this period is ψ_e=0.40 so the estimation of a small structural model suggests that Mexico observes fear of floating although their response to the exchange rate did decrease considerably from the managed exchange rate regime to the floating regime.

The estimate of the intertemporal elasticity of substitution is higher in the floating exchange rate regime τ=0.77 than in the pre-crisis regime τ=0.11. The estimated of the measures of trade openness α are 0.02 and 0.28 for the first and second regimes respectively. The measure for the floating exchange rate regime shows that Mexico has a great degree of trade openness, than the value estimated for Canada. This result is expected due to the observable high degree of integration of the economy through trade experienced in the last decades. Moreover, α in previous estimations of small open economy models, such as in Lubik and Schorfheide (2007), has been lower than the estimated for the Canadian import share, α=0.11. Lastly I estimate a ρ, the interest rate smoothing term, at similar levels (0.52 and 0.64) than what has been reported in previous estimations for Canada where ρ=0.69.

The sensitivity of inflation to movements in the output gap, κ, is larger in the pre-crisis regime than in the floating exchange rate regime. As addressed in previous sections, κ is a function of the Calvo parameter that denotes price stickiness in the economy, thus a lower κ is representative of prices that do not change over longer periods of time. Therefore, in the floating exchange rate regime I observe a lower κ, which indicates stickier prices. This parameter value for the second regime is consistent with the lower inflation levels reported by the Mexican economy that could be attributed to the monetary policy measures adopted by the central bank, namely inflation targeting. By contrast the monetary authorities in the pre-crisis regime intended to target exchange rate, not inflation, so I detect greater sensitivity of inflation to movements in the output gap in the first regime than in the second regime. The measure for $\kappa = 0.43$ in the floating exchange rate period is comparable to estimates for the U.S. or Canada, where κ=0.32 for the latter.

Table 3: Posterior Estimates

	Regime 1 (Benchmark model)	
Name	Mean	95% Post. Prob. Int.
τ	0.11	[0.06, 0.22]
α	0.02	[0.00, 0.04]
κ	0.88	[0.43, 1.33]
ρ_R	0.52	[0.42, 0.61]
ψ_π	0.74	[0.54, 0.98]
ψ_y	0.38	[-0.05, 0.86]
ψ_e	1.72	[1.33, 2.00]
ρ_{y^*}	0.91	[0.84, 0.97]
ρ_g	0.72	[0.52, 0.89]
ρ_u	0.85	[0.74, 0.93]
ρ_{π^*}	0.79	[0.70, 0.87]
ρ_q	0.60	[0.42, 0.79]
σ_R	9.87	[6.97, 11.44]
σ_y*	0.76	[0.63, 0.96]
σ_g	1.30	[0.82, 2.56]]
σ_u	14.55	[8.01, 18.04]
$\sigma_\pi*$	15.44	[12.77, 18.07]
σ_q	6.89	[5.88, 8.07]

Lastly, Calvo and Reinhart (2002) analyze the behavior of the volatility of interest rates to determine if an economy shows fear of floating. The authors conclude that due to the lack of credibility that market agents have in monetary authorities in the presence of fear of floating, interest rate volatility is likely to be higher than when policies are credible. Hence, the likelihood of observing relatively large fluctuations in interest rates will depend on both the lack of credibility of the exchange rate regime and on the willingness of the monetary authorities to use interest rate policies as a means of stabilizing the exchange rate. In my analysis, the standard deviation of the interest rate shocks is much higher in the fist regime (9.87) than in the second regime (0.08). In general, the standard deviations of the different shocks to the economy are more accentuated in the first regime than in the second regime. The decrease in the volatility of the shocks to monetary policy from the pre-crisis period to the floating exchange rate period show that Mexico's monetary policy has taken steps toward having a credible free floating monetary policy that targets inflation.

4.1. Taylor Rule with Expected Future Variables

In addition to the benchmark estimation I also estimate the small open economy model given by equations 1-3 and 5 with an alternative specification for the Taylor type of rule. In this alternative rule the interest rate responds to expected future inflation as well as the expected future output gap using the same data set $D_1(L)$ as the benchmark model. This forward looking specification allows the central bank to respond to what they think are the future conditions of the economy. The central bank responding to forward looking variables is a realistic feature and has been discussed in Clarida et al. (2000). The forward looking Taylor rule is specified by:

$$R_t = \rho_R R_{t-1} + (1-\rho_R)[\psi_\pi E_t \pi_{t+1} + \psi_y E_t y_{t+1} + \psi_e \Delta e_t] + \epsilon_t^R \quad (8)$$

The results (right hand side of Table 2) give the same conclusions as in the benchmark model, but now the short term interest rate responses to future expected inflation and output gap are higher ($\psi_\pi = 1.57$ and $\psi_y = 0.53$) and closer to the values estimated in Taylor (1993) for the U.S. They are similar to their assigned prior distributions but the posterior distributions are more concentrated. The exchange rate coefficient is very similar to the benchmark model ($\psi_e = 0.45$.)

Table 4: Log Marginal Likelihoods based on $D_1(L)$

Specification	$\ln p(Y \mid \mu)$	Bayes factor versus $\mu_1(L)$
Benchmark model $\mu_1(L)$	-231.43	1.00
Model with forward looking variables $\mu_2(L)$	-230.44	exp[0.99]

Note: The log marginal likelihoods for the DSGE model specifications are computed based on Geweke's Modified Harmonic Mean approximation.

The model comparisons of the benchmark model $\mu_1(L)$ and the model that responds to future expected variables $\mu_2(L)$ are summarized in Table 4. The log marginal likelihood of model $\mu_2(L)$ is -230.44 which yields a Bayes factor of the model $\mu_1(L)$ versus the model $\mu_2(L)$ of only $e^{0.99}$. Therefore estimating a model with a Taylor rule that responds only to future expected output and inflation has a slightly better fit. However, the data set $D_1(L)$ does not provide very strong evidence against the benchmark model.

4.2. Impulse Response Functions

In order to understand the monetary transmission mechanisms in the Mexican economy for the pre-crisis and post-crisis subperiods, I derive impulse response functions for the macroeconomic variables in the model to a monetary policy shock. The responses are presented in Figure 2. In addition, in order to gauge the different dynamics present in the model I also study the reaction of the different variables to various other structural shocks (Figures 3, 4, 5, and 6) for the pre-crisis and post-crisis subperiods. Impulse response functions for the structural shocks were derived using the last 10,000 draws from the MCMC, and they denote averages over the sample and across draws. In addition I present 2.5nd and 97.5th percentiles.

A contractionary monetary policy shock produces a decline in inflation, the output gap, and an appreciation of the currency in both periods. The dynamics observed after a shock to monetary policy in this model are close to the impulse responses reported by Martinez, Sanchez and Werner (1999) that result from an estimation of a VAR. This implies that the identification strategy is adequate for the study of monetary policy rules within the DSGE framework and has the traditional transmission mechanisms that do not present a price, interest rate, or exchange rate puzzles as in Del Negro and Obiol-Homs (2001). The effect of each one of the shocks to monetary policy dies out before five quarters have passed, which shows that shocks to monetary policy do not persist in the economy for long periods of time.

Figure 3 presents the responses to a shock to the terms of trade. An improvement in the terms of trade has a positive impact on inflation and a positive impact on output that fades pretty quickly; it also leads to an appreciation of the exchange rate. An advantage attributable to having a flexible exchange rate regime over having a fixed exchange rate regime lays on its ability to insulate the economy more effectively against real shocks (Broda 2004 and Friedman 1953). For example, in response to a positive terms of trade shock, countries with fixed exchange rates have large increases in real GDP, and gradual appreciation of the real exchange, as well as increases in prices. By contrast, countries with flexible exchange rate regimes experience small GDP increases with sudden appreciations. In this paper, the dynamics experienced after an improvement in the terms of trade are consistent with traditional responses reported in the literature. Furthermore, I observe that the response of GDP after a terms of trade shocks is more accentuated in the managed exchange rate regime than in the floating exchange rate regime. The gradual appreciation of the exchange rate after a terms of trade shock in the pre-crisis period and the sudden appreciation in the post-crisis period are also present. This provides some evidence that the Mexican central bank has improved its ability to insulate the economy against real shocks after they adopted the floating exchange rate regime.

A shock to U.S. output, presented Figure 4, has a negative impact on the output gap which is stronger in the pre-crisis period than in the post-crisis period. This response is a direct consequence of the definition of flexible price output $\overline{y}_t$ (defined after equation 2) that is a negatively related to foreign output. The shock to U.S. output results in an increase in inflation and causes a depreciation of the currency. A relevant feature of the dynamics observed after this shock remains visible in the economy for longer than twenty five quarters.

In addition, the responses to domestic shocks can be found on Figures 5 and 6. A shock that affetcts domestic inflation causes a decrease in output, an increase in the interest rates and a devaluation of the currency. The effect of this type of shock remains in the economy for over ten quarters. Lastly, the shock that moves the nominal exchange rate, found on Figure 7, leads to a considerably large impact on inflation, an increase larger than any other response to inflation produced by any other shock in the managed exchange rate period; and a negligible effect on inflation in the post-crisis period. Output increases and the interest rate increase in the pre-crisis period, while the perceived effect of an exchange rate shock has an almost unnoticeable effect on the interest rate in the post crisis period.

In sum, a contractionary monetary policy in Mexico portrays the traditional moderate dynamics observed in a small open economy model. The U.S. output shocks show the most persistence in the variables of the model, staying in the economy for over twenty five quarters. It is important to note that shocks to the terms and to the exchange rate have almost no impact on inflation in the floating regime, while in the managed regime the effect is positive and large. This evidence supports the idea that the central bank of Mexico, under their floating exchange rate regime, has been effective at insulating inflation from external shocks including shocks to the exchange rate. The dynamics observed from the estimation of impulse respones for small open economy model for the post-crisis subperiod portrait the behavior of a free floater country.

5. Conclusion

I estimate a small open economy model for Mexico that uses a Taylor type rule as an expression of the evolution of monetary policy. In particular, I address the question of whether or not there is strong evidence that the period after the balance of payments and the financial crisis shows fear of floating. I conclude that fear of floating is present in the Mexican economy after the crisis. Furthermore, through the estimation of the DSGE model I find that the exchange rate has been the nominal anchor of the economy before the crisis while inflation rate has become the nominal anchor of the economy after the crisis.

Additionally, the monetary policy transmission observed in the model implies that a contractionary monetary policy shock produces a decline in inflation, the output gap, and an appreciation of the currency. However, the shocks to monetary policy do not persist in the model for longer than 5 quarters. By contrast, shocks to the U.S. business cycle cause dynamics in the variables of the model that persist over 25 quarters in the economy. In addition, after estimating impulse responses to shocks to the terms of trade and to the exchange rate, we can conclude that the adoption of the Mexican Central Bank of a floating exchange rate regime has aided at insulating the economy against real shocks. The responses present in the model for the pre-crisis and the post-crisis subsamples are consistent with the responses associated with a fixed exchange rate regime and a floating exchange rate regime respectively.

The estimated structural parameters show that the model can fit the high degree of trade openness observed in Mexico and could be extended to study the behavior of this characteristic in other emerging markets. In addition, when compared with estimates for other small open economies, the value for the sacrifice ratio between inflation and the output gap in Mexico is similar. Even though fear of floating is present in the data, I still observe a low degree of exchange rate response in the period after the 1994 crisis compared to the period before the crisis. The inclusion and study of pass-through in Mexico and its link to fear of floating is a topic that requires further research.

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Table 4. Posterior Means Lubik and Schorfheide (2007)

Posterior Means Lubik and Schorfheide (2007)

New Zealand	Mean	90% Posterior Prob. Int.
ρ_R	0.63	[0.53,0.72]
ψ_π	1.69	[1.24,2.13]
ψ_y	0.25	[0.13,0.37]
ψ_e	0.04	[0.01,0.08]
UK	Mean	90% Posterior Prob. Int.
ρ_R	0.74	[0.66,0.81]
ψ_π	1.30	[0.96,1.62]
ψ_y	0.20	[0.07,0.32]
ψ_e	0.13	[0.07,0.19]
Canada	Mean	90% Posterior Prob. Int.
ρ_R	0.78	[0.70,0.86]
ψ_π	1.84	[1.23,2.43]
ψ_y	0.54	[0.24,0.82]
ψ_e	0.26	[0.13,0.40]

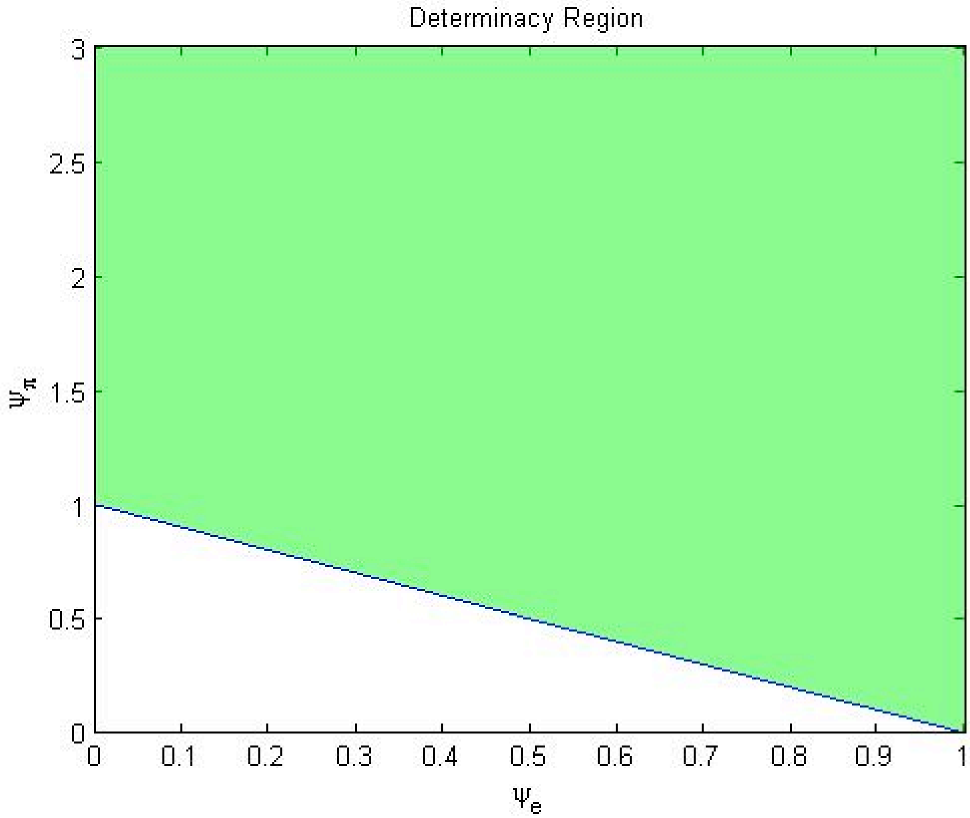

Figure 1: Determinacy Region

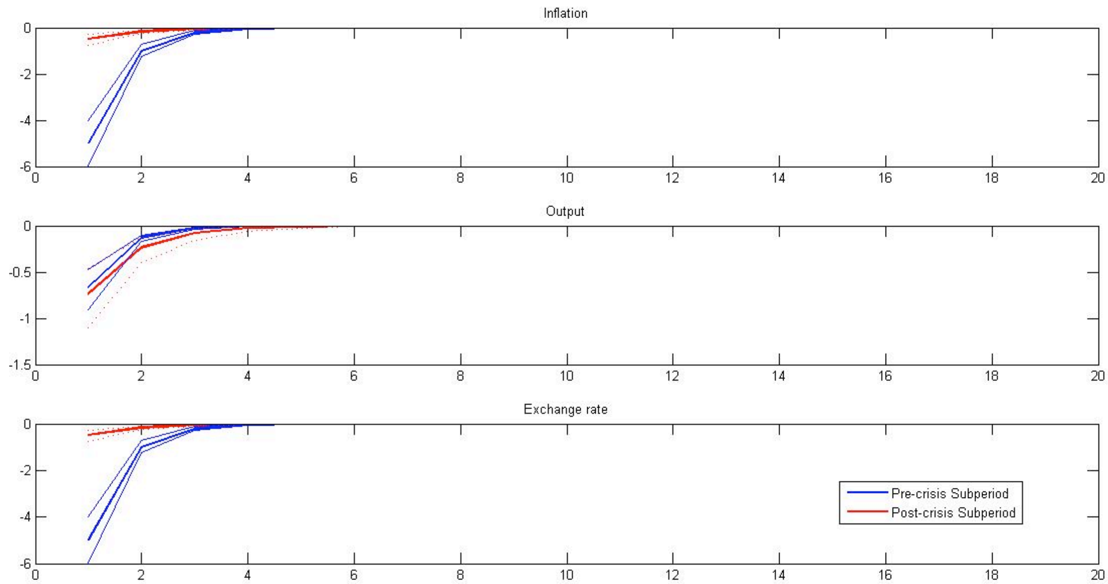

Figure 2: Impulse Responses to a Monetary Policy Shock

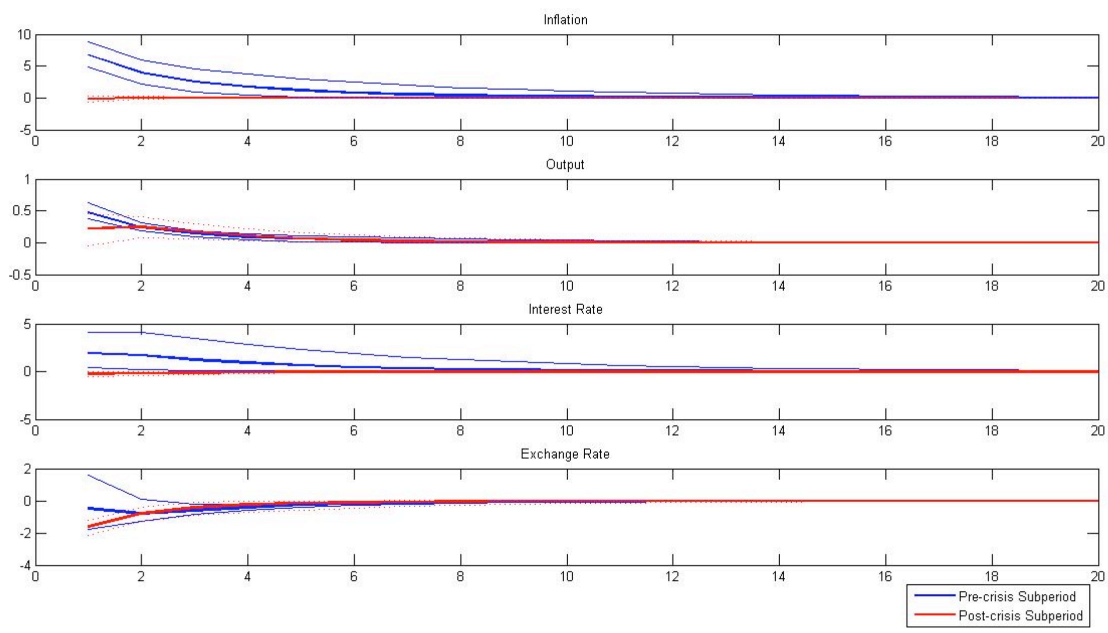

Figure 3: Impulse Responses to a Terms of Trade shock.

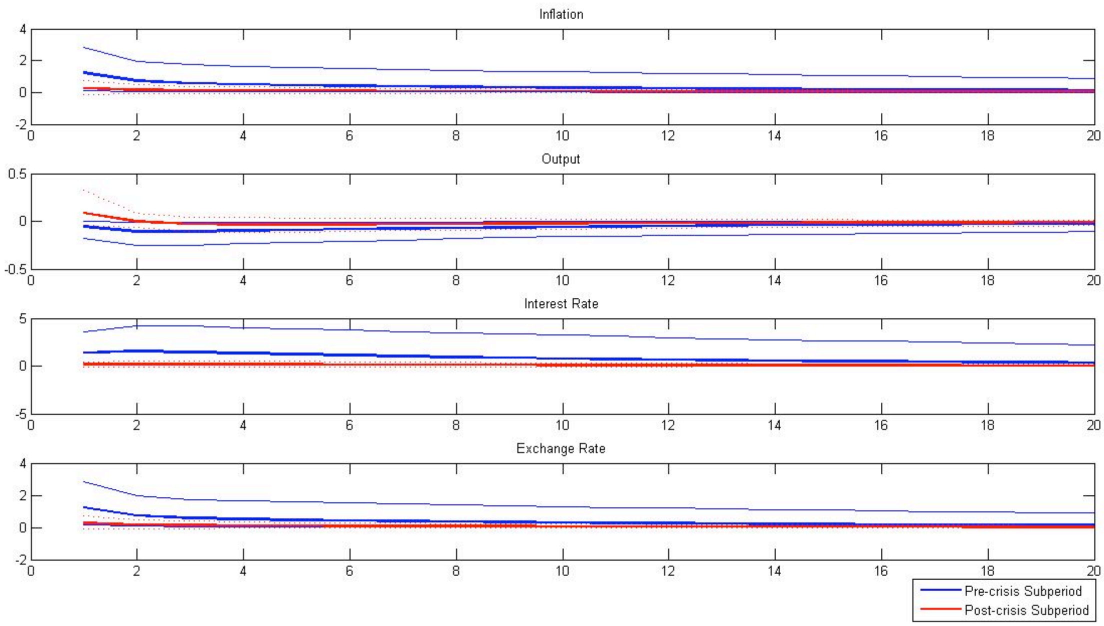

Figure 4: Impulse Responses to a Shock to U.S. Output.

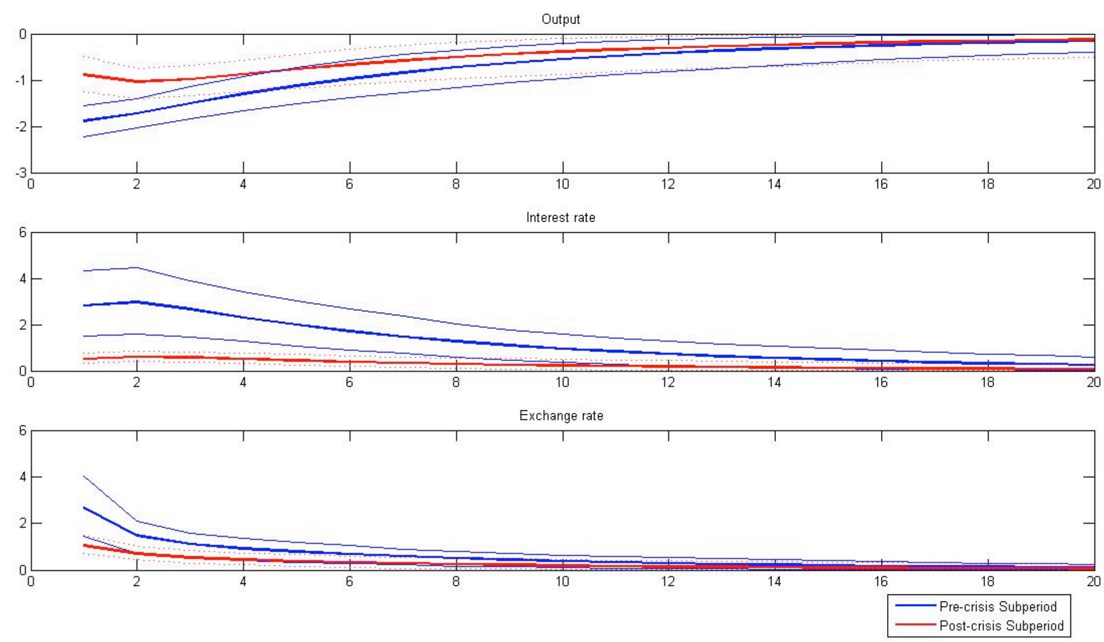

Figure 5: Impulse Responses to a Domestic Inflation.

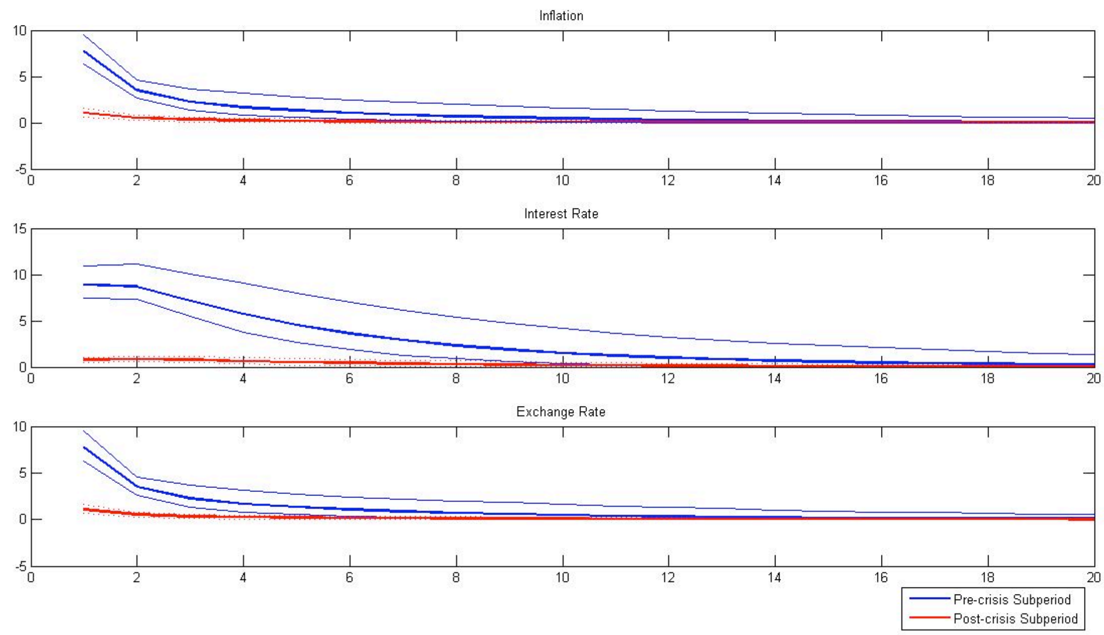

Figure 6: Impulse Responses to a Shock to Domestic Output.

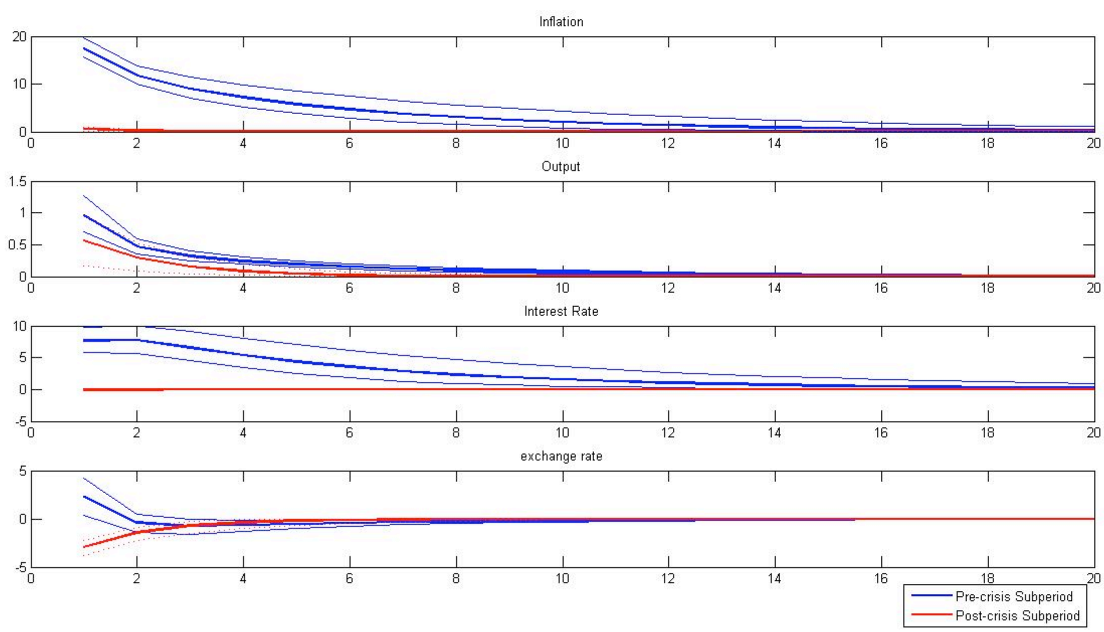

Figure 7: Impulse Responses to a Shock to the Exchange Rate.