

Documentos CEDE

ISSN 1657-7191 Edición electrónica.

Inflation Targeting in Colombia, 2002-2012

Franz Hamann
Marc Hofstetter
Miguel Urrutia

09

MARZO DE 2014

Serie Documentos Cede, 2014-09

ISSN 1657-7191 Edición electrónica.

Marzo de 2014

© 2012, Universidad de los Andes–Facultad de Economía–CEDE

Calle 19A No. 1 – 37 Este, Bloque W.

Bogotá, D. C., Colombia

Teléfonos: 3394949- 3394999, extensiones 2400, 2049, 3233

infocede@uniandes.edu.co

<http://economia.uniandes.edu.co>

Ediciones Uniandes

Carrera 1ª Este No. 19 – 27, edificio Aulas 6, A. A. 4976

Bogotá, D. C., Colombia

Teléfonos: 3394949- 3394999, extensión 2133, Fax: extensión 2158

infeduni@uniandes.edu.co

Edición y prensa digital:

Cadena S.A. • Bogotá

Calle 17 A N° 68 - 92

Tel: 57(4) 405 02 00 Ext. 307

Bogotá, D. C., Colombia

www.cadena.com.co

Impreso en Colombia – *Printed in Colombia*

El contenido de la presente publicación se encuentra protegido por las normas internacionales y nacionales vigentes sobre propiedad intelectual, por tanto su utilización, reproducción, comunicación pública, transformación, distribución, alquiler, préstamo público e importación, total o parcial, en todo o en parte, en formato impreso, digital o en cualquier formato conocido o por conocer, se encuentran prohibidos, y sólo serán lícitos en la medida en que se cuente con la autorización previa y expresa por escrito del autor o titular. Las limitaciones y excepciones al Derecho de Autor, sólo serán aplicables en la medida en que se den dentro de los denominados Usos Honrados (Fair use), estén previa y expresamente establecidas, no causen un grave e injustificado perjuicio a los intereses legítimos del autor o titular, y no atenten contra la normal explotación de la obra.

Inflation Targeting in Colombia, 2002-2012¹

Franz Hamann², Marc Hofstetter,³ and Miguel Urrutia⁴

Abstract

After decades using monetary aggregates as the main instrument of monetary policy and having different varieties of crawling peg exchange rate regimes, Colombia adopted a full-fledged inflation-targeting (IT) regime in 1999, with inflation as the nominal anchor, a floating exchange rate, and the short-term interest rate as the main instrument. We examine the experience of the Colombian Central Bank over the last decade, a period of consolidation and innovation of its IT strategy. We study the increasing number of instruments used by the CB, including systematic foreign exchange interventions, announcements, and, sporadically, macro-prudential policies, capital controls, and changes in reserve requirements, among others. The study also examines some political economy dimensions that help explain the behavior of the CB during this period. To guide the discussion, we estimate a small-scale open-economy-policy-model.

Key Words: Inflation Targeting, Monetary Policy, Exchange Rate, Taylor Rule, Colombia.

JEL Codes: E02, E32, E42, E43, E52, E58, E61, F31, F33, F42.

¹ This paper was written for the IDB project *Towards a "New" Inflation Targeting Framework in Latin America and the Caribbean*. We thank the Research Network of the IADB for financial support and feedback. We are also grateful to Andrés Fernández and an anonymous referee for valuable comments. Excellent research assistance by Rafael Hernández and Emilio Wills is also acknowledged.

² Banco de la República. Email: fhamansa@banrep.gov.co

³ Universidad de los Andes and CEDE, Bogotá, Colombia. Email: mahofste@uniandes.edu.co. webpage: <http://economia.uniandes.edu.co/hofstetter>.

⁴ Universidad de los Andes and CEDE, Bogotá, Colombia. Email: murrutia@uniandes.edu.co.

Inflación Objetivo en Colombia, 2002-2012⁵

Franz Hamann⁶, Marc Hofstetter,⁷ y Miguel Urrutia⁸

Resumen

Tras décadas utilizando los agregados monetarios como principal instrumento de política monetaria y de regímenes cambiarios tipo “devaluación gota a gota”, Colombia adoptó un esquema de inflación objetivo (IO) en 1999, con inflación como ancla nominal, una tasa de cambio flexible y con la tasa de interés de intervención como el principal instrumento. En este documento estudiamos el proceso de consolidación de IO durante la última década. Analizamos el uso de un número creciente de instrumentos por parte del Banco Central, incluyendo intervenciones cambiarias sistemáticas, anuncios, políticas macro-prudenciales, control de capitales y cambios de los encajes bancarios, entre otros. También examinamos aspectos de economía política que ayudan a entender el comportamiento del Banco Central durante esta década. Para guiar la discusión estimamos un pequeño modelo de política económica.

Palabras clave: Inflación objetivo, Política Monetaria, Tasa de Cambio, Regla de Taylor, Colombia.

Códigos JEL: E02, E32, E42, E43, E52, E58, E61, F31, F33, F42.

⁵ Este documento fue escrito para el proyecto de BID *Towards a “New” Inflation Targeting Framework in Latin America and the Caribbean*. Agradecemos a la Red de Investigación del BID por su ayuda financiera y valiosa retroalimentación. Agradecemos también a Andrés Fernández y un evaluador anónimo por sus comentarios. Un especial agradecimiento para Rafael Hernández y Emilio Wills quienes fueron de gran ayuda en el proyecto.

⁶ Banco de la República. Email: fhamansa@banrep.gov.co

⁷ Universidad de los Andes y CEDE, Bogotá, Colombia. Email: mahofste@uniandes.edu.co. web: <http://economia.uniandes.edu.co/hofstetter>.

⁸ Universidad de los Andes y CEDE, Bogotá, Colombia. Email: murrutia@uniandes.edu.co.

1. Introduction

Over the last 20 years, nearly 30 countries have adopted inflation-targeting (IT) regimes to conduct monetary policy. In addition to announcing specific inflation targets, IT regimes have been characterized by greater transparency, enhanced communication with the public, and explicit accountability mechanisms. Moreover, IT regimes base their policy strategy on setting short-run interest rates rather than on targeting monetary aggregates. In principle, IT regimes are also characterized by greater exchange rate flexibility.

The performance of IT regimes has been a matter of extensive research. For instance, Ball and Sheridan (2005) and Lin and Ye (2007) concluded that in industrialized countries, IT did not make a difference in inflation and output behavior. The spirit of these conclusions remains strong in two recent surveys on the performance of IT (Ball, 2010; Walsh, 2009). Another line of research concerning IT performance in industrialized countries studied its impact on sacrifice ratios—output losses per point of inflation during monetary-driven disinflations. According to IT proponents, IT anchors inflation expectations, and thus it should allow for less costly disinflation processes. While Goncalves and Carvalho (2009) find strong evidence supporting this hypothesis in developed countries, Brito (2010) shows that the results are not robust to the inclusions of time effects. De Roux and Hofstetter (2011) conclude that IT allows for less costly disinflations even when controlling for time effects, but only if disinflations are slow. For fast disinflations, IT does not yield less costly disinflations.

For developing countries, the evidence on IT performance is less conclusive. Goncalves and Salles (2007) conclude that IT allowed for a greater reduction in inflation and smaller output volatility, a result confirmed by Lin and Ye (2009). Brito and Bystedt (2010), however, suggest that the greater inflation reduction came at the expense of poorer output growth performance. In the surveys, Walsh (2009) concludes that evidence on IT performance in developing countries is clearly favorable to the regime, while Ball is more skeptical, calling the outcomes inconclusive.

More recently, Carvalho Filho (2011) shows that during the recent global financial crisis, IT nations outperformed non-IT nations in several dimensions for both developed and developing nations: their policy response was more aggressive, they allowed the exchange rate to absorb the shocks to a greater extent, and macroeconomic performance—output, industrial production, and unemployment—all exhibited better outcomes in IT countries.

The vast empirical literature comparing performance across different monetary regimes stands in contrast to the relatively scant research on the tools, strategies, goals, and dilemmas faced by IT central banks, especially in developing countries. While there is good information on the overall comparative performance of the IT regimes, little information is available about the political economy dimensions, the increasing variety of instruments and goals of IT central banks, and the challenges that lie ahead for them.

In this paper, we intend to fill part of this gap by examining the experience of the Colombian Central Bank over the last decade, a period of consolidation and innovation of its IT strategy. Colombia is one of five large Latin American economies that have well-established IT regimes, along with Brazil, Mexico, Peru, and Chile. In all of these countries, the IT regime was adopted more than ten years ago. However, their performance, tools, and goals have not been extensively studied. Central banks in the region have used a variety of tools beyond short-run policy interest rates. These include liquidity and reserve requirements, credit provisions, capital controls, and interventions in the foreign exchange markets.

We employ a variety of strategies to study these issues. We propose and estimate a small-scale open economy policy model for the Colombian economy. This allows us to pinpoint crucial parameters by which we can study some of the policy trade-offs and policy reactions of the Central Bank. We also provide narrative and anecdotal evidence for understanding some important episodes, tools, challenges, and trade-offs that marked the first decade of consolidation of IT.

Several findings are worth noting. Our model's estimates suggest that the impact of foreign variables on domestic outcomes is small and often insignificant. The pass-through of foreign shocks on domestic inflation and economic activity is negligible. While these findings might be surprising they are consistent with those found in other papers, e.g., Gomez, et al. 2002 and Rowland (2004) among others.

Despite the estimated dichotomy between the foreign and domestic blocks of our model, the results also suggest that real exchange rate misalignments trigger foreign exchange (FX) interventions by the CB. Moreover, the FX interventions have a short-lived impact on the exchange rate. Why does the CB react to the exchange rate if its impact on output and inflation is negligible? The hypothesis is that some of the FX interventions are explained by political economy issues. The CB has intervened in the FX market at times of strong political and media pressure to do so.

The FX interventions have been sizeable; they have almost quadrupled the international reserves (IR) over the last decade. This paper explores, both in the model and the narrative sections, whether these interventions have come at the cost of sacrificing the inflationary anchor or losing the credibility of the regime. It concludes that even though the Banco de la República (BR) has moved away from a purely floating IT regime, the inflationary anchor and the credibility of the regime have not been affected.

A related result studied is the build-up of IR. This poses new challenges for the CB, particularly recently, when yields on IR have been so low that they endanger the budgetary independence of the CB. We propose creating a sovereign fund that would be shielded from some of the problems that the BR would have if it tried to invest part of the IR more aggressively.

The rest of this paper is organized as follows. Section 2 presents a brief account of the road that led to the adoption of IT in Colombia by the turn of the century. Sections 3 and 4 present and estimate a simple macro policy model. Section 5 describes some trade-offs, political economy issues, and challenges faced by the CB during the 2002-2012 decade. They include the buildup of FX reserves, the role of financial stability and

supervision, political pressures, and the use of a reserve requirement, among others. The challenges in these areas are highlighted and policy recommendations are provided when appropriate. Section 6 concludes.

2. The Road to Inflation Targeting in Colombia

With the abandonment of the crawling peg that had been in place for 32 years, in 1999 Colombia formally adopted the monetary policy of inflation targeting (IT).⁹ While during the crawling peg and crawling band era the monetary instrument was the imperfect control of M1, after the exchange rate regime was abandoned the Banco de la República (BR) started using the short run policy interest rates as the main policy tool.

In 1991, the transition to IT in Colombia began when a new constitution conferred greater independence upon the CB's board and defined its principal function as maintaining the value of the national currency. In 1992, constitutional language was added mandating that the board would announce annual inflation targets.

The 1991 reforms resolved that the CB's board would have seven members, including the finance minister, who would head the board. The other members were the governor of the CB—named by the rest of the board members for four-year-periods, with a maximum of two reelections—and five independent members. The latter are named by the president—with the caveat that the president can only name two members during the second half of his or her mandate. This structure was originally designed to guarantee that most of the board would be elected by previous presidents to ensure its independence. Nevertheless, in 2005 a constitutional change allowed for the presidents to be reelected once, so that toward the end of a potential second presidential term, the president could have chosen four of the members of the board.

In the first seven years following the reform, control of monetary aggregates was difficult, and inflation was slowly reduced from the 32 percent per year recorded in 1991. Between 1992 and 1999, the CB instituted policies to deepen the money market and freed

⁹ From 1994 to 1999, the exchange rate floated within a crawling band.

different types of interest rates, while the Ministry of Finance actively created a market in government debt in pesos by taking advantage of the declining inflation rate. These institutional changes made possible a more effective use of interest rates as the monetary policy tool.

Full-fledged IT required more room to float the exchange rate. After more than a quarter of a century with a crawling peg and a few years with an exchange rate band, there were deep political constraints to floating the exchange rate. The crawling peg had been a popular policy, since many government officials and export lobbyists believed it was essential for stabilizing the exchange rate. By the 1980s, the export lobby had become the most influential lobby. As capital flows and oil development increased the supply of foreign exchange in that decade, the export lobbyists—fearing revaluation—mobilized against any policy that would free the exchange rate.

These exchange rate regimes, nevertheless, made the control of monetary aggregates difficult during the 1990s, amidst unprecedented volatility of capital flows—sharp inflows during the early part of the decade and outflows during the latter part of the decade. These lobbies favored floating only when the persistent and strong market pressure for devaluation that followed the Asian and Russian crises arose during the late 1990s. When this cornerstone was finally in place, Colombia adopted a full IT policy framework in 1999. The legal changes in the early 1990s and the economic circumstances during the following years paved the way for adoption of IT by the turn of the century.

In its early stages, the monetary strategy was a textbook IT system. In 2002, Gomez, Uribe and Vargas identified three key aspects of the Colombian transmission mechanism: an inflation process that is persistent, a strong aggregate demand channel, and a relatively weak and indirect exchange rate effect. The board's decision making reflected this conclusion during the early stages of IT in Colombia. Monetary policy concentrated on setting interest rates, taking into account the projection of inflation and the output gap: exchange rate intervention was not in the toolkit, except for the necessary buildup of international reserves that had been partially depleted after the crisis, according to the IMF stand-by loan commitment. The BR's toolkit expanded significantly over the following

decade to include systematic FX interventions, capital controls, changes in reserve requirements, and changes in credit provisions, among others.

Our analysis is divided into two parts. First, a small-scale macro model has been estimated. The results of the model will be an input for analyzing the BR's performance in the IT era. Second, a narrative section is presented in which details of the trade-offs, pressures, operational characteristics, and the like, for the BR during the first decade of the IT's consolidation are analyzed. Insights beyond those included in the model are provided by, for example, emphasizing several political economy dimensions, while adding to the interpretations and policy lessons of the model's empirical findings.

3. The Model

We start with a three block model a la Galí and Gertler (2007) summarizing the (i) economic activity—via an IS curve—, (ii) the determination of inflation—via a Phillips curve—and (iii) monetary policy reaction function—via a Taylor rule—. We adapt these equations to the Colombian peculiarities and expand them to incorporate open economy dimensions crucial for understanding the policy options and dilemmas of the BR.

Variables are expressed in deviations with respect to trend—or long run values—unless otherwise stated. A superscript e denotes the one-step-ahead expected value of the variable conditioned on all available information at date t . The symbol ε_t^j denotes a shock to variable j at time t .

Equation (1) represents an expectations-augmented Phillips curve:

$$\pi_t = a_0\pi_t^e + (1 - a_0)\pi_{t-1} + a_1d_t + a_2y_t + \varepsilon_t^\pi \quad (1)$$

where π_t is the annual inflation rate (in deviation with respect to the inflation target), π_{t-1} is the lagged inflation rate, π_t^e are the inflation expectations, d_t denotes the nominal depreciation rate and y_t the output growth gap, defined as the deviation of observed annual GDP growth with respect to its long run value, which we assume is exogenous to the model, ε_t^π is a supply shock.

Lagged inflation captures the inertia of the inflationary process or the adaptive component of expectations and π_t^e the forward-looking. The sum of their corresponding coefficients adds to one because in the steady state the observed inflation rate should converge to the inflation target, that is $\pi_{t-1} = \pi_t = \pi_t^e = \bar{\pi}$, where $\bar{\pi}$ is the central bank inflation target. The term $a_1 d_t$ describes the potential pass-through effects from the nominal exchange rate to prices.

The second equation of the model is the IS curve:

$$y_t = b_0 y_{t+1}^e - b_1 r_t + b_2 e_t + \varepsilon_t^y \quad (2)$$

where r_t is the real interest rate (ex-post), y_t^e is the expected output growth gap, e_t is the real exchange rate and ε_t^y is the demand shock. This IS curve takes into account the effects of the real exchange rate on the output growth gap. The implicit assumption is that net exports are part of aggregate demand and they depend on the real exchange rate.¹⁰ Whether the parameter b_2 is positive or negative has been a matter of debate. For some, it should be positive because a real depreciation stimulates exports and deteriorates imports. For others, real exchange rate depreciations are mostly associated with recessions and not with expansions. Later, when we confront the model with the data, the Colombian data will speak for themselves.

What about the policy reaction functions of the central bank? For that purpose, it is important to have some background on the targets of CBs and the instruments that they use. In spite of having an IT regime, it is apparent that the CB has several targets, such as inflation, economic activity, financial stability, the exchange rate, and having an adequate level of international reserves. This variety of goals creates room for potential trade-offs and conflicts among them. The variety of goals needs a variety of instruments. The BR has used different tools during the IT era. The two most important tools are the policy interest rate and interventions in the FX market. They will be incorporated into the model. To a lesser extent, the BR has also used macro-prudential policies, reserve requirements, and

¹⁰ We are also assuming that foreign output gap does not affect net exports. This assumption is for convenience because we do not have good monthly estimates of foreign economic activity.

capital controls. While these are not explicitly modeled, they are discussed later in the paper.

The way the CB sets the nominal interest rate is modeled via a Taylor rule. As a starting point, a simple interest rate rule that captures the basic logic of the conventional monetary policy instrument is used, where the Bank reacts to output and inflation gaps. The short-term interest rate is defined as:

$$i_t = c_0 i_{t-1} + c_1 \pi_t + c_2 y_t + \varepsilon_t^i$$

where i_t is the (domestic) nominal interest rate defined as $i_t = r_t + \pi_t^e$. When the analysis delves deeper into FX intervention, this interest rate rule will be modified.

Before describing the second instrument, FX interventions, the foreign block of equations of the model is introduced. It is inspired by the framework reported in Ostry et al., (2012), where the determination of the real exchange rate is modeled through the balance of payments: capital flows, the current account, and the reserves accumulation. The capital flows and the current account are linked through the balance of payments identity:

$$k_t + ca_t = x_t \quad (3)$$

where x_t are the net foreign exchange purchases of the central bank. Capital flows, assumed to be imperfectly mobile, are described as:

$$k_t = d_0 k_{t-1} + d_1 [r_t - r_t^* - (e_t^e - e_t)] + \varepsilon_t^k \quad (4)$$

where k_t are net capital flows, and d_1 is a parameter that captures the degree of capital mobility. We expect this parameter to be positive, as the larger the interest rates differential, the greater the capital inflows. Also, the perfect capital mobility case would correspond to d_1 approaching infinity.

In addition, as has been common in the macroeconomic programming analysis, the current account, ca_t , depends positively on the real exchange rate and negatively on local domestic activity:

$$ca_t = f_1 e_t - f_2 y_t + \varepsilon_t^{ca} \quad (5)$$

Thus, we expect f_1 and f_2 to be positive. An unusual rate of appreciation ($e_t < 0$) would imply a deteriorated current account. The opposite would happen if the exchange rate depreciates above its long equilibrium depreciation rate. Also, if the output growth gap is positive (negative), we expect a deterioration (improvement) of the current account.

The model is closed with an FX intervention rule. FX interventions—while rare at the beginning of this decade—took center stage after 2007. For purposes of modeling the FX interventions, the relevant question is: how does the CB intervene?

During the past ten years, the Banco de la República has used a variety of intervention strategies in the FX market. The CB has adopted four main intervention modalities to fulfill its objectives. Figure 1 shows the importance of each of them: options for reserve accumulation, options for the control of volatility, discretionary interventions, and pre-announced fixed daily interventions.

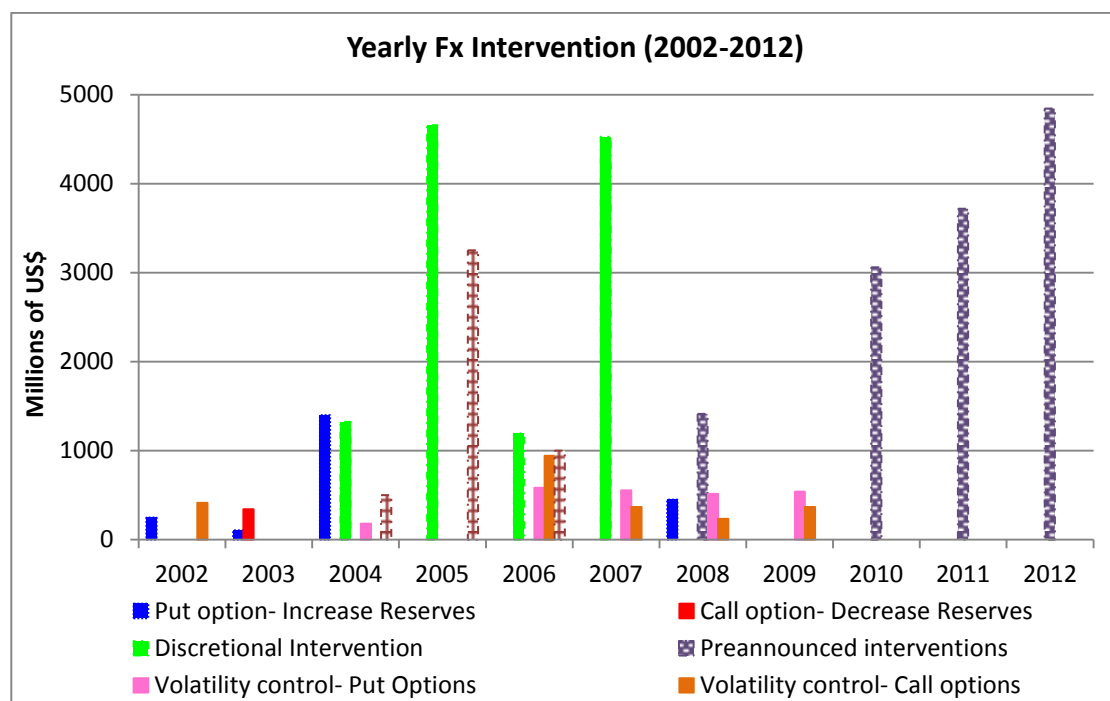
The options for reserve accumulation are based on put/call option auctions to increase/decrease the amount of international reserves. They were established in November 1999 under the floating exchange rate regime to counterweigh the strong reduction of reserves that took place in 1997-2000. These options were used until September 2004 and then again in the second quarter of 2008.

Exchange rate volatility control operations were the primary mechanism used by the CB for selling FX. During the period studied, the CB was eager to accumulate reserves. The CB reduced its FX reserves only by this means and by sales to the government.¹¹ Volatility options allowed the CB to automatically auction call or put options if the

¹¹ The CB also used the options for reserve accumulation strategy, but only in March and May of 2003 and sold a total of US\$344.5 million. Sales to the national government accounted for a total of US\$4,750 million and took place in 2004, 2005, and 2006.

exchange rate was above (call option) or below (put option) its 20-day rolling average¹². They were used as both a purchase and a sale mechanism in 2002, 2004, and 2006-2009.

Figure 1



In September 2004, the CB adopted the discretionary interventions that explain most of the purchases in 2004-2007. This instrument allowed the board of directors to decide, with no strings attached, the amount and the mechanism used to purchase international reserves. In 2005 and 2007, the CB purchased an historical amount of international reserves of over US\$4.65 billion and US\$4.5 billion, respectively.

By mid-2008, the CB introduced the preannounced fixed daily purchases, which became the most important FX purchase strategy during the next five years. The idea of the strategy was to announce how much daily intervention there would be over the next few months, in an effort to influence market expectations. Most often, the CB announced

¹² This percentage has fluctuated in the past ten years: it began at 4% and changed to 2% in February 2006; to 5% in June 2008; and back to 4% in October 2011.

US\$20 million daily FX purchases over a three to four-month period. By January 2013, the announced purchases were boosted to US\$30 million per day.

These facts highlight the importance of a monetary policy model to capture the alternative types of the CB's FX intervention: unexpected discretionary interventions, rule-based interventions as well as announcements. In the model, this is done by considering an FX intervention equation with systematic and non-systematic components.

The first one works like a Taylor rule: the instrument is the net FX purchases—as a share of the stock international reserves—and adjusts to meet a real exchange rate target. The second component has two elements: a direct shock, which is interpreted as unexpected FX interventions, and a news shock, which is interpreted as announcements of planned purchases. Thus, the FX intervention equation encompasses three types of interventions: a rule-based, a discretionary, and a pre-announced:

$$x_t = g_0 x_{t-1} - g_1 e_t + \varepsilon_t^x \quad (6)$$

which indicates that the bank follows a simple international reserves intervention rule with systematic and non-systematic components. The first, captured by the first two terms of equation (6), says that when the real exchange rate deviates from its long-run level, the central bank responds systematically by buying or selling international reserves, x_t . That is, a positive real exchange rate gap denotes that the local currency is undervalued with respect to its long run equilibrium, and the bank sells reserves. The opposite happens if the currency is overvalued.

The second term, ε_t^x , is the non-systematic component of the intervention. The Colombian experience of the last ten years showed that FX intervention is performed not only through direct FX purchases or sales, but also through announcements, threats, and all sort of events that do not necessarily involve any direct intervention. Therefore, we model ε_t^x as the sum of two orthogonal i.i.d. terms:

$$\varepsilon_t^x = u_t + n_{t-1} \quad (7)$$

where the time subscripts of the variables represent the date when they are known to private agents. Thus, n_{t-1} becomes known at the previous month, representing news or all other events that may affect the amount of FX intervention, even if no intervention has happened at all at date t . This way, we seek to capture any event that becomes known to private agents in the previous month before the central bank surprises them by buying or selling FX intervention during the current month. Also, when $u_t = -n_{t-1}$, the announcement or news might not be transformed into actual interventions.

Just as the standard model assumes that by changing the nominal interest rate the central bank's actions impact economic activity, the non-standard portion of our model assumes that the second instrument has some degree of effectiveness. An FX purchase shock leads to an adjustment of both capital flows and the current account, which in turn could affect the real exchange rate, output, inflation, and interest rates. Whether the central bank has been effective in impacting the real exchange rate, as well as other variables, through the use of all these instruments is an empirical question. To measure the relative importance of discretionary interventions (measured through the importance of u_t , and “announced” interventions (measured through the importance of n_{t-1}), a shock decomposition exercise with the estimated model is performed.

We postulate and later test the hypothesis that, when the central bank intervenes in the FX market, it may send conflicting signals about the exchange rate regime. When the BR sells or purchases reserves, agents will assign a probability—that can be estimated—of being in a peg, instead of a floating regime. Consider two polar cases. In a fixed exchange rate regime, the nominal interest rate would be fully determined by the foreign interest rate, that is, $i_t = i_t^*$; in a floating IT regime the nominal interest rate is determined by a Taylor rule. Let $q(x_t)$ be the probability that the agents assign to the peg. It is an increasing function of the amount of FX purchases defined below. Conversely, $1 - q(x_t)$ is the probability that agents assign to being in the IT flexible exchange rate regime. Then the nominal interest rate would be:

$$i_t = [1 - q(x_t)][c_0 i_{t-1} + (1 - c_0)(c_1 \pi_t + c_2 y_t) + \varepsilon_t^i] + q(x_t) i_t^* \quad (10)$$

$$\text{where } q(x_t) = \frac{1}{1+e^{-x_t^2}} - q_0.$$

Note that when $x_t \rightarrow 0$ and $q_0 = 1/2$, $q(0) \rightarrow 0$, the economy behaves as in a full-fledged IT floating exchange rate regime. On the contrary, any FX intervention ($x_t > 0$) implies a positive value of $q(x_t)$, weakening the power of the interest rate rule. This is one way to capture the credibility cost of such interventions, performed during the last ten years of IT in Colombia. To our knowledge, this type of credibility cost has not been implemented yet in the literature of central banking.

The last set of equations of the model corresponds to the exogenous AR(1) process for the external real interest rate and foreign inflation:

$$r_t^* = \rho_{r^*} r_{t-1}^* + (1 - \rho_{r^*}) r^* + \varepsilon_t^{r^*}. \quad (11)$$

$$\pi_t^* = \rho_{\pi^*} \pi_{t-1}^* + (1 - \rho_{\pi^*}) \pi^* + \varepsilon_t^{\pi^*}. \quad (12)$$

where the external nominal interest rate $i_t^* = r_t^* + \pi_{t+1}^e$.

In practice, the BR's toolkit included systematic FX interventions, capital controls, changes in reserve requirements, and changes in credit provisions, among others. The focus so far has been on the role of FX intervention in its different versions, but later there will be commentary about other instruments.

4. Estimation and Results

We now turn to the estimation of the model. First we summarize the complete model in Table 1.

Table 1: Summary of the Model

$\pi_t = a_0\pi_t^e + (1 - a_0 - a_1)\pi_{t-1} + a_1d_t + a_2y_t + \varepsilon_t^\pi$	(1)
$y_t = b_0y_{t+1}^e - b_1r_t + b_2e_t + \varepsilon_t^y$	(2)
$k_t + ca_t = x_t$	(3)
$k_t = d_0k_{t-1} + d_1[r_t - r_t^* - (e_t^e - e_t)] + \varepsilon_t^k$	(4)
$ca_t = f_1e_t - f_2y_t + \varepsilon_t^{ca}$	(5)
$i_t = r_t + \pi_t^e$	(6)
$i_t = [1 - q(x_t)][c_0i_{t-1} + (1 - c_0)(c_1\pi_t + c_2y_t) + \varepsilon_t^i] + q(x_t)i_t^*$	(7)
$q(x_t) = \frac{1}{1+e^{-x_t^2}} - q$	(8)
$x_t = g_0x_{t-1} - g_1e_t + \varepsilon_t^x$	(9)
$\varepsilon_t^x = u_t + n_{t-1}$	(10)
$r_t^* = \rho_{r^*}r_{t-1}^* + (1 - \rho_{r^*})r^* + \varepsilon_t^{r^*}$	(11)
$\pi_t^* = \rho_{\pi^*}\pi_{t-1}^* + (1 - \rho_{\pi^*})\pi^* + \varepsilon_t^{\pi^*}$	(12)
$i_t^* = r_t^* + \pi_{t+1}^{*e}$	(13)

We estimate the model by Bayesian methods, incorporating additional information on parameters through the use of priors. We follow Schorfheide (2000) proceeding in five steps. First, for a given set of parameters, we solve the model, according to Klein (2000), to find the state transition equation. This approximation to the solution defines the behavior of the system around the deterministic steady state. The state-space representation is then completed by adding a measurement equation to the model dynamics. Next, we compute the likelihood through Kalman filtering and combine it with the prior distribution of the parameters. This yields the posterior density. Draws from the posterior density are derived using the random walk Metropolis-Hastings algorithm. The algorithm is started at the posterior mode, or at some point nearby with a high probability density, found by numerical optimization.

Data

Monthly data from 2002:1 to 2012:6 were used. This is another novel aspect of this research because most estimated models for policy analysis use quarterly data. By using monthly data, the reliability of some information was sacrificed, particularly about economic activity, since Colombia lacks monthly GDP data. Since, however, part of the focus is on quantifying the impact of FX intervention, a high frequency dataset is better suited for this task.

All data, unless otherwise stated, were detrended by the Hodrick and Prescott filter. The smoothing parameter was set using the frequency rule suggested by Ravn and Uhlig to the power of 8. This relatively high-power smoothing parameter removes only the very low frequency movements of the time series.

As a proxy of the nominal interest rate, we use the central bank's policy intervention rate. The inflation measure is the annual growth rate of the CPI. To account for the Colombian disinflation process, inflation data was detrended using the midpoint of the official central inflation rate target for that year. Output is measured as the year-over-year real GDP growth rate estimated by the IMACO, a 12-month economic activity indicator calculated by the Banco de la República. As a proxy for the real exchange rate, we use the TCR-IPC index published by the central bank, which is a RER index weighted by Colombian trade with the main trade partners and deflated by the consumer price index.

The Central Bank also provided us with its data of the net foreign exchange purchases. This time the series was not detrended, as net purchases can be positive or negative when the central bank buys or sells FX reserves. As a proxy of the foreign interest rate, the Fed funds rate were used (as a deviation from a long term value of 2%), adjusted by a risk term, which was measured as the VIX index in deviations from trend.¹³ Also used was a proxy time series data for the variable “net capital flows,” k . The Foreign Exchange

¹³ To compute the risk term we take the VIX in levels and transform it into logs and extract the Hodrick-Prescott trend. The difference between the observed log (VIX) and its trend is the risk factor in percent deviations. We add this factor to the deviations from trend of the Fed funds rate.

Balance (*Balanza Cambiaria*), a monthly statistical report of the central bank, was employed as a source for the data of net private capital flows.¹⁴

Priors

Let $X_t = (y_t, \pi_t, i_t, e_t, x_t, r_t^*, \pi_t^*)$ denote the observed data and let $\beta = (a_0, a_1, a_2, b_0, b_1, b_2, c_0, c_1, c_2, d_0, d_1, f_1, f_2, g_0, g_1, q, \rho, \sigma)$ be the parameters to be estimated, where $\rho = (\rho_\pi, \rho_y, \rho_k, \rho_x, \rho_{r^*}, \rho_{\pi^*})$ and $\sigma = (\sigma_i, \sigma_\pi, \sigma_y, \sigma_k, \sigma_u, \sigma_n, \sigma_{r^*}, \sigma_{\pi^*})$ are the vectors of parameters that characterize the autocorrelation and the variances of the shocks. In the model there are two sets of parameters: those who correspond to the standard neo-Keynesian model $(a_0, a_1, a_2, b_0, b_1, b_2, c_0, c_1, c_2)$, and those of the small open economy block, including the FX intervention rule, $(d_0, d_1, f_1, f_2, g_0, g_1, q)$.

In the micro-founded neo-Keynesian model, the values of parameters $(a_0, \dots, b_2)$ depend on the discount factor of households, the degree of risk aversion, the labor supply elasticity, and the frequency of price adjustments, among other deep parameters. In our simple specification of the model we do not have such micro-foundation. Thus, we use as priors the posterior estimates obtained by González and Hamann (2011), who estimate a micro-founded neo-Keynesian model for the Colombian economy.

For the Taylor rule coefficients, c_0, c_1 and c_2 , we also use as priors the posteriors obtained in that study because the estimates are similar to the values obtained in previous studies in Colombia: 0.2, 1.6 and 0.2. For the policy rate persistence we use a beta distribution with standard deviation of 0.2, while for c_1 and c_2 , we use a gamma distribution with standard deviations of 0.16 and 0.02, respectively.

Note that parameters b_0, d_0 and g_0 determine the degree of autocorrelation of output, capital flows, and FX intervention. We use beta distributions for them based on the estimated values obtained from independent OLS estimations of their respective equations.

¹⁴ We used the item reintegros netos de capital privado. Data is available from January 2002 to September 2012. We do not use the Balance of Payments because it contains only quarterly data. By using the FX Balance we are not fully capturing private net capital flows. Nonetheless, the FX Balance is a timely tool used actively in the central bank's discussions and decisions about monetary policy.

For the remaining autoregressive parameters, we use a uniform prior between [0,1) and, for all standard deviations of shocks, an inverse gamma distribution with mean obtained from running independent regressions for each equation of the model and computing its standard error of the regression.

Considering the scant evidence about the values of the parameters of the small open economy block, comprised by equations (4) to (8), we run independent OLS regressions for equations (4), (5) and (6) and use these estimates as our priors. The estimated results were:

$$k_t = 0.002 + \mathbf{0.28}k_{t-1} + \mathbf{0.003}[r_t - r_t^* - (e_t^e - e_t)]$$

$$ca_t = 0.003 + 0.017e_t - \mathbf{0.38}y_t$$

$$x_t = 0.003 + \mathbf{0.25}x_{t-1} - \mathbf{0.115}e_t$$

Results

We use a Random Walk Metropolis-Hastings algorithm to draw two chains of 200,000 draws from the posterior distribution of β and construct the estimates for each parameter using half the draws of each chain. The acceptance rates for each chain were 0.2778 and 0.2776. We use methods developed by Brooks and Gelman (1998) to monitor the convergence of the posterior draws estimates. Estimation results are shown in Table 2. In the appendix 2 we report the impulse response functions of all variables to each of the model's shocks (Figure 8 to Figure 14).

There are several interesting results from the estimation. First, there is a muted pass-through from nominal depreciation to inflation—the value of parameter a_1 is close to zero. The tightness of the posterior distribution shows that the data strongly support this observation. It is also consistent with previous research of the CB, which documents that the degree of pass-through has been low and declining over time.

Second, there is no direct impact of the real exchange rate on aggregate economic activity. The estimated coefficient of the real exchange rate in the IS curve lies around zero, between -0.01 and 0.01 with 95 percent confidence. Unlike many models that assume that real depreciation is expansionary, the estimated results strongly support the notion that if there is any relationship between real exchange rate misalignments and unusual output growth, the relationship is weakly negative. This result is important because the nonconventional block of the model is linked to the conventional one through the real exchange rate. Even if FX interventions were effective, in that they were able to explain a significant portion of exchange rate movements, the impact on economic activity would be small. FX interventions could operate through other channels, like changing the portfolio of private agents, or like banks and pension funds potentially affecting saving and consumption decisions.

Third, in the Phillips curve we obtain a high estimated value of the forward-looking parameter, close to the priors, and a higher than expected response of inflation to economic growth. Inflation shocks, such as those that come from food and/or regulated prices, display a high degree of persistence and translate to observed inflation.

Table 2 Estimation Results

Parameters	Prior Mean	Posterior Mean	[Confidence Interval]		Prior Distribution	Posterior Standard Deviation
a0 (Forward-looking weight in Phillips curve)	0.5700	0.6298	0.4960	0.7609	Beta	0.2000
a1 (Passthrough coefficient)	0.0000	0.0037	-0.0064	0.0141	Normal	0.0100
a2 (Slope of Phillips curve)	0.1750	0.6710	0.6362	0.6990	Gamma	0.0500
b0 (Forward-looking weight in IS curve)	1.0000	0.7112	0.5837	0.8328	Normal	0.5000
b1 (Slope of IS curve)	0.2000	0.6452	0.5905	0.6968	Gamma	0.0500
b2 (Output response to RER)	0.0000	-0.0037	-0.0129	0.0057	Normal	0.0100
c0 (Backward-looking weight in Taylor rule)	0.1700	0.2055	0.1723	0.2390	Beta	0.0170
c1 (Taylor rule weight on inflation)	1.6000	1.9101	1.7246	2.0904	Gamma	0.1600
c2 (Taylor rule weight on output)	0.2200	0.2234	0.1842	0.2594	Gamma	0.0220
d0 (Capital flows inertia)	0.2770	0.2542	0.1126	0.3925	Beta	0.0880
d1 (Interest rate elasticity of capital flows)	0.0030	0.0207	0.0121	0.0293	Normal	0.0070
f1 (Current account elasticity to RER)	0.0170	0.0325	0.0177	0.0459	Gamma	0.0050
f2 (Current account elasticity to output)	0.3820	0.1252	0.0270	0.2166	Gamma	0.2000
g0 (Backward-looking weight in FX rule)	0.2500	0.2176	0.1093	0.3220	Beta	0.0800
g1 (NFX purchases response to RER)	0.1150	0.2661	0.2139	0.3161	Gamma	0.0300
qb (Probability of fixed exchange rate)	0.0000	0.0114	0.0025	0.0197	Uniform	0.2887
ρ_π (Supply shock persistence)	0.5000	0.9659	0.9394	0.9967	Uniform	0.2887
ρ_y (Demand shock persistence)	0.5000	0.9758	0.9566	0.9967	Uniform	0.2887
ρ_k (Capital flows shock persistence)	0.5000	0.2014	0.0000	0.3708	Uniform	0.2887
ρ_{r^*} (US interest rate shock persistence)	0.5000	0.7439	0.6509	0.8376	Uniform	0.2887
ρ_{π^*} (US inflation shock persistence)	0.5000	0.9225	0.8733	0.9782	Uniform	0.2887
Standard Deviation of Shocks						
ε^π (Inflation Shock)	0.0200	0.0029	0.0025	0.0032	Inverse Gamma	Inf
ε^y (IS curve shock)	0.0200	0.0025	0.0024	0.0026	Inverse Gamma	Inf
ε^i (Monetary policy shock)	0.0100	0.0253	0.0221	0.0287	Inverse Gamma	Inf
ε^k (Capital flows shock)	0.0200	0.0190	0.0170	0.0210	Inverse Gamma	Inf
u (Discretionary intervention shock)	0.0200	0.0183	0.0061	0.0294	Inverse Gamma	Inf
n (News intervention shock)	0.0200	0.0220	0.0091	0.0325	Inverse Gamma	Inf
ε^{r^*} (US interest rate shock)	0.1500	0.1544	0.1388	0.1705	Inverse Gamma	Inf
ε^{π^*} (US inflation shock)	0.0300	0.0057	0.0051	0.0062	Inverse Gamma	Inf

Fourth, the estimates of the Taylor rule coefficients are similar to those obtained in previous studies, although the estimated response to inflation deviations from target is higher in our figures.

Fifth, the credibility cost in the Taylor rule implied by the FX intervention is small. FX interventions have not induced agents to assign a probability beyond 2 percent of being in a fixed exchange rate regime.

Sixth, capital flows are volatile, as their persistence is quite low, and there is a low degree of capital mobility in the economy in the sense that the reaction to the domestic-external interest rate differential is very small. In turn, the response of the current account

to output and the real exchange rate is also small. In all cases, the posterior estimated coefficients are statistically significant.

Seventh, the data support the idea of the existence of an FX reaction function of the central bank. The response of FX sales/purchases to real exchange rate depreciation/appreciation rate is large and significant. This elasticity lies between 0.39 and 0.42 with 95 percent confidence. The data strongly favor the idea that the central bank responds to real exchange rate misalignments.

Finally, our model also has something to say about the effectiveness of interventions. Take, for instance, the impact of the “news” shock. Table 2 shows that the standard deviation of this shock is 2.2 percent. Given that the interventions are expressed in the model as a percentage of the stock of IR, this intervention corresponds to daily interventions of close to US\$40 million. The stock of IR by the end of 2012 was US\$37.5 billion; one standard deviation of the news shock is 2.2 percent; thus US\$37.5 billion x 2.2 percent is the monthly shock we study in the impulse response functions; if there are 20 weekdays in a month, the latter figure corresponds roughly to daily interventions of US\$40 million, close to the latest announcements by the CB. Figure 13 reports the reaction of the endogenous variables to such a news shock. Again, we find that the domestic block of variables—output, inflation, interest rates—does not react. Nevertheless, there is a short-lived reaction to the real exchange rate. During the first month, the pace of appreciation would be slowed by close to 6 percent. The impact, however, evaporates by the second month. This result is within the ballpark estimates of Adler and Tovar (2011).

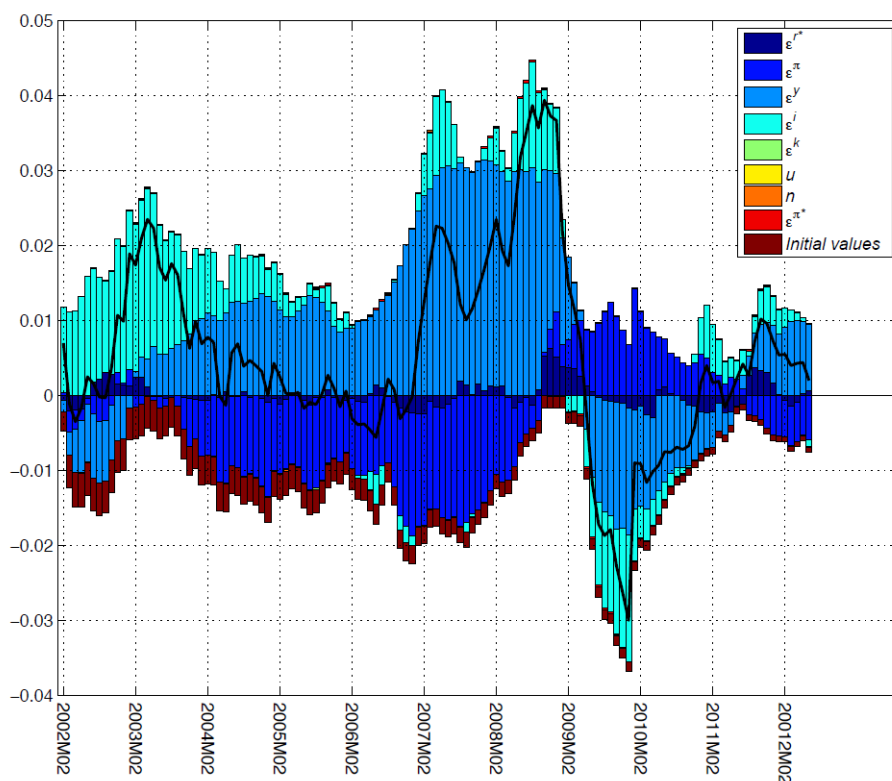
Results 1 and 2—the weak external channel in the Colombian economy—confirm the early findings in Gomez et al., 2002. Together these results imply that the domestic and external factors are quite disconnected in Colombia. The fact that inflation stays relatively immune to changes in the exchange rate implies that its joint dynamics, together with output and interest rates, would look a lot like those of a closed economy.

These results are confirmed by the impulse response functions. Impulse responses to foreign shocks, like capital flows, FX intervention, and external interest rates, have either

small or no significant impact on inflation, output growth gap, and domestic interest rates. The results reported in Appendix 1 show that while these shocks affect capital flows, FX intervention, and the real exchange rate, the response of domestic variables is negligible. Also, the effects of domestic shocks (demand, supply, and monetary policy shocks), reported in Appendix 2, mainly impact output, inflation, and interest rates, while the response of other variables is either insignificant or small.

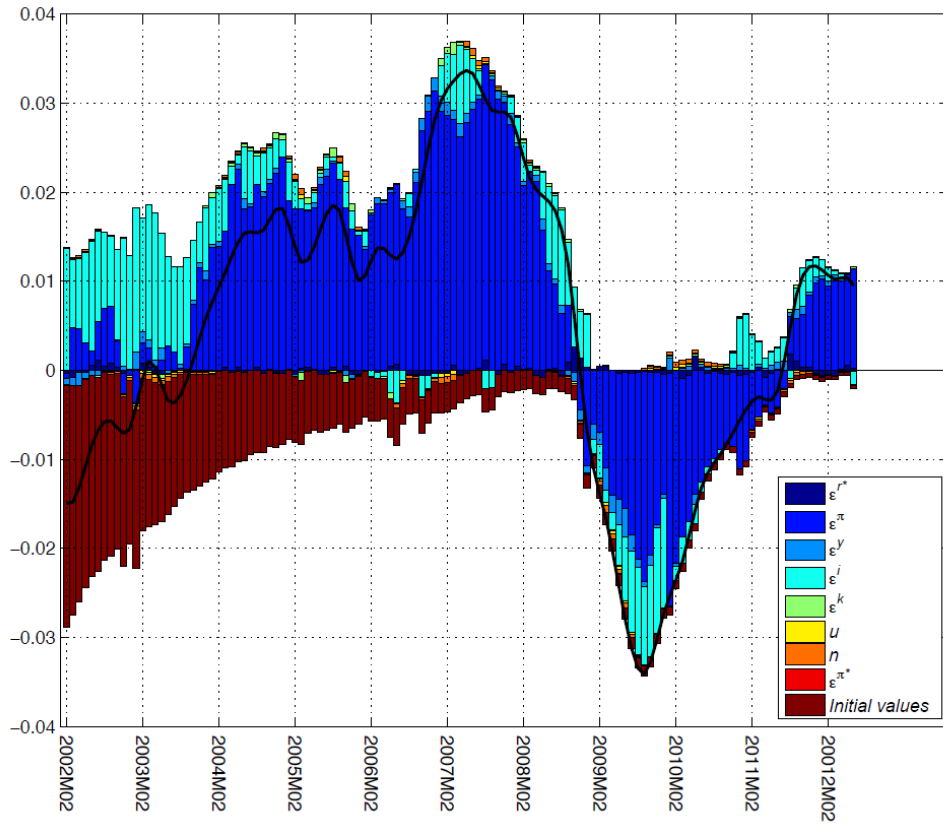
A shock decomposition analysis was performed to gauge the estimated contribution of the shocks on the observed movements of the variables in the model. By inspecting the shock decomposition of inflation (in deviations from target), shown in Figure 2, it can be seen that most of the movements of inflation are explained by demand and supply shocks and a little portion by interest rate shocks. Foreign shocks participation is negligible. A similar pattern can be observed in the shock decomposition of the output growth gap, in Figure 3.

Figure 2. Shock Decomposition - Inflation



The shock decomposition of capital flows tells a different story, mainly explained by their own shocks and shocks to external interest rates. The contribution of domestic shocks on demand, supply or local interest rates is very small. This domestic-external disconnect property of the economy may have had important implications for how the BR has conducted exchange rate management and on the consequences of the latter.

Figure 3. Shock Decomposition - Output Growth Gap



Finally, we report the shock decomposition of the real exchange rate in Figure 5. Real exchange rate movements (deviations from annual growth rate) are explained mainly by capital flows shocks, news about FX intervention, and discretionary FX intervention shocks. Foreign interest rate contribution is small. Both discretionary and news shocks explain a large portion of exchange rate fluctuations. We interpret this result to mean that the estimated intervention rule does not fully account for real exchange rate movements, but unanticipated shocks to FX intervention may have had more power, especially before

the beginning of pre-announced interventions in June 2008, as the contribution of both shocks has declined since then.

Figure 4. Shock Decomposition - Capital Flows

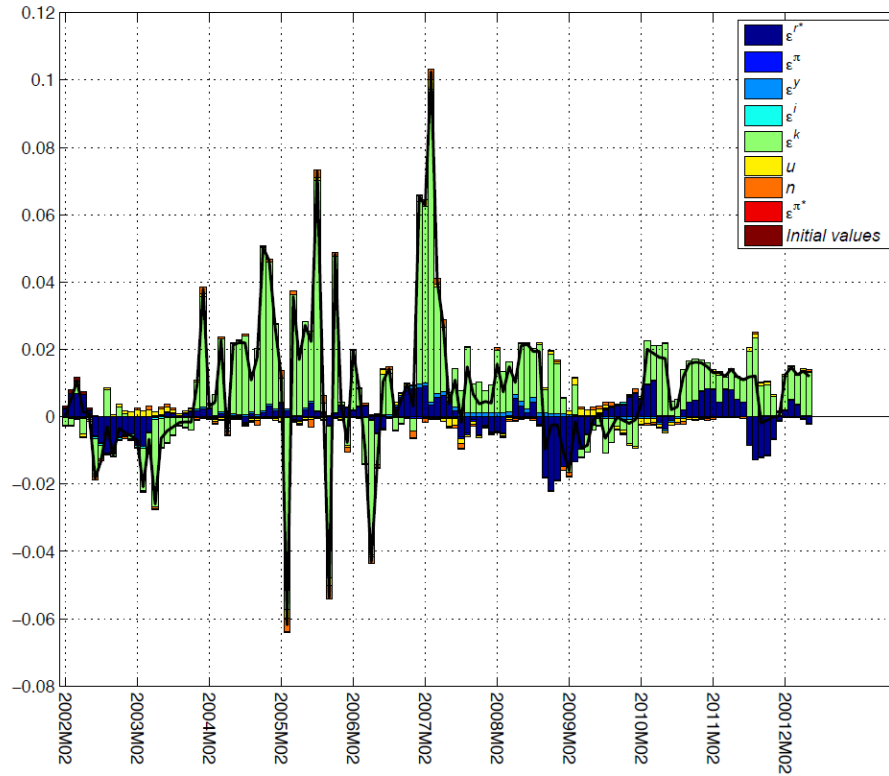
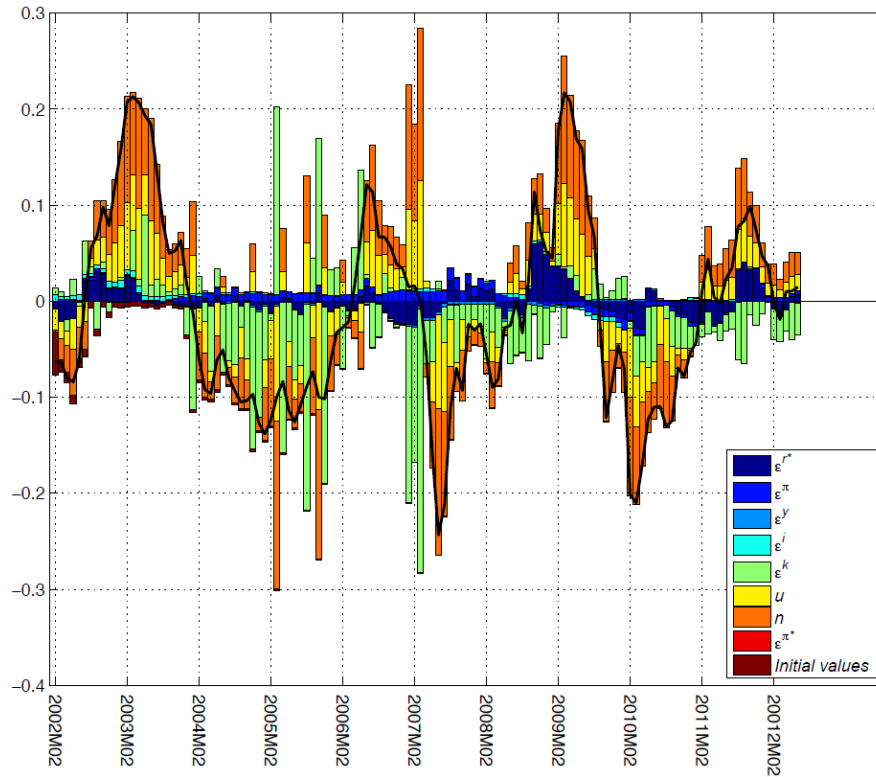


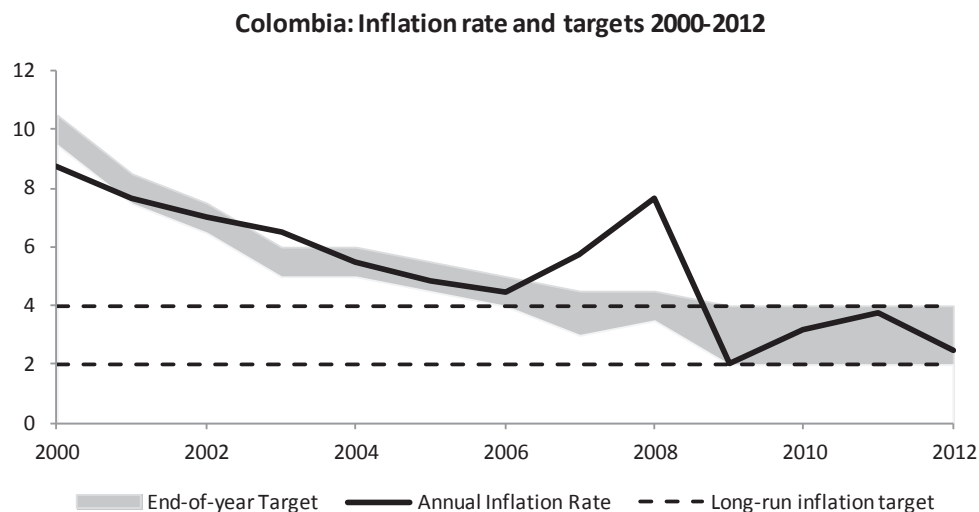
Figure 5. Shock Decomposition - Real Exchange Rate



5. Consolidation of Inflation Targeting in Colombia: 2002-2012

In Figure 6 we report the inflation rate over the IT era along with the announced annual and long-run targets, respectively. Colombia's Central Bank has been able to stabilize the inflation rate close to its long-run target of 3 percent. To achieve this it has used a variety of instruments beyond the policy interest rates. We study them in this section with a particular emphasis on the most important one, FX interventions.

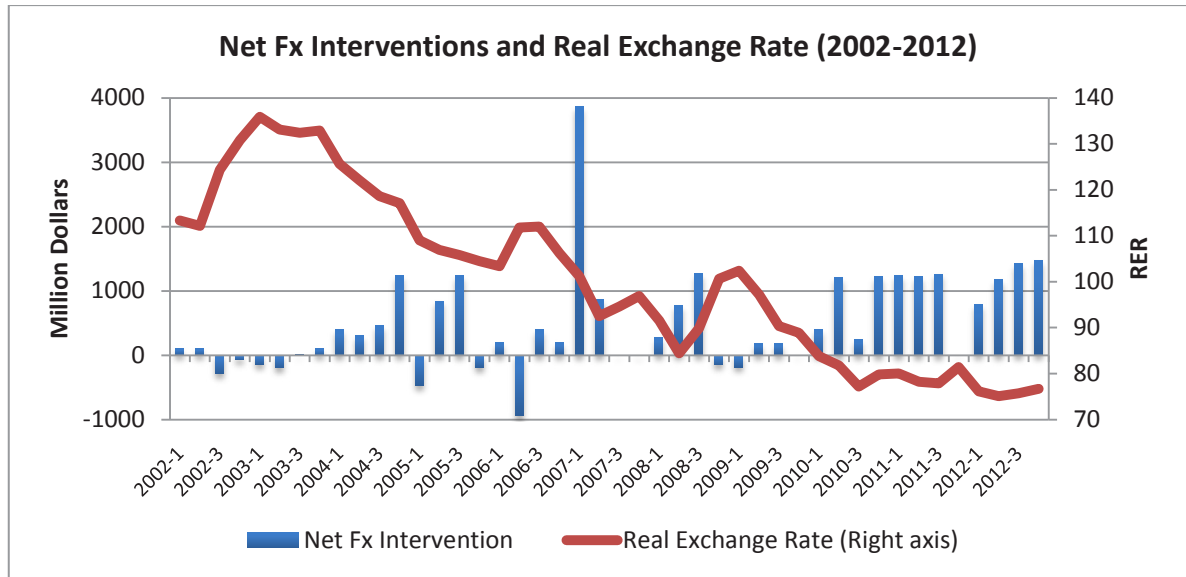
Figure 6



FX interventions have taken place since the start of the regime, but they have been particularly severe since the middle of the decade. For instance, in 2012, the CB purchased close to US\$5 billion. While most interventions have been purchases, the BR has also sold non-negligible amounts of reserves, mostly during times where it preannounced interventions aimed at reducing exchange rate volatility. Over the period January 2002-December 2012, the net purchases of US\$27.2 billion hide total purchases of FX adding up to almost US\$31.9 billion and sales of US\$4.7 billion. Figure 7 reports the FX interventions for 2002-2012.

Why does the CB intervene in the FX market? On the one hand, the CB needs to keep an adequate level of international reserves (IR). The CB has published several documents explaining its strategy regarding the level and investment of IR (i.e., *Informe sobre Reservas Internacionales*, 2011; *Gerencia Técnica*, 2012). In them, the CB gives a detailed account of the set of criteria used to determine an adequate range of IR, based on the behavior of the current account, external debt, the world financial situation, the size of the economy, and the size of monetary aggregates, among others.

Figure 7



On the other hand, interventions could also be related to implicit exchange rate targets in terms of the level of the exchange rate as well as its volatility. As Figure 7 shows, FX purchases tend to be larger when the peso is stronger. This result is confirmed by our estimates in the previous section. Moreover, interventions have been justified as a means to mitigate exchange rate volatility or as attempts to influence its trend. At times, the CB has had explicit mechanisms that triggered sales or buys of FX when exchange rate volatility trespassed certain thresholds. While the CB has never stated that it has an explicit exchange rate target, interventions have often been stepped up at times when there have been perceived or actual FX misalignments, suggesting that it might have been part of the policy reaction function. Our model does not allow for testing whether the CB has had implicit exchange rate targets, but it does show that exchange rate misalignments triggered FX interventions.

Nevertheless, both Gomez et al. and our results suggest a disconnect between the domestic and the foreign variables. If the foreign block of variables does not affect the domestic variables of interest for a central bank, and the interventions have a small and short-lived effect on the exchange rate, then there must be alternative reasons explaining the intensive FX interventions of the last few years. In particular, the FX interventions

should be studied in light of pressures exerted upon the CB by government officials, the press, and lobbies at times of actual or perceived exchange rate misalignments.

A first episode that illustrates the pressures that the CB has faced took place during 2003 and 2004. At that time, President Uribe made several public appeals claiming that the Banco de la República should play a more active role in achieving the social goals of the government (Moreno, 2011). He publicly asked the CB to use part of its FX reserves to buy government external debt. Public opinion and part of the political establishment picked up on the proposal. In an historic event, the Senate rejected the CB's report to the Congress. As a former member of the CB's board put it, this request constituted an act of political extortion to push the CB to accept giving up part of the reserves (Moreno, 2011).

The IMF entered the debate, claiming it thought there were no excess reserves in Colombia, and that fiscal problems should be solved through fiscal policies and by highlighting the role of IR as shock absorbers.¹⁵ President Uribe insisted that the CB should estimate the amount of its excess reserves. In the end, the BR produced a document concluding that at most the excess reserves were US\$ 500 million—close to 5 percent of IR at the time. While the amount in relative terms is significant, it was well below the expectations that some senators had—figures as high as US\$5 billion were mentioned.¹⁶ The process ended up with the CB buying external debt for US\$500 million.

This was the first example of the political pressures that the BR faced in relation to its FX stock, and an explanation behind some of the movement in IR stocks. It also shows how the CB successfully—to a certain extent—used technical arguments, published in different series with varying technical depth, to partially refute strong political pressure, mitigating its institutional and economic consequences. The better communication skills of the IT strategy may have proven useful in that case.

¹⁵ “FMI fija límites a Colombia para utilizar reservas internacionales”. *Caracol*. Nov, 13, 2003. Retrieved from: <http://www.caracol.com.co/noticias/actualidad/fmi-fija-limites-a-colombia-para-utilizar-reservas-internacionales/20031113/nota/117074.aspx> Accessed October 15, 2012

¹⁶ “Pago de deuda externa con reservas evitaría reforma tributaria”. *Caracol*. July 7, 2004. Retrieved from: <http://www.caracol.com.co/noticias/actualidad/pago-de-deuda-externa-con-reservas-evitaria-reforma-tributaria-senador-velez/20040707/nota/121390.aspx>. Accessed October 15, 2012,

The next example is paradoxical when compared to the one in 2003-2004. In mid-2012, the Ministry of Finance produced a technical document supporting the claim that the stock of international reserves was too low (Mejia, 2012). By calibrating Jeanne's (2007) model of optimal international reserves, the document claimed that Colombia's IR were below optimal at close to US\$20 billion and proposed a fast track of daily FX acquisitions to close this gap. The document came at a time of FX appreciation and could be read as a technical argument to support the claim that more intervention by the CB to depreciate the exchange rate was needed.

The CB responded to the request with another paper (*Gerencia Técnica*, 2012) in which it disregarded the technical arguments of the government by showing how sensitive its results were to the model's choice of parameters in the calibration. Rather than focusing on an optimal level of reserves, it claimed that the CB focuses on what it calls an adequate level of reserves. It cited several criteria to estimate this level, and showed that the current amount of IR was close to the desired figure according to these criteria. This time, compared to the 2003 debate, the exchange of ideas was kept at a more technical, and less political, level. Still, the pressures on the CB to change its IR goals, or at least to speed its FX acquisitions in the short run, were obvious, and shortly after the exchange of arguments, the BR's board of directors stepped up its daily preannounced FX purchases (although by much less than Mejia's (2012) suggestion). By January 2013, the CB stepped up its preannounced purchases of FX, amid claims by the finance minister that the peso was at least 8 percent overvalued.

Another case that illustrates this point is President Uribe's attempts to fix the exchange rate. In December 2004, after a period of exchange rate appreciation Uribe asked his main legal advisor to write a decree that would fix the exchange rate (Moreno 2011). On another occasion, the President phoned the governor, who was at a board meeting at the Fondo Andino de Reservas, to tell him that the next day he would announce that the country would go back to the crawling peg. The official announcements, however, never occurred; the institutions and the legal independence of the CB proved to be strong enough to avoid such moves. These examples show that the de jure CB independence has

also blocked other attempts by the government to intervene in spheres that the Constitution assigns to the CB.

The preceding three examples illustrate scenarios where the government has tried to influence the direction and strength with which the BR buys and sells FX reserves. The examples suggest that political pressure with respect to the level of IR has been used to push for both an increase and a decrease of FX stock. The examples also show that, to a certain extent the CB has yielded to such pressures in spite of its de jure independence. As its deputy director once said, (Betancourt and Vargas, 2008) maintaining independence implies to some extent compromises with public opinion or with the government. The CB has also used its strong research capabilities to make its case when it thinks that the proposals/pressures are incompatible with its overall goals.

While the discussion has focused on cases where pressures have come from the government, there are many comments by speakers from the private sector, such as exporters, importers, the industrial sector, agricultural producers, and coffee-growers, among others, that voice their desired policies regarding the exchange rate in an attempt to influence CB's decisions directly or by influencing government policy.

To sum up, the interventions by the BR in the FX market have been common since at least after 2003. At times they have represented a consequence of the need to build an adequate level of IR. At other times, they have been prompted by exchange rate misalignments. In both cases, the CB's decisions have been made amid strong media and political pressures. In spite of this, the CB has effectively used its communication skills, its technical staff, its de facto and de jure independence, to bow to pressure only as long as they believe they can afford it without risking their constitutional mandate to keep prices stable. With the exceptions of 2007-2008, targets have been met or missed by a narrow margin. As the model shows, the credibility of the regime has not been endangered.

Yields on International Reserves

The Banco de la República, like many central banks, has a conservative approach to its investment strategies regarding IR. While a conservative strategy may be inherent to the

central banks' character, in the case of the Banco de la República, the conservative tactic has gained relevance since the fall of Lehman Brothers in 2008. At that time, a popular and well-known left-wing congressman, Gustavo Petro, publicly accused the board of directors of the BR of recklessly investing Colombia's foreign reserves. Petro stated that more than US\$2.5 billion was invested in high-risk assets and could be lost due to the crisis.¹⁷ The Banco de la República responded to Congressman Petro by showing that the majority of the foreign exchange reserves were invested in secure bonds, such as U.S. treasury bonds, but it did recognize that the crisis hit the FX reserves. The losses, however, were less than 0.012 percent of the total amount of reserves.¹⁸ While the figures Petro cited proved to be wrong, a small part of the reserves have never been recovered. In its last report to congress in 2012, the board of directors devoted a few pages to explaining the legal actions that had been taken to recover the fraction of the reserves that were lost during the financial crisis (*Informe al Congreso*, July 2012). That the amount lost compared to the total amount of reserves was small was irrelevant in terms of the consequences of that debate. Beyond the political pressures that the board members received, there was a real threat that the loss would end up in legal actions against them. The Office of the Attorney General (Procuraduría)—the entity in charge of investigating and judging public officials for actions related to their jobs—began a legal investigation of the loss to evaluate whether board members and Central Bank officials should be sanctioned.

The CB's reaction was to strengthen its investment standards, sacrificing potential returns in exchange for greater security. This strategy is behind the recent poor performance in terms of returns of Colombia's international reserves, shown in Table 3. Indeed, the annual returns denominated in dollars over the last three years have been below 1 percent. Although the IR stock has more than tripled over the last ten years, its returns have been reduced from US\$810.5 million to an average of US\$180 million in the past three years. Part of the reason for the low returns is the low interest rates in the United

¹⁷ "Petro alerta sobre la necesidad de proteger reservas internacionales". *El Espectador*. Oct, 6, 2008. Retrieved from: <http://www.elespectador.com/noticias/politica/articulo-petro-alerta-sobre-necesidad-de-proteger-reservas-internacionales>. Accessed October 24, 2012

¹⁸ "Quiebra de Lehman Brothers sí afectó reservas internacionales de Colombia". *Caracol*. September 30, 2008. Retrieved from: <http://www.caracol.com.co/noticias/economia/quiebra-de-lehman-brothers-si-afecto-reservas-internacionales-de-colombia/20080930/nota/681195.aspx>. Accessed October 24, 2012.

States and the depreciation of the euro. Another reason is that high risk aversion shows up in low average returns. The country's current equilibrium is one where it gets very low returns on its IR, and the board has no incentives to change the strategy.

Table 3. Annual Yield on International Reserves

Year	IR Annual % Yield	IR Annual Return (Million US Dollars)
2002	7.7	810.5
2003	4.2	464.8
2004	2.7	324.5
2005	0.6	81.4
2006	5.5	815.2
2007	7.4	1326.2
2008	4.5	1004.5
2009	1.3	321.4
2010	0.6	159.7
2011	0.4	136
2012	0.7	241.9

In addition to the low returns on IR, the acquisitions of FX are costly, especially if they have to be sterilized. Given the pressure to buy more FX to attenuate the appreciation of the peso against the dollar, the BR has estimated the costs of sterilized interventions. According to the 2012 Report to the Congress, for each US\$100 million of FX acquisitions on behalf of the Central Bank, its balance is hit by more than US\$4.5 million. In 2012, the Banco de la República ended the year with FX purchases of US\$4,844 million; this intervention had a quasi-fiscal cost of more than US\$230 million.

The low returns on IR, the high costs of sterilized interventions, and the appreciation of the peso against the US dollar have hit the balance of the CB. Since 2010, the BR has reported net losses in large amounts at year's end with obvious fiscal consequences. The sum of the losses over the last three years surpassed US\$500 million. The board has tried

to carefully explain the causes of the losses to Congress in a manner that is easily understood. Absent budgetary independence, the actual policy independence of the CB could be at risk. This could also explain the BR's resistance to more forcefully intervening in the FX market. Maintaining the appropriate level of policy independence in this context is a new challenge for the BR.

With respect to investments of IR in Colombia, the CB's strategy is currently focused on very secure and mostly liquid assets. This strategy makes sense as long as the amount of FX reserves remains close to the adequacy level dictated among others by potential short run liquidity needs. As the stock of IR grows and the losses, explained mostly by low returns on the IR investments, mount—threatening the budgetary independence of the BR—it becomes more important to search for alternative schemes for the CB to invest in less liquid and more risky portfolios or projects enhancing the long-run returns of part of the IRs.

The latter seems difficult for Colombia. While in principle the CB could decide to invest part, or the excess, of the IR in long-term assets or in riskier and more profitable alternatives, the reality is that it has no incentive to do so. This reluctance is explained by the experience after the Lehman Brothers fall where the board faced threats of legal actions for “endangering the country's reserves”. We propose a way to exit this bad equilibrium, which encompasses the creation of a separate investment fund inspired in the sovereign wealth funds (SWF) that some Asian countries have established to invest part of their IRs. The CB would put part of the stock (flow) of IR into the SWF. The SWF would be an independent fund with a clear mandate to maximize revenues over longer terms (at least five years or more). An evaluation of the returns and performance should be made over the chosen horizon.

The fund's revenues would be redirected to the CB, and eventually to the government. As with most SWFs, it would be managed by a third party, but its board would be controlled by government officials. The heads of the CB, the Ministry of Finance, the national planning department, and possibly of the Economic Commission of the

Congress, to enhance transparency and accountability and also to shield the fund from political manipulation, are obvious picks to be on the SWF's board.

The fund's success in mixing accountability while providing shields to allow for adequate investment strategies lies in the fine-tuning of its mandate. The experience of other countries and even Colombia's experience with a different SWF where part of the oil revenues are saved could be valuable when designing its charter. One experience that should be studied is that of a few Asian countries where the CBs built a separate investment fund, specifically, Korea, China, and Singapore.

Macro-prudential Policies

At the start of the 21st century, the discussion at the international level of macro-prudential policies intensified. Colombia put in place marginal reserve requirements on financial intermediaries and on non-interest bearing deposits on foreign credit to diminish dangerous rates of credit growth. In 2006 and 2007 real rates of credit growth reached 32 percent, and the transmission mechanism from policy interest rates to market rates showed delays. The board of Banco de la República felt that in addition to interest rate increases to decelerate credit growth, additional reserve requirements and a disincentive to foreign credit flows were warranted. After the start of the global financial crisis of 2008, both of these measures were quickly reversed.

Other prudential measures and regulatory decisions taken to meet Basel Standards were implemented by the Superintendency of Banks (Superintendencia Financiera, or SF), a government agency independent from the CB. In Colombia, the SF sets the supervision of the financial sector and the rules regarding credit provisions that financial institutions should adhere to. Accordingly, macro-prudential policies regarding credit provisions are not directly set by the BR. Nevertheless, the coordination between the CB and the SF has increased over time. For example, recently the SF increased bank provisions required for consumption credits, after repeated calls from the CB suggesting that the growth rate of these credits might be excessive.

Capital Controls

Capital controls are also part of the toolkit used by the Colombian Central Bank during the IT era to meet its goals. Over the last decade, the BR and the government have used barriers to capital inflows at times of strong exchange rate appreciation. The strategy has been to impose Chilean-type restrictions based on unremunerated reserve requirements on foreign loans and portfolio investments to make them less attractive.

For example, in May 2007, the Banco de la República established a mandatory deposit on foreign debt. Those acquiring foreign debt had to deposit without remuneration part of the loan. These restrictions were abandoned in September 2008 when appreciation pressures receded in the midst of the global financial crisis.

Portfolio investments have also been targeted at times of exchange rate appreciation. Still, it is not the CB but the government that is in charge of regulating portfolio investments. During the period of interest, 2004-2006, short-term investments from abroad were prohibited. Later, in May 2007 unremunerated requirement deposits similar to those on short-term debt were imposed with a 40 percent deposit for a six-month period. A year later it was increased to 50 percent.

Have capital controls worked to contain the exchange rate appreciation in Colombia? The latest evidence suggests that most likely not. While Rincón and Toro (2010) show mixed results—with capital controls having some effect on the exchange rate but only in 2008, and only when combined with foreign exchange rate interventions—the rest of the recent evidence is skeptical regarding the usefulness of these restrictions.

Clements and Kamil (2009), for example, study the effects of capital controls implemented since 2007. While they show that they were successful in limiting external borrowing, they did not moderate the appreciation of the peso. In a similar vein, Concha et al. (2012), studying the effects of capital controls over the period 1998-2008 in Colombia, also find that they did not mitigate the exchange rate appreciation, nor did they reduce capital inflows. The only statistically relevant effect is a reduction in financial volatility, but the economic importance of the effect is negligible. These results are in line with Forbes

and Warnock (2012), who find little association between capital controls and the probability of having surges or stops driven by foreign capital flows.

6. Conclusion

The estimations of our small-scale monetary policy model suggest that there is a weak link between domestic and external macroeconomic variables in Colombia at the monthly data frequency. First, the real exchange rate appears to have small effects on aggregate economic activity. Second, total inflation stays relatively immune to changes in the nominal exchange rate. In addition, the sensitivity of capital flows to the domestic-foreign interest rates differential is also small. Together, these results imply that foreign shocks hitting the economy tend to be adjusted by the balance of payments equilibrium conditions so that their effects on domestic economic variables are small. Likewise, domestic shocks tend to have their highest impact on local variables such as economic activity, inflation, and domestic interest rates.

According to our estimated model, the Banco de la República has used at least two policy instruments, a Taylor rule and an FX intervention rule, as part of its IT strategy. The external-internal disconnect of the economy may have facilitated the implementation of both instruments, without facing significant economic policy trade-offs. In terms of credibility, we find that the determination of the domestic interest rate is consistent with a flexible exchange rate regime rather than a peg. Thus, at least in this dimension, the CB may have had enough room to intervene in the FX market without putting the credibility of the IT regime at risk. We also find the FX interventions have a short-lived impact on the exchange rate.

Our paper also shows that, despite the strong political and media pressures that the CB has faced to implement policies that could come at the cost of not complying with its main objectives, it has used its technical strength and increasingly better communication skills to explain its actions and only bow to pressures inasmuch as they do not compromise its main goals.

One challenge the CB faces is low yields on an increasingly large stock of international reserves. Over the last few years, the CB has reported net losses by the end of the year. Policy independence depends to a certain extent on budgetary independence. Our paper suggests that to escape the constraints, the CB should invest more aggressively a part of the IR, and Colombia should thus consider forming a sovereign fund. Beyond considering the choice of a better balance between risk and return, this fund could be pivotal to maintaining an appropriate level of CB independence.

Overall, the balance of this decade of consolidation of IT is positive. By keeping its eye on inflation, economic activity, exchange rate, credit variables, and financial stability, among other variables, the CB has effectively used a variety of instruments beyond the short-run interest rate. Foreign exchange interventions, macro-prudential policies, reserve requirements, and, increasingly, the use of announcements are all now part of the toolkit of the monetary authority. For purists, this might not be labeled as textbook IT, but it is a strategy that is better equipped to navigate the torrid waters that developing countries have sailed through after the onset of the global financial crisis.

There are limits to our findings. The model presented here considers only a small subset of transmission channels and leaves out potentially important ones and focuses on high frequency data. The model does not consider longer time horizons, since it is a monetary policy model which is naturally designed to be used at time horizons of one to two years. Nor does it consider balance-sheet effects or the role of stocks in the economy or financial and real linkages, which may have been important in Colombia in the last ten years. Introducing these linkages into the model is beyond the scope of this study, but if included in a structural DSGE model, we suspect that, when confronted with the same monthly data, it would be difficult to reject our main findings. This is so because, given the external-internal disconnection property of the Colombian economy, the financial and real linkages may have been dealt with by the authorities using other policy instruments, such as capital requirements, restrictions on the balance sheet management of banks, and counter-cyclical provisioning requirements, to name a few. This is an empirical question that needs to be addressed in future research.

References

- Adler, G. and C. Tovar. 2011. "Foreign Exchange Intervention: A Shield against Appreciation Winds?" IMF Working Paper WP/11/165. Washington, DC: International Monetary Fund.
- Aizenman, J., M. Hutchison, and I. Noy. 2008. "Inflation Targeting and Real Exchange Rates in Emerging Markets." NBER Working Paper 14561. Cambridge, MA: National Bureau of Economic Research.
- An, S. and F. Schorfheide. 2007. "Bayesian Analysis of DSGE Models." *Econometric Reviews* 26(2-4): 113-172.
- Ball, L. 2010. "The Performance of Alternative Monetary Regimes." In Friedman, B. M and M. Woodford (Eds.). *Handbook of Monetary Economics*. Edition 1, Vol. 3, Chapter 23. New York, NY: Elsevier.
- Ball, L. and N. Sheridan. 2004. "Does Inflation Targeting Matter?" In Bernanke, B. S. and M. Woodford (Eds.). *The Inflation-Targeting Debate*. Chicago, IL: University of Chicago Press.
- Banco de la República. 2009. Administración de las Reservas Internacionales.
- Banco de la República. 2012. "Nivel óptimo y adecuado de reservas internacionales." *Gerencia Técnica*. Bogotá, Colombia.
- Banco de la República. Informe de la Junta Directiva al Congreso de la República. Julio 2012.
- Bernal, R. 2002. "Monetary Policy Rules in Colombia." Documento CEDE 003251. Bogotá, Colombia: CEDE, Universidad de los Andes.

- Bernanke, B. S. and F. S. Mishkin. 1997. “Inflation Targeting: A New Framework for Monetary Policy.” NBER Working Paper 5893. Cambridge, MA: National Bureau of Economic Research.
- Betancourt, Y. R. and H, Vargas. 2008. “Encajes bancarios y la estrategia de inflación objetivo.” Borradores de Economía 533. Bogotá, Colombia: Banco de la República.
- Brito, R. 2010. “Inflation Targeting Does Not Matter: Another Look at OECD Economies’ Output Sacrifice Ratios.” Insper Working Paper, Insper Instituto de Ensino e Pesquisa.
- Brito, R. and B. Bystedt. 2010. “Inflation Targeting in Emerging Economies: Panel Evidence.” *Journal of Development Economics* 91(2): 198-210.
- Brooks, S. and A. Gelman. 1998. “General Methods for Monitoring Convergence of Iterative Simulations.” *Journal of Computational and Graphical Statistics* 7: 434-55.
- Calvo G. A., A. Izquierdo, and R. Loo-Kung. 2012. “Optimal Holdings of International Reserves: Self-Insurance against Sudden Stop.” NBER Working Papers 18219. Cambridge, MA: National Bureau of Economic Research.
- Cardozo, P. A., et al. 2011. “Mercado Interbancario Colombiano y Manejo de Liquidez del Banco de la República.” Borradores de Economía 673. Bogotá, Colombia: Banco de la República.
- Chang, R. 2008. “Inflation Targeting, Reserves Accumulation, and Exchange Rate Management in Latin America.” Borradores de Economía 487. Bogotá, Colombia: Banco de la República)

- Clavijo, S. 2000. “Reflexiones Sobre Política Monetaria e “Inflación Objetivo” en Colombia.” *Borradores de Economía* 141. Bogotá, Colombia: Banco de la República.
- Clements, B. and H. Kamil. 2009. “Are Capital Controls Effective in the 21st Century? The Recent Experience of Colombia” IMF WP/09/30. Washington, DC: International Monetary Fund.
- “Colombia persiste en uso de reservas internacionales pese a FMI.” *Invertia*. Nov, 14, 2003: Accessed October 15, 2012.
- Concha, A., A. J. Galindo, and D. Vasquez. 2011. “An Assessment of Another Decade of Capital Controls in Colombia: 1998-2008.” *The Quarterly Review of Economics and Finance* 51(4): 319-38.
- de Carvalho Filho, I. 2011. “28 Months Later: How Inflation Targeters Outperformed Their Peers in the Great Recession”. *The B.E. Journal of Macroeconomics* 11(1). Berkeley Electronic Press.
- de Roux, N. and M. Hofstetter. 2012. “Sacrifice Ratios and Inflation Targeting: The Role of Credibility.” Documento CEDE 2012-03. Bogotá, Colombia: Universidad de los Andes.
- “FMI fija límites a Colombia para utilizar reservas internacionales.” *Caracol*. Nov, 13, 2003. Accessed October 15, 2012.
- Forbes, K. J. and F. E. Warnock. 2012. “Capital Flow Waves: Surges, Stops, Flight, and Retrenchment.” *Journal of International Economics* 88(2): 235-51.
- Gamboa, F. A. 2011. “Determinants of the Exchange Rate in Colombia under Inflation Targeting.” *Borradores de Economía* 635. Bogotá, Colombia: Banco de la República.

- Gómez, J. 2004. "Inflation Targeting, Sudden Stops, and the Cost of Fear of Floating." Borradores de Economía 276. Bogotá, Colombia: Banco de la República.
- Gómez J. 2006. "La Política Monetaria en Colombia." Borradores de Economía 394. Bogotá, Colombia: Banco de la República.
- Gomez, J. and J. M. Julio. 2001. "Transmission Mechanisms and Inflation Targeting: the Case of Colombia's Disinflation." Borradores de Economía 168. Bogotá, Colombia: Banco de la República.
- Gómez, J., J. D. Uribe, and H. Vargas. 2002. "The Implementation of Inflation Targeting in Colombia." Borradores de Economía 202. Bogotá, Colombia: Banco de la República.
- Gonçalves C. and J. Salles. 2008. "Inflation Targeting in Emerging Economies: What do the Data Say?" *Journal of Development Economics* 85 (1-2): 312-18.
- Gonçalves, C. and A. Carvalho. 2009. "Inflation Targeting Matters: Evidence from OECD Economies' Sacrifice Ratio." *Journal of Money, Credit and Banking*. 41(1): 233–43.
- González, A. and F. Hamann. 2011. "Lack of Credibility, Inflation Persistence and Disinflation in Colombia" Borradores de Economía 658. Bogotá, Colombia: Banco de la República.
- Gonzalez, E. et al. 2006. "Forecasting Food Price Inflation in Developing Countries with Inflation Targeting Regimes: the Colombian Case." Borradores de Economía 409. Bogotá, Colombia: Banco de la República.

- Hamann, F., J. M. Julio, P. Restrepo, and A. Riascos, 2004. “Inflation Targeting in a Small Open Economy: The Colombian Case.” Borradores de Economía 308. Bogotá. Colombia: Banco de la República.
- Jeanne, O. and R. Rancière. 2011. “The Optimal Level of International Reserves for Emerging Market Countries: A New Formula and Some Applications”. *The Economic Journal*. 121(555). 905-930.
- Klein, P. (2000). “Using the Generalized Schur Form to Solve a Multivariate Linear Rational Expectations model.” *Journal of Economic Dynamics and Control* 24(10): 1405-23.
- Lin, S. and H. Ye. 2007. “Does Inflation Targeting really make a difference? Evaluating the treatment effect of inflation targeting in seven industrial countries.” *Journal of Monetary Economics* 54(8): 2521-33.
- , 2009. “Does inflation targeting make a difference in developing countries?” *Journal of Development Economics* 89(1): 118-23.
- López, M. 2003. “Efficient Policy Rule for Inflation Targeting in Colombia”. Borradores de Economía 240. Bogotá, Colombia: Banco de la República.
- López, M. 2006. “Algunos criterios para evaluar una meta de inflación de largo plazo.” Borradores de Economía 386, Bogotá, Colombia: Banco de la República.
- Lubik, T. and F. Schorfheide. 2003. “Computing Sunspot Equilibria in Linear Rational Expectations Models.” *Journal of Economic Dynamics and Control* 28(2): 273-285.
- Mejía, L. F. 2012. ¿Se encuentran las reservas internacionales en un nivel óptimo? Notas Fiscales. MHCP.

- Moreno, A. 2011. *Moneda Sana: Siete capítulos clave en la historia moderna del Banco de la República*. Bogotá, Colombia: Imprenta Comercial.
- Ostry, J., A. Ghosh, and M. Chamon. 2012. “Two Targets, Two Instruments: Monetary and Exchange Rate Policies in Emerging Market Economies.” IMF Staff Discussion Note SDN/12/01. Washington, DC: International Monetary Fund.
- “Pago de deuda externa con reservas evitaría reforma tributaria.” *Caracol*. July 7, 2004. Accessed October 15, 2012,
- Pérez Amaya, J. 2005. “Evaluación de Reglas de Tasa de Interés en un Modelo de Economía Pequeña y Abierta.” Borradores de Economía 385. Bogotá, Colombia: Banco de la República.
- “Petro alerta sobre la necesidad de proteger reservas internacionales”. *El Espectador*. October 6, 2008. Accessed October 24, 2012.
- Posada, C. E. and A. F. García. 2006. “¿No importa la cantidad de dinero?: “Inflation Targeting” y la teoría cuantitativa.” Borradores de Economía 403. Bogotá, Colombia: Banco de la República.
- “Quiebra de Lehman Brothers sí afectó reservas internacionales de Colombia.” *Caracol*. September 30, 2008. Accessed October 24, 2012.
- Rabanal, P., and J. Rubio-Ramírez. 2008. “Comparing Neo-Keynesian Models in the Euro Area: A Bayesian Approach.” *Spanish Economic Review* 10(1): 23-40
- Restrepo, P. 2005. “Disinflation Costs under Inflation Targeting in a Small Open Economy.” Borradores de Economía 328. Bogotá, Colombia: Banco de la República.

- Rincón, H. and J. Toro. 2010. “Are Capital Controls and Central Bank Intervention Effective?” Borradores de Economía 625. Bogotá, Colombia: Banco de la República.
- Rodrik, D. 2006. “The Social Cost of Foreign Exchange Reserves.” NBER Working Paper # 11952. Cambridge, MA: National Bureau of Economic Research.
- Rowland, P. 2004. “Exchange Rate Pass-Through to Domestic Prices: the Case of Colombia.” *Ensayos sobre Política Económica* 47: 106-125
- Schorfheide, F. 2000. “Loss Function-based Evaluation of DSGE Models.” *Journal of Applied Econometrics* 15(6): 645-670.
- Superintendencia Financiera de Colombia (2007). Circular Externa 40 of 2007.
- Superintendencia Financiera de Colombia (2009). Circular Externa 017 of 2009.
- Tipo de cambio, una marranada” *El Tiempo*. December 1, 2004. Accessed February 12, 2012.
- “Uribe preocupado por la tasa de cambio.” *El Tiempo*. May 19, 2003. Accessed February 12, 2012
- Uribe, J. D. 2012. “En defensa del marco actual de política cambiaria.” Bogotá, Colombia: Banco de la República. August 17, 2012.
- Uribe, J. D. 2012. “How can Macro-Prudential policies or frameworks for financial stability be designed to preserve the credibility of monetary policy to keep inflation low? Reflections from a commodity exporting, small open economy” Bogotá, Colombia: Banco de la República. March 1, 2012.

- Vargas, H. 2007. "The Transmission Mechanism of Monetary Policy in Colombia: Major Changes and Current Features." Borradores de Economía 431. Bogotá, Colombia: Banco de la República.
- Vargas, H. 2011. "Monetary Policy and the Exchange Rate in Colombia." Borradores de Economía 655. Bogotá, Colombia: Banco de la República.
- Vargas, H. and C. Varela. 2008. "Capital Flows and Financial Assets in Colombia: Recent Behaviour, Consequences and Challenges for the Central Bank." Borradores de Economía 502. Bogotá, Colombia: Banco de la República.
- Vargas, H. and P. Cardozo. 2012. "El uso de encajes en un marco de política monetaria óptima." Borradores de Economía 716. Bogotá, Colombia: Banco de la República.
- Vargas, H. and P. Cardozo. 2012. "The Use of Reserve Requirements in an Optimal Monetary Policy Framework." Borradores de Economía 716. Bogotá, Colombia: Banco de la República.
- Vargas, H. et al. 2010. "Effects of Reserve Requirements in an Inflation Targeting Regime: The Case of Colombia." Borradores de Economía 587. Bogotá, Colombia: Banco de la República)
- Walsh, C. 2009. "Inflation Targeting: What have we Learned?" *International Finance* 12(2): 195-233.
- West, M. and J. Harrison. 1999. *Bayesian Forecasting and Dynamic Models*. New York, NY: Springer-Verlag.

Appendix 1: Bayesian Impulse Response Functions

Figure 8. Impulse Response Function to a Demand Shock

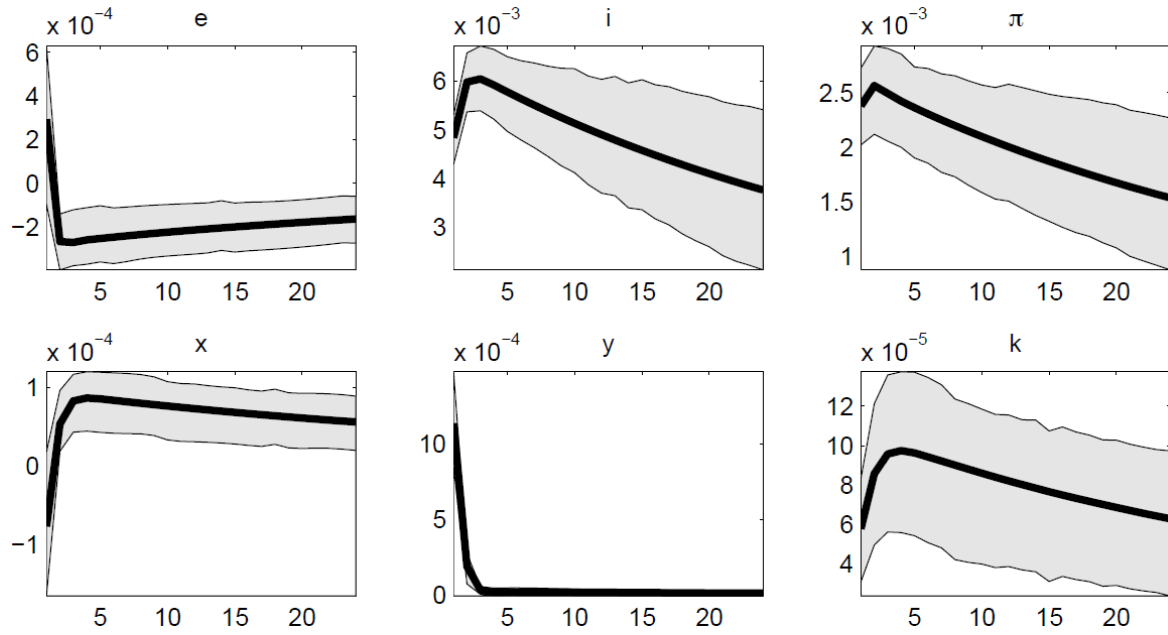


Figure 9. Impulse Response Function to an Inflation Shock

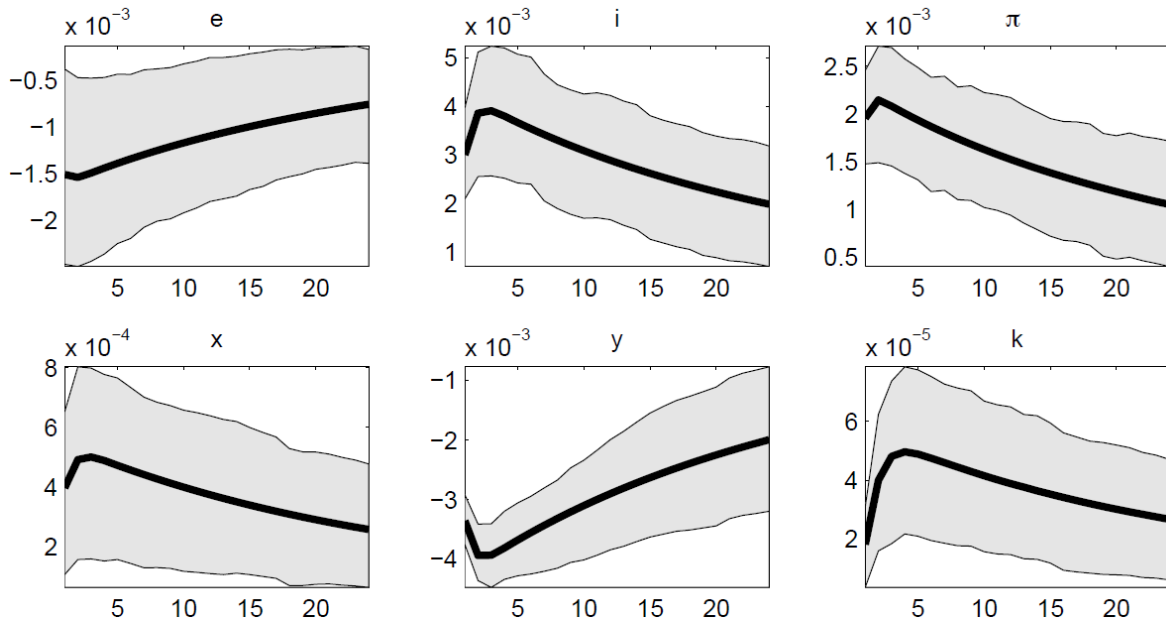


Figure 10. Impulse Response Function to Monetary Policy Shock

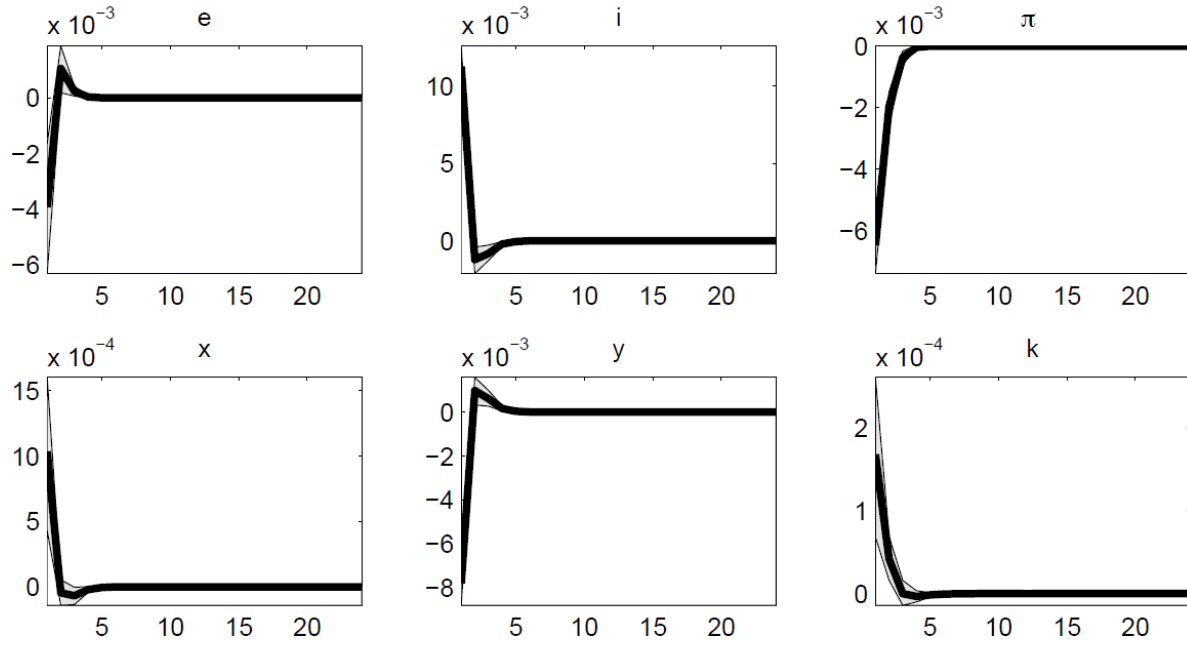


Figure 11. Impulse Response Function to Capital Flows Shock

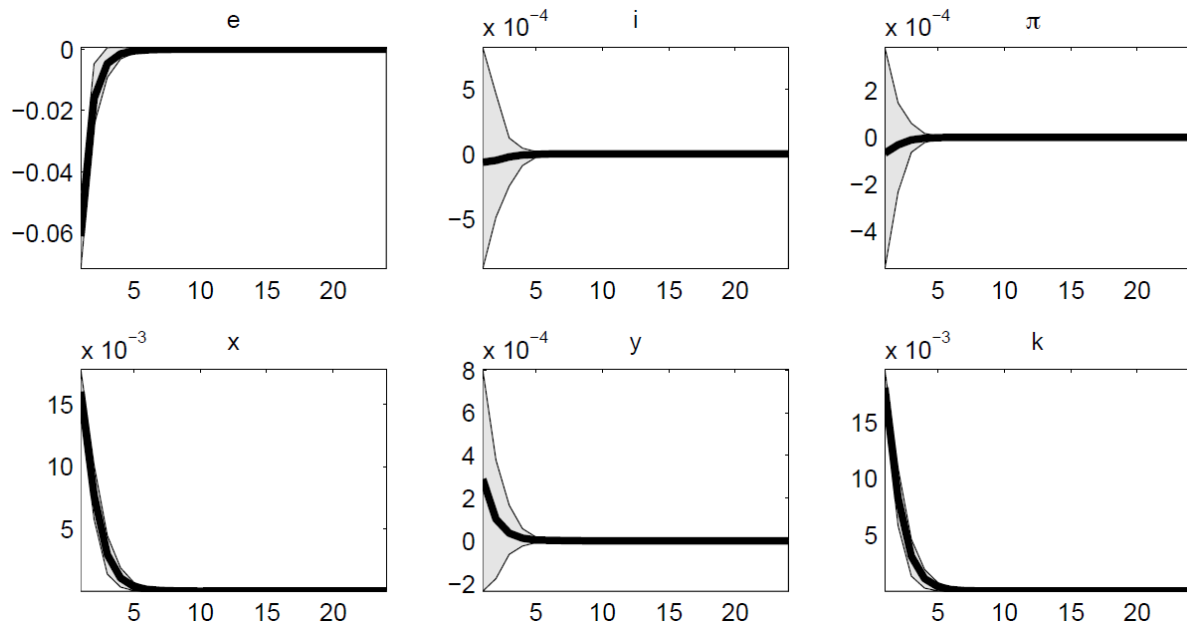


Figure 12. Impulse Response Function to FX Intervention Shock

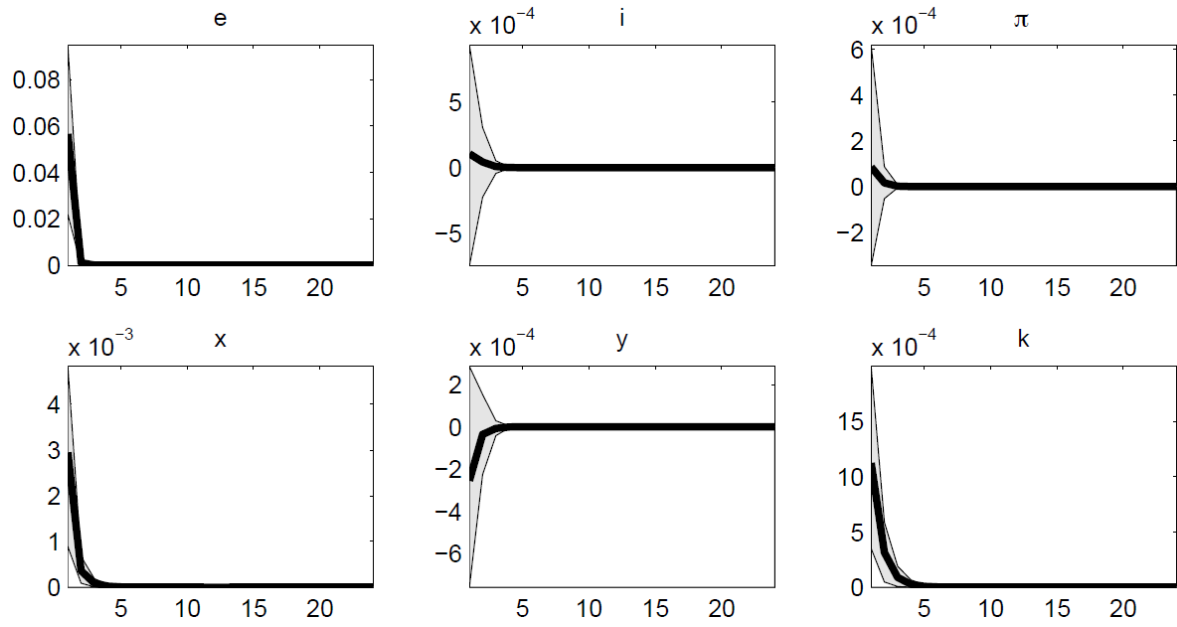


Figure 13. Impulse Response Function to FX “News” Intervention Shock

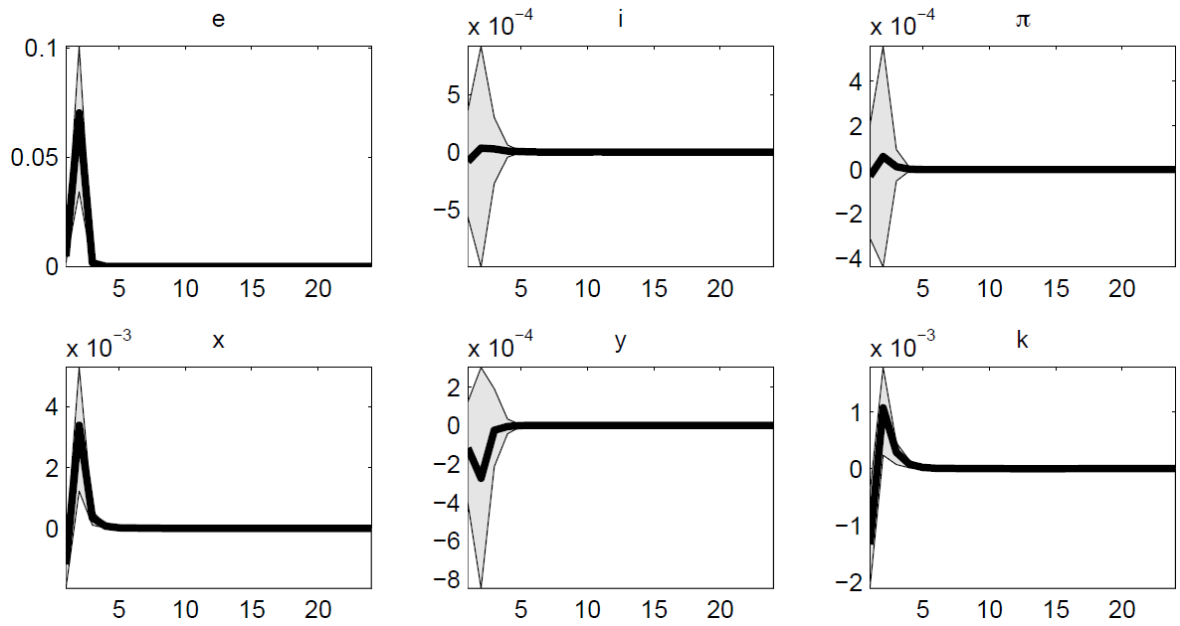


Figure 14. Impulse Response Function to US Interest Rate Shock

