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The role of external shocks for monetary policy in Colombia and Brazil: A Bayesian SVAR analysis

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Abstract

This paper identifies the effects of US interest rate and commodity price shocks on the monetary policy of two inflation targeting emerging economies from Latin America, Colombia and Brazil. We estimate country-specific Bayesian SVARs with block exogeneity restrictions and account for the fact that central banks in both countries use two different instruments of monetary policy, a policy interest rate and foreign exchange market interventions. Our findings show that the Colombian and, to a lesser degree, the Brazilian central bank use sterilized interventions as a systematic component of their inflation targeting regimes, which are more accurately described as "inflation-targeting-cum-intervention". Foreign exchange interventions are used in both countries to set domestic interest rates more independently from US monetary policy and, in Colombia, to increase interest rates in response to rising import prices without further deteriorating the terms of trade. Our results also indicate a lower susceptibility to shocks emanating from outside Colombia or Brazil under this policy regime than what studies for the pre-inflation targeting period have found.

JEL codes: C32, E52, E58, F31, O54
Keywords: External Shocks, Inflation Targeting, Foreign Exchange Intervention, Bayesian SVAR, Block Exogeneity

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1 Introduction

How does a central bank from a small open economy react to external shocks when it practices inflation targeting under fear of floating? We answer this question for two representative inflation targeters from the emerging world, Colombia and Brazil, by estimating country-specific Bayesian structural vector autoregressions (SVARs) with block-exogeneity restrictions. Block-exogeneous SVARs are a well-established tool to analyze the impact of external shocks on small open emerging economies, with notable contributions to the literature by Canova (2005) and Maćkowiak (2007). In contrast to these earlier studies, we conduct our analysis for a specific policy regime, inflation targeting, and account for the fact that central banks may employ interventions on the foreign exchange (FX) market as an additional instrument of monetary policy. This two-instrument approach to monetary policy has become increasingly popular among emerging inflation targeters in recent years, a trend termed as "inflation-targeting-cum-intervention" by Ostry et al. (2012). While this phenomenon has already been studied by single-equation approaches, such as the estimation of Taylor rules and FX reaction functions, it still lacks broad recognition in the SVAR literature on emerging economies.[1] To the best of our knowledge, our paper is the first to formally incorporate "inflation-targeting-cum-intervention" into an SVAR analysis of emerging world inflation targeting, thus combining two strings of literature to provide a more realistic insight into how external shocks are actually handled under this policy regime.

The fact that many inflation targeting emerging economies still target the exchange rate as a secondary central bank objective has been well documented in the literature (Stone et al., 2009a; Aizenman et al., 2011; Ostry et al., 2012). In the presence of shocks to external variables that a small open economy takes as given, this may put an inflation targeting

[1] The role of interventions for monetary policy in the US has been studied by, among others, Kim (2003).

central bank that wants to attain both targets into a dilemma. Our paper focuses on two of these dilemmas, the one caused by US interest rate shocks and the one caused by global commodity price increases. First, a less-than-flexible exchange rate regime under high capital mobility leads to a loss of monetary policy independence, causing what Edwards (2015) calls "policy contagion" from the US Fed to the interest rate setting decisions of other central banks. Under policy contagion, US monetary policy decisions must be at least partially accommodated by the domestic interest rate, which restricts the central bank from the small country in using the interest rate instrument for domestic purposes such as controlling domestic inflation. Second, inflation targeting can exacerbate the effects of an adverse terms of trade shock, which affects any central bank that is also concerned about the stability of its terms of trade. Whereas such stability would require a real depreciation of the currency in response to an exogenous import price increase, an inflation targeting central bank might be forced to raise domestic interest rates to counter the inflationary impact of the shock, thus causing a real appreciation and a further deterioration of the terms of trade. Frankel (2011) argues that this scenario is especially important for countries with a high share of commodities in the trade structure, for which the terms of trade are especially volatile.

Since inflation targeting has been introduced by a large and heterogeneous group of emerging economies, we apply our empirical model to a comparative case study of two most-similar countries for which we know the external shocks discussed above to be particularly relevant. Both Colombia and Brazil are financially integrated economies with traditional links to US financial markets, thus increasing the risk of policy contagion' from US monetary policy, and they are among the inflation targeting countries with the highest share of commodities in overall trade. Besides belonging to the same world region, both countries also share a comparatively long and established history of inflation targeting, and their respective central banks show a well-documented propensity to engage in non-conventional measures of monetary policy such as FX interventions (Barajas et al., 2014). Colombia and Brazil are also the two biggest inflation targeting countries from South America in terms of population and GDP, albeit there is still a considerable difference in size between them that makes for an important aspect of our comparison. Due to data restrictions, our estimation period is 2000:02-2014:12 for Colombia and 2004:01-2014:12 for Brazil, thus omitting all years prior to 1999 when different monetary policy regimes were in place.

Our empirical results show that policy reactions to external shocks in these two economies can only be fully understood if both the policy interest rate instrument and FX interventions are accounted for. The combination of these two instruments allows both countries to mitigate the dilemmas described above, which only partially appear in our results. For Colombia, we find evidence for a considerable contagion of US monetary policy into domestic interest rates, but the Colombian central bank appears to intervene on the FX market to impede a full equalization of interest rates and to dampen the ensuing exchange rate reaction. In response to an adverse terms of trade shock, Colombia uses a combination of higher interest rates and foreign exchange interventions that leaves both the price level and the exchange rate largely unaffected. Our results are somewhat more mixed for Brazil, a larger and less open economy, where policy contagion from US monetary policy to domestic interest rates is virtually inexistent. We find evidence for some FX interventions aimed at the effects of US monetary policy on the Brazilian exchange rate, but cannot fully control for the effects of other measures such as capital controls. Commodity-induced terms of trade shocks are met with a more restrained reaction by the Brazilian central bank, indicating that it does not consider these shocks as paramount. Overall, our results indicate that external shocks had little impact on output and price volatility in both countries that we study, which stands in contrast to the high importance of external shocks for emerging economies found in studies for the pre-inflation targeting period.

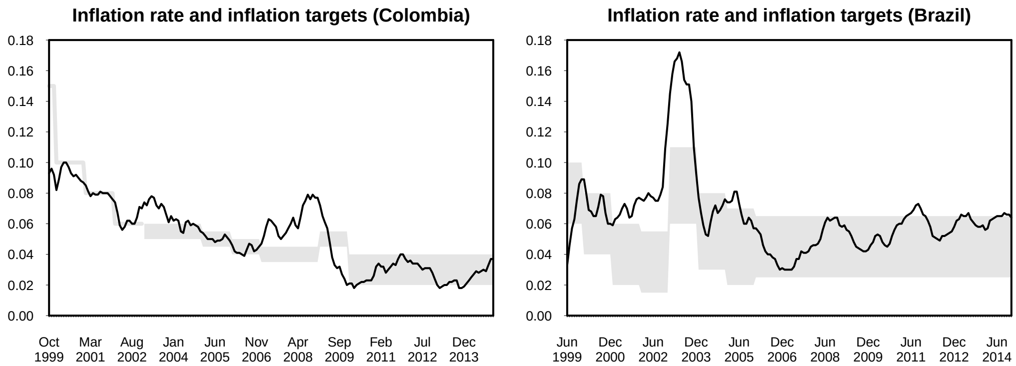
The remainder of our paper is structured as follows. In section 2 we briefly discuss the inflation targeting regimes of Colombia and Brazil and the instruments of monetary policy employed in these countries. Section 3 introduces our empirical model and the identifying restrictions we use. After discussing the data set in section 4, we present our empirical results in section 5. The final section concludes.

2 Monetary policy in Colombia and Brazil

Inflation targeting was introduced in both Colombia and Brazil in 1999, when contagion effects from the late 1990s emerging market currency crises caused intense devaluation pressure on many Latin American currencies. In June 1999, Brazil had to give up the Plano Real, an asymmetric currency band regime that had only been introduced five years earlier to end a severe hyperinflation. Colombia followed suit in September 1999, when the country's long-standing crawling band arrangement was given up. Following the end of these exchange rate pegs as nominal anchors for monetary policy, central banks in both countries engaged in a relatively abrupt switch to inflation targeting, publishing the first inflation targets for June and October 1999, respectively.

The trajectory of inflation rates and inflation targets in both countries can be seen in figure 1. Since 1999, inflation targets were gradually reduced in a process of disinflation, having now seemingly achieved stable levels at 3 per cent in Colombia and 4.5 per cent in Brazil. The higher level at which long-run inflationary expectations in Brazil are anchored is likely a result of the more convoluted inflationary history of that country, which suffered recurring episodes of high inflation and stabilization attempts throughout the second half of the 20th century, and of the stronger tradition of price and wage indexation in Brazil. In

Figure 1: Inflation rates and inflation targets in Colombia and Brazil, 1999-2014



Inflation targets are marked by a shaded area for inflation target corridors and a shaded line for point targets, used by Colombia from 1999 to 2002

both countries, the success rate of inflation targeting has been relatively high: From 1999 to 2014, the root mean squared deviation of inflation from the point target (or center of the target range) stands at 1.41 percentage points for Colombia and 2.66 percentage points for Brazil, where target bands are broader.[2] As a cap on inflationary expectations, the targets performed remarkably well; the only two upward adjustments of an inflation target occurred in 2009 in Colombia, in the middle of the global financial crisis, and in 2003 in Brazil.

The 2003 upward adjustment relates to the Brazilian currency crisis of 2001-03, which we briefly discuss since it affects our sample length for Brazil. Due to the impeding presidential election of Lula da Silva in 2002, who ran on what was perceived to be a socialist platform, the Brazilian Real came under devaluation pressure in 2001. Blanchard (2004) describes this as a period of fiscal dominance, where the Brazilian central bank was restrained in the use of its interest rate instrument because higher interest rates would have the perverse consequence of making the perceived risk of government default even more

[2]This measure of target compliance was suggested by Roger and Stone (2005).

likely. In consequence, the central bank could do little to prevent the pass-through of devaluation into prices, resulting in a surge of inflation. For our empirical setup, this episode presents a serious problem since, although the crisis originated in Brazil, it coincided with external events such as the collapse of the dot-com bubble and the resulting decrease in US interest rates. Including the 2001-03 period in our estimation sample therefore produces unreasonable results concerning the effects of a US monetary policy shock in Brazil, a problem that we are not able to control for by the introduction of crisis-specific dummy variables. We therefore cut our sample for Brazil to the period beginning in January 2004, when the Lula government was well-established and inflation had returned to its pre-crisis level. This has the additional benefit of making the Brazilian sample more comparable to the Colombian one: From 2004 to 2014, the root mean squared deviation of Brazilian inflation from its target falls to 1.51 percentage points, a measure similar to the one earlier observed for Colombia.

As in most inflation targeting economies, a policy repo rate became the prime instrument of monetary policy in Colombia and Brazil once exchange rate pegs were given up. For Colombia, the relevant interest rate has since been the policy intervention rate (Tasa de Intervención), whereas Brazilian monetary policy relies on the interest rate for overnight interbank loans, known as SELIC. Taylor rule estimations from Moura and de Carvalho (2010), de Mello and Moccero (2011), and Barajas et al. (2014) have mostly confirmed that these rates react in the expected positive and significant way to deviations of inflation from its target, indicating a consistent use of the instrument within the respective inflation targeting framework. It should be noted that the interest rate is generally seen as a less-than-perfect instrument to control the money supply in emerging economies, where capital market imperfections are often prevalent; this is clearly the case for Brazil, where such imperfections are considered one of the main reasons for the very high level of real interest rates (Segura-Ubiergo, 2012).

While the aforementioned Taylor rule studies found no evidence that the policy interest rates of either Colombia or Brazil react significantly to changes in the respective exchange rates, it cannot be concluded that fear of floating is inexistent in these countries. Instead, a growing empirical literature suggests that many emerging economies use a second instrument of monetary policy to attain their implicit exchange rate target, namely central bank interventions on the foreign exchange market. These interventions, if successfully sterilized, can be used to influence the level of the exchange rate without altering the money supply, thus giving the central bank an instrument that is independent of conventional monetary policy. Barajas et al. (2014) show that both Colombia and Brazil use this instrument to influence the exchange rate of their respective currencies, with FX interventions in both countries reacting significantly to misalignments in the real exchange rate.

Whereas FX interventions are sometimes considered a merely occasional central bank instrument, it is hard to interpet their occurrence in Colombia and Brazil over the past 15 years as anything but systematic. Table 1 shows episodes collected by Barajas et al. (2014) in which one of the two countries actively intervened on the foreign exchange market, indicating nearly continuous FX interventions in both countries over the majority of the time period that we analyze. Only some of these interventions can be linked to specific events such as the 2001-03 turbulences in Brazil or the September 2008 collapse of Lehman Brothers, but the general incidence and timing of interventions indicates a rather permanent concern by the respective central bank about the level of the exchange rate. This is corroborated by official central bank communications, especially from the Colombian central bank, which explicitly reserves itself a right to intervene in the foreign exchange market in order to prevent excessive exchange rate volatility (Chang, 2008). For the remainder of the paper, we will therefore assume FX interventions to be a systematic feature

Table 1: Foreign exchange market interventions in Colombia and Brazil, 1999-2014

Colombia	Brazil
	End of 2001
End of 2002 to 2003	End of 2002
2004 to 2007	2004 to 2008
Mid-2008	
Sept. 2008	Sept. 2008 to 2009
Early 2010 to late 2011	2009 to 2013
2012	

Source: Barajas et al. (2014).

of monetary policy in both countries that we study.

The theoretical literature on sterilized interventions has traditionally been skeptical about the effectiveness of the instrument for currency manipulation.[3] An impact of interventions on the exchange rate is usually modeled around a portfolio balance channel, which would allow the domestic central bank to affect the risk premium between domestic and foreign assets and induce investors to rebalance their portfolios irrespective of the actual interest rate differential (Stone et al., 2009a). Such a channel requires the rather strong assumptions of imperfect asset substitutability and failing Ricardian Equivalence (which would lead investors to anticipate the future costs of a change in domestic assets), and is therefore rejected on theoretical grounds. However, recent empirical studies have been more supportive of intervention effectiveness, finding at least temporarily significant effects on the exchange rate in many emerging economies. This includes case studies for Colombia and Brazil by Chang (2008), Kamil (2008), and Adler and Tovar (2011), all of which confirm our hypothesis that the central banks of these countries are able to use FX interventions as an effective instrument of monetary policy.

[3]Non-sterilized interventions unambiguously affect the exchange rate via the money supply, in a similar way as interest rate policy does.

Before we proceed to show how the two instruments discussed above are included in our empirical model, we conclude this section by making some qualifications to the extent of actual central bank policy that we are able to cover. With regard to FX interventions, we are aware that not all central bank activities on the foreign exchange market are necessarily targeted at manipulating the exchange rate, and interpret our findings with the appropriate degree of caution.[4] In addition, emerging economies are known to employ other non-conventional measures of monetary policy that we do not capture in our model, notably capital controls. These played a role in both countries that we study during our observation period: Colombia briefly imposed capital controls (in the form of higher marginal reserve requirements on foreign portfolio investment) from May 2007 to October 2008, whereas Brazil introduced a Tobin-like tax on foreign purchases of domestic securities that lasted from March 2008 to January 2012, resulting in a total duration of capital controls of almost four years, albeit with differing intensity. The effectiveness of these controls on the exchange rate is even less clear than it is for the case of FX interventions. Clements and Kamil (2009) and Concha et al. (2011) find no evidence for an impact of the 2007-08 Colombian capital controls on the exchange rate of the Peso, but Baba and Kokenyne (2011) suggest that both Colombia and Brazil were able to maintain higher interest rate differentials to the US for the duration of their respective capital controls, a finding that resonates in our own empirical results in section 5. While keeping these additional monetary policy measures in mind, we choose not to incorporate capital controls directly into our empirical model, given that they are both unsystematic and asymmetric, with virtually all capital controls imposed during recent years targeted at capital inflows rather than outflows.

[4]Other rationales for the buying or selling of international reserves by the central bank might be the desire to fill up a "war-chest" for crisis prevention (Chang, 2008), or the provision of FX liquidity to domestic corporations during times of crisis (Stone et al., 2009b)

3 The model

3.1 Mathematical framework

Our empirical model is based on a general SVAR model of the form

$$\mathbf{y}_t'\mathbf{A}_0 = \sum_{l=1}^{L} \mathbf{y}_{t-l}'\mathbf{A}_l + \mathbf{x}_t'\mathbf{B} + \mathbf{e}_t', \tag{1}$$

where $t = 1, \ldots, \mathrm{T}$ is the discrete time index and $l = 1, \ldots, L$ is the discrete lag index. The vector $\mathbf{y}_t' = (y_{1,t} \ \ldots \ y_{\mathrm{K},t})$ includes the $k = 1, \ldots, \mathrm{K}$ endogenous variables of the model at time t, $\mathbf{x}_t' = (x_{1,t} \ \ldots \ x_{\mathrm{J},t})$ includes the $j = 1, \ldots, \mathrm{J}$ exogenous variables, and $\mathbf{e}_t = (e_{1,t} \ \ldots \ e_{\mathrm{N},t})$ includes the disturbances in each structural equation $n = 1, \ldots, \mathrm{N}$. $\mathbf{A}_0$ and $\mathbf{A}_l$ are parameter matrices associated with the contemporaneous and the lagged variables, each of the dimension $\mathrm{K} \times \mathrm{N}$, and $\mathbf{B}$ is the $\mathrm{J} \times \mathrm{N}$ parameter matrix associated with the exogenous variables. The number of structural equations N equals the number of endogenous variables K.

It is convenient to stack our model in (1) to

$$\mathbf{Y}\mathbf{A}_0 = \mathbf{Z}\mathbf{A}_Z + \mathbf{E}, \tag{2}$$

where $\mathbf{Y} = (\mathbf{y}_1' \ \ldots \ \mathbf{y}_\mathrm{T}')'$ is the $\mathrm{T} \times \mathrm{K}$ matrix of contemporaneous variables, $\mathbf{Z} = (\mathbf{z}_t' \ \ldots \ \mathbf{z}_\mathrm{T}')'$ is the $\mathrm{T} \times (\mathrm{KL} + \mathrm{J})$ matrix of lagged variables with $\mathbf{z}_t' = (\mathbf{y}_{t-1}' \ \ldots \ \mathbf{y}_{t-L}' \ \mathbf{x}_t')$, $\mathbf{A}_Z = (\mathbf{A}_1 \ \ldots \ \mathbf{A}_L \ \mathbf{B})'$ is the $(\mathrm{KL} + \mathrm{J}) \times \mathrm{N}$ parameter matrix associated with the lagged endogenous and exogenous variables, and $\mathbf{E} = (\mathbf{e}_1' \ \ldots \ \mathbf{e}_\mathrm{T}')'$ is the $\mathrm{T} \times \mathrm{N}$ matrix of structural disturbances. $\mathbf{E}$ is by assumption matricvariate Gaussian with mean matrix $E[\mathbf{E}] = \mathbf{0}$ and diagonal covariance matrices $\mathbf{P}_\mathbf{E} = \mathbf{I}_\mathrm{T}$ and $\mathbf{Q}_\mathbf{E} = \mathbf{I}_\mathrm{N}$, which determine the correlation between the row and column elements of $\mathbf{E}$ such that there is neither correlation across time nor across equations in the structural disturbances.

3.2 Identification restrictions

In order to obtain a system of structural equations, economic beliefs about the interdependencies between variables are incorporated via linear restrictions on the parameter matrices $\mathbf{A}_0$ and $\mathbf{A}_Z$. In principle, the model in (2) assumes all K variables to be mutually endogenous, and many contributions to the SVAR literature rely exclusively on restrictions on the contemporaneous parameter matrix $\mathbf{A}_0$ to give their model an economic structure. For a model that tries to capture the behavior of a small open economy, such an approach is insufficient: While foreign variables such as US interest rates or global commodity prices are of obvious importance to the small economy, it is unclear why these variables should in turn be affected by events in a country of comparatively little importance to the global economy.

To incorporate the small open economy assumption, we therefore employ the block exogeneity approach first introduced to the SVAR literature by Cushman and Zha (1997). We further subdivide our data vector into $\mathbf{y}_t' = (\mathbf{y}_{t_F}' \ \mathbf{y}_{t_D}')$, where F denotes the foreign and D the domestic variables, and suppress any contemporaneous or lagged influence of the domestic on the foreign block by a corresponding block of zero restrictions in the respective parameter matrices. Formally, this means (2) is rewritten as

$$\mathbf{Y}\begin{pmatrix} \mathbf{A}_{0_{F,F}} & \mathbf{A}_{0_{F,D}} \\ \mathbf{0} & \mathbf{A}_{0_{D,D}} \end{pmatrix} = \mathbf{Z}\begin{pmatrix} \mathbf{A}_{1_{F,F}} & \mathbf{A}_{1_{F,D}} & \dots & \mathbf{A}_{L_{F,F}} & \mathbf{A}_{L_{F,D}} \\ \mathbf{0} & \mathbf{A}_{1_{D,D}} & \dots & \mathbf{0} & \mathbf{A}_{L_{D,D}} \end{pmatrix}' + \mathbf{E}, \qquad (3)$$

where the lower left block of each parameter matrix, $\mathbf{A}_{0_{D,F}}, \mathbf{A}_{1_{D,F}}, \dots, \mathbf{A}_{L_{D,F}} = \mathbf{0}$, contains only zeros. These block exogeneity restrictions are the only restrictions that we impose on the lagged coefficients in $\mathbf{A}_Z$.

For the contemporaneous coefficients in $\mathbf{A}_0$, we use an identification scheme based on the SVAR models for Canada by Cushman and Zha (1997) and Bhuiyan (2012), but expanded by a market for foreign exchange that these models do not consider. We follow Cushman and Zha in the setup of our exogenous block, which includes a measure of US output, US prices, the Federal Funds rate (FFR), and two commodity price indices which represent both an export and an import commodity of the respective country (the commodities chosen for each country are discussed in section 4). Formally, this means $\mathbf{y}'_{t_F} = (Y^*_t \quad P^*_t \quad i^*_t \quad c1^*_t \quad c2^*_t)$. The inclusion of US output and US prices can be warranted by the possible transmission of US shocks via a bilateral trade channel as in Canova (2005), but we do not give special attention to this channel. In the domestic block, we include measures of output and prices, the current account balance, the money stock, net foreign exchange interventions, the policy interest rate and the nominal exchange rate, i.e. $\mathbf{y}'_{t_D} = (Y_t \;\; P_t \;\; CA_t \;\; M_t \;\; fx_t \;\; i_t \;\; s_t)$.

Equation (4) presents our contemporaneous restrictions on $\mathbf{A}_0$, with the 12 structural equations of the model written in vertical order. The first five equations (FS1 to FS5) correspond to our foreign sector, i.e. the foreign block of variables, which is by definition not affected by the domestic block ($\mathbf{A}_{0_{D,F}} = \mathbf{0}$). We restrict these equations in a recursive order, with the US production sector – output and prices – contemporaneously affecting the other external variables. A recursive ordering of the foreign sector is necessary to ensure the strict block structure of $\mathbf{A}_0$, which might otherwise be lost once the matrix is inverted during the estimation process. We follow the literature in making commodity prices contemporaneously dependent on US monetary policy, an identifying assumption that can be seen as an implicit asset price view of commodity prices, and allow the oil price index (which is included in both models) to contemporaneously affect the second commodity.

$$
\mathbf{A}_0 = \begin{array}{c} \\ Y^* \\ P^* \\ i^* \\ c1^* \\ c2^* \\ \\ Y \\ P \\ CA \\ M \\ fx \\ i \\ s \end{array}
\begin{array}{c}
\begin{array}{cccccccccccc} FS1 & FS2 & FS3 & FS4 & FS5 & PS1 & PS2 & FXD & MD & FXS & MS & Inf \end{array} \\
\left(\begin{array}{cccccccccccc}
a_{0_{1,1}} & a_{0_{1,2}} & a_{0_{1,3}} & a_{0_{1,4}} & a_{0_{1,5}} & 0 & 0 & a_{0_{1,8}} & 0 & 0 & 0 & a_{0_{1,12}} \\
0 & a_{0_{2,2}} & a_{0_{2,3}} & a_{0_{2,4}} & a_{0_{2,5}} & 0 & 0 & 0 & 0 & 0 & 0 & a_{0_{2,12}} \\
0 & 0 & a_{0_{3,3}} & a_{0_{3,4}} & a_{0_{3,5}} & 0 & 0 & a_{0_{3,8}} & 0 & a_{0_{3,10}} & a_{0_{3,11}} & a_{0_{3,12}} \\
0 & 0 & 0 & a_{0_{4,4}} & a_{0_{4,5}} & 0 & 0 & 0 & 0 & a_{0_{4,10}} & a_{0_{4,11}} & a_{0_{4,12}} \\
0 & 0 & 0 & 0 & a_{0_{5,5}} & 0 & 0 & 0 & 0 & a_{0_{5,10}} & a_{0_{5,11}} & a_{0_{5,12}} \\
 & & & & & & & & & & & \\
0 & 0 & 0 & 0 & 0 & a_{0_{6,6}} & a_{0_{6,7}} & a_{0_{6,8}} & a_{0_{6,9}} & 0 & 0 & a_{0_{6,12}} \\
0 & 0 & 0 & 0 & 0 & 0 & a_{0_{7,7}} & 0 & a_{0_{7,9}} & 0 & 0 & a_{0_{7,12}} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & a_{0_{8,8}} & 0 & a_{0_{8,10}} & a_{0_{8,11}} & a_{0_{8,12}} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a_{0_{9,9}} & a_{0_{9,10}} & a_{0_{9,11}} & a_{0_{9,12}} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a_{0_{10,10}} & a_{0_{10,11}} & a_{0_{10,12}} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & a_{0_{11,8}} & a_{0_{11,9}} & 0 & a_{0_{11,11}} & a_{0_{11,12}} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & a_{0_{12,8}} & 0 & a_{0_{12,10}} & a_{0_{12,11}} & a_{0_{12,12}}
\end{array}\right)
\end{array} \qquad (4)
$$

Equations PS1 and PS2 represent the domestic production sector. We also restrict it in a recursive fashion, assuming that production and price setting decisions are made with a lag. We then include a set of equations to describe the two instruments of monetary policy that we want to capture in our model, the variables fx (net foreign exchange interventions) and i (the policy interest rate). For both instruments, we start with establishing a demand function that the central bank is supposed to react to. We model the demand for foreign exchange (FXD) by an equation that captures movements in the current account balance and assume that these movements respond contemporaneously to income and interest rate changes in the foreign and the domestic country, as well as to exchange rate changes between them. Our money demand equation (MD) is based on Cushman and Zha and has contemporaneous demand for real money being driven by income y and the nominal interest rate i.

The only restrictions that we place on the foreign exchange supply (FXS) and money supply equations (MS), i.e. our implicit central bank reaction functions, are zero restrictions on output and prices, which are typically measured with a lag and not available to the central bank within the month. We assume that policymakers react contemporaneously to all other information available to them, including the US Federal Funds rate and commodity prices. However, it is necessary to specify a contemporaneous prioritization of our two instruments of monetary policy, since their joint identification is not possible if both are allowed to react simultaneously to each other. We do this by following Kim (2003) and setting $a_{0_{11,10}}$ to zero, thus indicating that innovations in the FXS equation have an immediate impact on interest rates, but not the other way round. This decision is warranted by the fact that an FX intervention may be sterilized as well as non-sterilized, the latter having an obvious and immediate impact on conventional monetary policy. We conclude our model by an exchange rate equation that models a market for information (Inf) and reacts contemporaneously to all other variables of the system.

With $\mathrm{K} = 12$ variables, our model in (2) is exactly identified for the case of $\mathrm{K}(\mathrm{K}-1)/2 = 66$ restrictions on $\mathbf{A}_0$ and $\mathbf{A}_Z$. We are thus working with an overidentified model as we place 89 contemporaneous restrictions on $\mathbf{A}_0$ alone, a number that further grows by 35 restrictions for each lag included in the model. To ensure that we can still estimate such an overidentified model, we follow Rubio-Ramírez et al. (2010) to show that the conditions for global identification are fulfilled, i.e. that a unique estimation of the parameter matrices $\mathbf{A}_0$ and $\mathbf{A}_Z$ is possible a priori. For global identification, our identification scheme must satisfy both the order condition from Rothenberg (1971) and the rank condition from Rubio-Ramírez et al. (2010); we have already verified the order condition, which means that the number of restrictions must be greater or equal to 66, and are able to show that the rank condition is fulfilled as well.[5] In the following section, we now briefly turn to our

[5]The proof that our identification scheme fulfills the rank condition is available upon request.

estimation procedure.

3.3 Estimation parameters

We derive the main results of our empirical analysis by using the Markov chain Monte Carlo (MCMC) method of Waggoner and Zha (2003).[6] The method is based on a Gibbs sampling approach and has better performance in terms of finite-sample accuracy and convergence speed in comparison to other methods, such as the importance-sampling based method used in Leeper et al. (1996) and Zha (1999).

We briefly refer to our Bayesian prior specification for the N contemporaneous and lagged structural parameter vectors $\mathbf{a}_0^n$ and $\mathbf{a}_Z^n$. As usual, we drop the zero restrictions in the parameter vectors for simplicity in the notation. The vectors thus differ in length, labeled here as q_0^n and q_Z^n. Following Litterman (1986), Waggoner and Zha (2003) and Sims and Zha (1998), we set the prior in the following manner:

$$\mathbf{a}_0^n \sim N(\mathbf{0}, \overline{\mathbf{S}}^n) \tag{5}$$

$$\mathbf{a}_Z^n | \mathbf{a}_0^n \sim N(\overline{\mathbf{P}}^n \mathbf{a}_0^n, \overline{\mathbf{H}}^n) \tag{6}$$

The prior variances are set such that

$$\underset{q_0^n \times q_0^n}{\overline{\mathbf{S}}^n} = diag\left(\left(\frac{\lambda_0}{\sigma_1}\right)^2 \dots \left(\frac{\lambda_0}{\sigma_{\mathrm{K}}}\right)^2\right), \tag{7}$$

$$\underset{q_Z^n \times q_0^n}{\overline{\mathbf{P}}^n} = \begin{pmatrix} \mathbf{I}_{q_0^n} \\ \mathbf{0} \end{pmatrix} \text{ and} \tag{8}$$

[6] We implement the algorithm in R. The code can be received upon request.

$$\underset{q_Z^n \times q_Z^n}{\overline{\mathbf{H}}^n} = diag\left(\left(\frac{\lambda_0\lambda_1}{1^{\lambda_3}\sigma_1}\right)^2 \ldots \left(\frac{\lambda_0\lambda_1}{1^{\lambda_3}\sigma_{\mathrm{K}}}\right)^2 \left(\frac{\lambda_0\lambda_1}{2^{\lambda_3}\sigma_1}\right)^2 \ldots \quad \left(\frac{\lambda_0\lambda_1}{L^{\lambda_3}\sigma_{\mathrm{K}}}\right)^2 \lambda_{3+j} \ldots \lambda_{3+J}\right). \quad (9)$$

The conditional prior for $\mathbf{a}_Z^n$ incorporates the idea of Litterman (1986) that a random walk behavior is a plausible a priori assumption for each variable. We choose the same values as Bhuiyan (2012) for the hyperparamters in (7) and (9), with $\lambda_0 = 1$, $\lambda_1 = 0.5$, $\lambda_3 = 0.1$ and all $\lambda_{3+j} = \lambda_0\lambda_4$ with $\lambda_4 = 1$. The scaling parameters σ_n are the standard deviations of the estimated residuals from univariate autoregressive models fit to each variable.

Since we estimate our model for monthly data and want the lag structure of the SVAR to cover a reasonably long time interval, we determine the optimal lag length by using the Akaike information criterion and likelihood ratio tests, which tend to find higher values for L. We apply these criteria to the maximum likelihood estimates that we use to initialize the Gibbs sampler rather than to our sampling results, due to the fact that the latter are biased towards shorter lag lengths because of our prior specification in (9). For both Colombia and Brazil, this results in an optimal lag length of $L = 8$.

4 The data set

We estimate our model with monthly data, due to the high frequency with which FX interventions tend to occur. Since monthly data on GDP is not available, we use industrial production as an alternative measure of economic activity.[7] We also lack monthly data for the Colombian current account balance; following Urrutia et al. (2014), we use monthly data on the foreign exchange balance as a proxy. As in Cushman and Zha (1997) and Bhuiyan (2012), we include the industrial production and price indices as levels, and the

[7]We are aware of the problems that this choice implies, given the lower level of industrialization in many emerging economies and the important role of other sectors like mining and aggriculture, but we consider Colombia and Brazil to be sufficiently industrialized for our approach to still make sense. In any case, the large role of the informal sector in both economies means that neither measure of output is a perfect representation of the full scope of economic activity.

exchange rate as the dollar price of the respective domestic currency.

Our data are obtained from several original sources via Datastream, with the exception of commodity price data that we take directly from the IMF Primary Commodity Price System. In order to analyze terms of trade shocks, we choose representative export and import commodities for both countries, based on commodity trade data from the UN Trade Statistics Database (UN Comtrade). For Colombia, we include the IMF's oil price index as the representative export commodity, given that oil exports make up more than 90 percent in value of that country's commodity exports. Colombian commodity imports are captured by a cereal price index based on the four cereal price series contained in the IMF's food price index, which we construct by using the same relative weights.[8] Brazil has a more diversified commodity trade structure, with iron ore, soybeans, sugar, meat and coffee all being important export commodities. We focus on iron ore and convert the IMF's price series for this commodity into an index representing Brazilian commodity exports, mainly because it shows the lowest correlation with the oil price index, included for Brazil as the representative import commodity.[9]

A detailed enlisting of all our variables can be found in the appendix. Since official data on central bank interventions only becomes available for both countries in 2000, our data set for Colombia is restricted to the 2000:02-2014:12 period, thus leaving out the first four months of inflation targeting in that country. In an alternative empirical setup, we estimated our model for the full 1999:10-2014:12 period and used changes in central bank reserves as a proxy for FX interventions; however, this model resulted in less significant impulse responses for the intervention variable, arguably due to the fact that changes in

[8] These weights are based on the 2002-2004 average world export earnings.

[9] Brazil has recently experienced a dramatic increase in its domestic oil production, reporting net exports of crude oil from petroleum between 2009 and 2012, but the UN Comtrade data shows that Brazil's net trade in all petroleum products (as defined by HS code 27) was negative throughout the entire period that we study.

net foreign reserves can also be caused by valuation effects and other causes not related to central bank activity. For Brazil, central bank intervention data is available from January 2000, but we restrict our sample to the 2004:01-2014:12 time period due to the problems discussed in section 2.

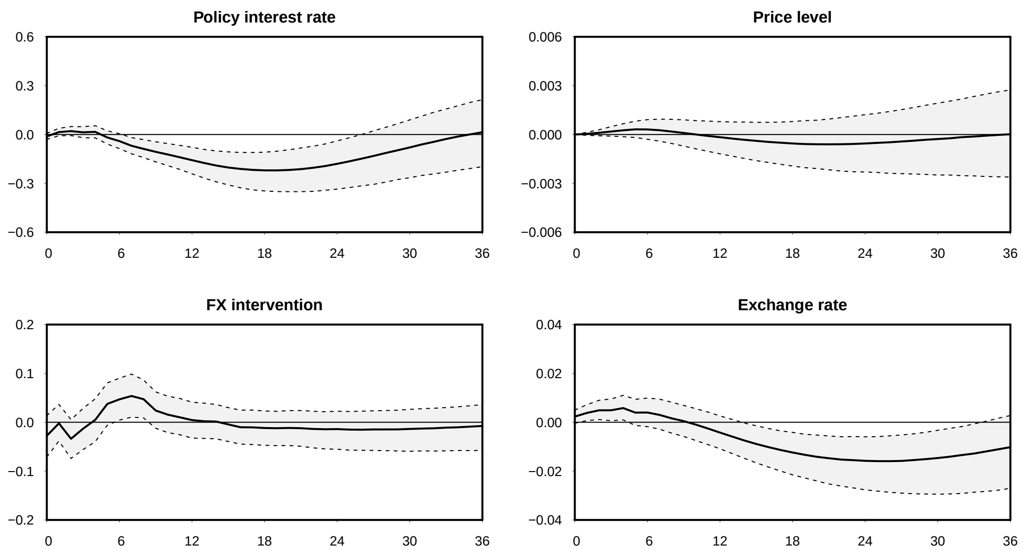
We transform all variables but the interest rates from a linear to a logarithmic scale. For negative values, we use a modified version of a procedure suggested by Busse and Hefeker (2007), where a variable x with both positive and negative values is transformed by employing the formula $\tilde{x} = \ln(x + \sqrt{x^2 + \sigma_x^2}) - \ln(\sqrt{\sigma_x^2})$, with σ_x denoting the standard deviation of x. Industrial production and the money stock are deseasonalized using X-13ARIMA-SEATS. Our model is completed by two exogenous variables, a constant and a dummy variable capturing the global financial crisis, which takes the value of 1 for all months when the US was in recession as defined by the NBER, i.e. the 2007:12-2009:06 time period.

5 Empirical results

5.1 Colombia's reaction to external shocks

We begin the discussion of our empirical results for Colombia, the smaller and more open economy that we study. Figure 2 presents the impulse responses of four domestic Colombian variables to an expansionary one-standard deviation shock to the policy interest rate equation from the exogenous block, i.e. to a shock that leads to a decrease in the Federal Funds rate. In contrast to the convention typically found in the SVAR literature, we do not discuss monetary policy shocks for the (symmetric) case of contractionary monetary policy, given that expansionary shocks from the US are far more relevant for the time period that

Figure 2: Colombian impulse responses to expansionary US monetary policy



we analyze.[10]

It is useful to distinguish between two phases of the Colombian policy reaction in figure 2: An early phase, including the impact reaction and the first few months of the post-shock period, and a later phase that begins about half a year after the initial shock. During the early phase, we observe no significant reaction of Colombia's policy interest rate to a drop in the FFR, an insignificant positive reaction of the price level, no significant reaction of the intervention instrument, and a significant positive impact on the exchange rate, which in our notation implies a currency appreciation. These reactions are in line with what we would expect from a small economy without fear of floating; the interest rate shock from the US is absorbed by the exchange rate of the Peso, whose value rises due to increasing capital flows to Colombia. The resulting higher domestic aggregate demand might have an

[10]The impulse responses presented here and in the following figures are the median result from 5,000 iterations of the Gibbs sampler, with an additional 1,000 iterations discarded for the burn-in. The confidence interval is given as the 0.68 probability band, i.e. the 16th and 84th percentiles of our results.

inflationary effect on the Colombian price level, but our results suggest that this effect is not significant.

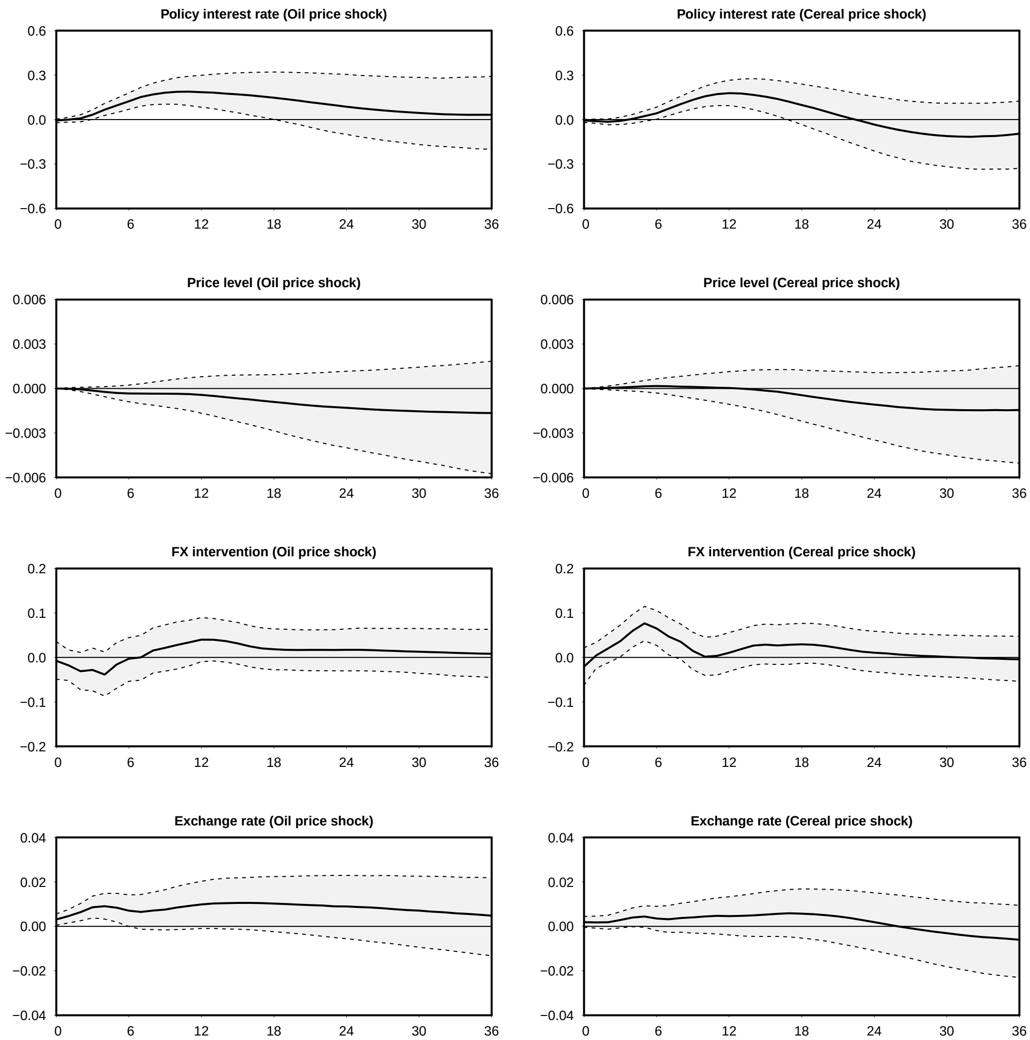
In the fifth and sixth month after the shock, a different reaction pattern sets in. We now observe a significant reaction of the Colombian interest rate, which is gradually lowered to stay in line with US interest rate policy. At the same time, we observe a succession of positive and significant central bank interventions on the foreign exchange market, which imply an increase in the bank's international reserves. Since we observe no corresponding increase in the domestic money stock (not depicted), these interventions appear to be successfully sterilized. Both central bank instruments are therefore used to take appreciation pressures away from the Peso exchange rate, once by reducing the difference in nominal interest rates, once through the portfolio balance channel. As we can see, the exchange rate does indeed stop to appreciate with the enactment of these policy measures, and even shows depreciating tendencies in the second year after the shock.

The impulse responses in figure 2 can be interpreted as a delayed policy contagion effect from US monetary policy to Colombia. Although the reduction of domestic interest rates is not as strong as the reduction of the Federal Funds rate itself (not depicted), there is a clear and significant tendency of the Colombian central bank to follow US interest rate setting decisions in the long run. Our results show that this tendency is most likely motivated by the appreciating effect a US monetary policy shock has on the Peso exchange rate, given that there is no corresponding significant impact on domestic prices. This implies fear of floating and, as a consequence, reduced monetary policy independence in Colombia. Our finding matches the results from a recent empirical study by Edwards (2015), who found Colombia to be the Latin American inflation targeter with the highest degree of monetary policy contagion, importing 74 % of US interest rate changes in the long run. However, we also find that at least part of the realignment of the Colombian exchange rate seems to be achieved via sterilized FX interventions, thus allowing the central bank to recover some of its lost independence. Given Colombia's apparently strong concerns about the exchange rate, policy contagion would likely be even stronger if the central bank did not possess this additional policy instrument.

We now turn to the Colombian reaction to commodity price shocks that affect the country's terms of trade. Figure 3 presents the impulse responses to a one-standard deviation shock in one of the two commodity price equations, i.e. to a price increase of the export commodity (oil) or the import commodity (cereals). We observe a strong and significant positive reaction of the policy interest rate in response to both shocks, which is just what we expect from an inflation targeting central bank from a small and fairly open economy. Both interest rate increases can be seen as responses to the shock's inflationary impact, which can be caused by higher aggregate demand at home (for an improvement of the terms of trade) or higher prices for an inelastic import good (for a deterioration). Our results indicate that the central bank is largely successful in maintaining price stability, since there is no significant reaction of the Colombian price level in response to either shock.

The two shocks differ in their impact on central bank interventions and the Peso exchange rate. For the case of an oil price shock, we observe the significant currency appreciation that is to be expected from an oil exporting economy. There is no evidence for significant central bank intervention on the foreign exchange market in this scenario. On the other hand, the central bank significantly intervenes on the FX market in the case of a cereal price shock, which worsens Colombia's terms of trade. In accordance with our discussion in section 1, this policy reaction can be motivated by the dilemma a small open economy faces when combining inflation targeting with a secondary exchange rate target: The strong interest rate reaction by the Colombian central bank is needed to maintain price stability, but can inadvertently appreciate the Colombian currency and further deteriorate

Figure 3: Colombian impulse responses to oil and cereal price shocks



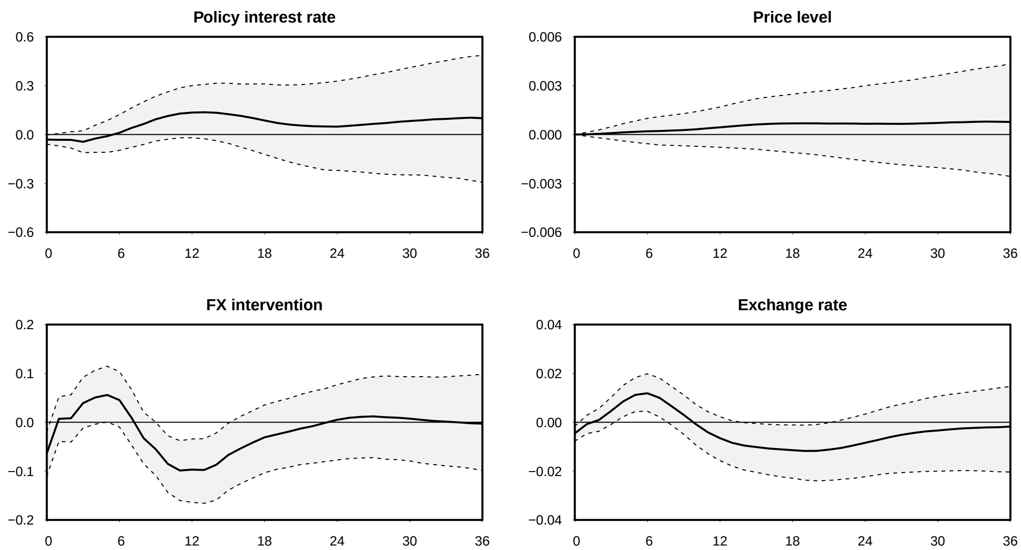
the country's terms of trade. These appreciating tendencies of the Peso are apparently countered by the Colombian central bank with reserve-increasing FX interventions, which are again successfully sterilized since the money stock remains unaffected (not depicted). Our interpretation is in line with the result we find for the impulse response of the Colombian exchange rate to a cereal price shock, which is positive but mostly insignificant.

5.2 Brazil's reaction to external shocks

While we encounter some of the central bank behavior observed for Colombia in Brazil as well, there are also noteworthy differences between the two countries. Many of these can be explained by the fact that Brazil is a considerably larger economy with less openness in both the current and the capital account. Figure 4 presents the impulse responses of four Brazilian domestic variables to an expansionary US monetary policy shock. We observe a significant negative impact reaction of the Brazilian policy interest rate, but find that it is decidedly lower than the impact reaction of the Federal Funds rate itself (not depicted). A few periods after the shock, this interest rate reaction becomes insignificant with a tendency for positive values. There is virtually no evidence for a long-term policy contagion from US monetary policy to Brazilian interest rates, and our results suggest that the Brazilian central bank is able to set its interest rates independently from decisions by the Fed.

As for the other variables, there is no significant reaction of the Brazilian price level, a positive and barely significant reaction of the FX instrument, and a significant increase in the dollar value of the Brazilian Real. The currency appreciation can once again be explained by capital inflows from the US to Brazil, given that expansionary monetary policy in the US results in a higher interest rate differential between both countries. This appreciating impact is apparently countered by interventions on the FX market that increase the central bank's international reserves and dampen the exchange rate reaction via the portfolio balance channel. The insignificant reaction of the Brazilian money stock (not depicted) implies that these interventions are once again successfully sterilized. While this reaction pattern is broadly reminiscent to our results for Colombia, it should be noted that the evidence for FX intervention in Brazil is less significant, and that there is no evidence

Figure 4: Brazilian impulse responses to expansionary US monetary policy



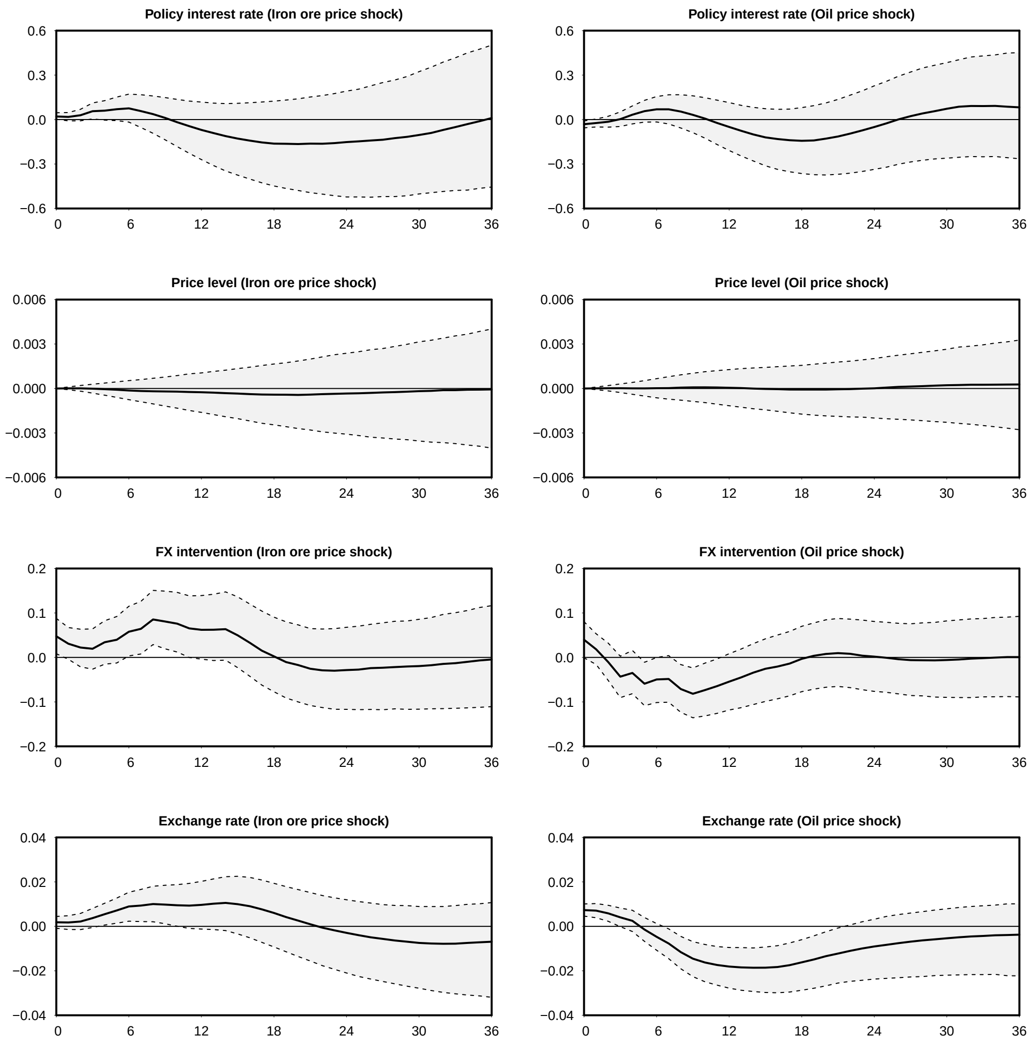
for a corresponding cut in domestic interest rates to stop further currency appreciation.

Overall, our results present somewhat of a "policy contagion puzzle" for Brazil: We observe a surprisingly weak reaction of the Real to a US monetary policy shock, given that the Brazilian central bank neither actively follows US interest rate policy nor heavily intervenes on the foreign exchange market. In terms of the Mundell-Fleming "trilemma" of international macroeconomics, such a combination of independent monetary policy and relatively stable exchange rates can only be achieved in a world with less-than-perfect capital mobility; as our discussion in section 2 suggests, this was indeed the case for Brazil during our observation period, with capital controls imposed by the country between 2008 and 2012. Since we do not control for the effects of these measures in our empirical setup, we can only assume that they explain Brazil's high degree of monetary policy independence, in line with the results found in Baba and Kokenyne (2011).

Effects of commodity-induced terms of trade shocks on the Brazilian economy are presented in figure 5, where iron ore now denotes the representative export commodity and oil the corresponding import commodity. Again, we observe a positive reaction of the policy interest rate in response to both shocks. This reaction is, however, barely significant for the case of a terms of trade improvement, and insignificant for a terms of trade deterioration. In comparison with Colombia, these results imply that the Brazilian central bank is less concerned about the inflationary impact of either terms of trade shock. Theoretically, this could be motivated by either a lower commitment to inflation targeting or a lower importance of terms of trade shocks for inflation, due to Brazil's lower trade openness. Our results strongly support the latter hypothesis, given that the Brazilian price level does not react significantly to either of the two shocks. The considerable size of Brazil's domestic economy, in combination with the resulting lower importance of trade for overall economic activity, apparently shield Brazil more effectively from global commodity price swings, indicating a reduced need to take terms of trade shocks into account for domestic interest rate policy.

The remaining impulse responses in figure 5 give further evidence to the hypothesis that the terms of trade dilemma for inflation targeting countries is not relevant for the case of Brazil. In response to a positive terms of trade shock, we observe a significant and continuous appreciation of the Real and a significant increase in the level of international reserves held by the Brazilian central bank. Since the latter does not appear to have any impact on the exchange rate, this is most likely a case where central bank interventions are not directed at the exchange rate, but rather indicate the use of commodity windfalls to fill up a central bank "war-chest" for future crises. The adverse terms of trade shock leads to a significant depreciation of the Brazilian currency, which is the normal behavior of a flexible exchange rate under such a scenario. There is some evidence for a significant reduction of Brazil's international reserves in response to an oil price shock, but these interventions are

Figure 5: Brazilian impulse responses to iron ore and oil price shocks



likewise without an obvious effect on the exchange rate.[11] Overall, the Brazilian central bank appears to be less inclined to use its instruments of monetary policy in response to a commodity price shock, and more willing to let the exchange rate fluctuate with the terms

[11] A reason for the lowering of government reserves in response to an oil price shock might be the fact that the Brazilian government subsidizes domestic consumer prices for oil and other petroleum products.

of trade.

The results from this section suggest that external shocks are less influential in shaping Brazil's monetary policy stance than they were for Colombia, which strongly supports the view that country size and openness matter for the design of an inflation targeting regime in the emerging world. It should also be noted that some of the features of Colombian monetary policy are also visible in Brazil, notably the use of foreign exchange interventions in response to a US monetary policy shock. Rather than presenting two entirely different patterns of reaction, our case studies show that inflation targeting central banks from emerging economies have a general incentive to employ their FX intervention instrument in response to external shocks, with smaller and more open economies being more inclined to practice “inflation-targeting-cum-intervention”.

5.3 The relative importance of external shocks

The relative importance of external shocks – both in comparison to each other and to the other shocks included in our model – can be measured in terms of the variance decomposition for domestic variables, which gives the percentage of these variable's variances explained by each structural shock in the model. In tables 2 and 3, we report these values for output and prices in Colombia and Brazil. The tables dissect the shocks emanating from the foreign sector into a US monetary policy shock, positive and negative commodity-terms-of-trade shocks, and “other foreign shocks”, i.e. the two shocks from the US production sector. The impact of foreign shocks is averaged over 12-month-intervals, starting with the first period after the shock since we impede any contemporaneous effect of the foreign sector on domestic output and prices.

The results show that external shocks are not the dominant source of output and price fluctuation in either Colombia or Brazil, never explaining more than 25 % of output

Table 2: Variance decomposition of domestic output

Country	Months after initial shock	US monetary policy shock	Export commodity price shock	Import commodity price shock	Other foreign shocks	Domestic shocks
Colombia	1-12	0.68	0.02	0.02	0.16	99.12
	13-24	5.07	0.03	0.17	1.47	93.27
	25-36	7.92	0.02	1.46	2.66	87.94
Brazil	1-12	1.48	0.29	0.80	0.13	97.30
	13-24	2.02	0.67	4.42	5.06	87.83
	25-36	1.78	0.62	4.16	13.63	79.80

Percentage of output variance explained by each shock. Numbers may not add up to 100 due to rounding errors.

Table 3: Variance decomposition of domestic prices

Country	Months after initial shock	US monetary policy shock	Export commodity price shock	Import commodity price shock	Other foreign shocks	Domestic shocks
Colombia	1-12	0.09	0.12	0.02	0.03	99.74
	13-24	0.27	0.79	0.19	0.10	98.65
	25-36	0.42	2.44	1.52	0.30	95.31
Brazil	1-12	0.04	0.02	0.00	0.02	99.91
	13-24	0.37	0.13	0.00	0.18	99.31
	25-36	0.65	0.17	0.02	0.26	98.90

Percentage of CPI variance explained by each shock. Numbers may not add up to 100 due to rounding errors.

variance and an even smaller share of CPI variance. The only shock discussed in the previous two sections that accounts for more than 5 % in any of the decompositions is the US monetary policy shock for Colombia, which starts to explain a meaningful fraction of Colombian output volatility after 12 months and more. This is in line with our discussion in 5.1, where we have seen that the Colombian central bank follows US monetary policy with a lag of several months; over a longer time horizon, this loss of monetary independence implies that Colombia can only imperfectly target its domestic output gap by the interest rate instrument, implying higher output volatility. US monetary policy shocks play a considerably lower role for Brazilian output variance, and a negligible one for CPI variance in both countries.

Commodity price shocks are not important for any of the variances discussed in tables 2 and 3, with the possible exception of the import commodity price shock for the variance of Brazilian industrial production (where the import commodity is oil, an important industrial imput). They explain a higher share of CPI variance in Colombia than in Brazil, which supports our deliberations regarding trade openness in the previous section. However, the explained share of the variance is still small in both cases, and the impulse responses discussed in 5.1 show that commodity price shocks only have an insignificant impact on Colombian prices.

The findings above present a different picture of the importance of external shocks for emerging economies than what was found in earlier block-exogenous SVAR studies, notably those by Canova (2005) and Maćkowiak (2007). Although these studies differ from the present one both in their country and time sample selection and in their empirical specification, the differences between results are striking enough to be pointed out: Canova, whose sample includes Brazil, found external shocks to explain more than 80 percent of output and inflation volatility for a sample of Latin American countries between 1990 and 2002, whereas Maćkowiak found them to explain over 50 percent of output and CPI volatility for a broader sample of emerging economies between 1986 and 2000. The results of this paper stand in marked contrast to these figures, and imply that both Colombia and Brazil were less susceptible to external shocks since their respective adoption of inflation targeting in 1999 than a typical emerging economy was during the pre-inflation targeting era. While further research on this question is needed, our results suggest that this is not only a consequence of higher exchange rate flexibility across the emerging world, but also of increased monetary policy independence due to higher levels of international reserves and a greater ability to intervene on the foreign exchange market.

6 Conclusion

This paper shows that the effects of US monetary policy and commodity price shocks on the monetary policy of an inflation targeting emerging economy can only be fully understood if all relevant policy instruments are accounted for. We conduct case studies for Colombia and Brazil, two major inflation targeting countries from South America, and find that their central banks react to external shocks with a policy mix of both the interest rate instrument and foreign exchange interventions. For both countries, there is evidence that sterilized foreign exchange interventions allow a decoupling of interest rate setting decisions from US monetary policy without suffering strong exchange rate reactions, thus allowing for a certain degree of fear of floating under an inflation targeting regime for as long as international reserves are available. Commodity price shocks are met with interest rate increases in both countries; in Colombia, this interest rate increase is combined with additional FX interventions if the price increase occurs in the import commodity. Our results also suggest that country size and openness, both in the current and the capital account, are important determinants in how strongly an emerging economy reacts to external shocks, with Brazil being generally less inclined to do so than Colombia.

Our study adds to the growing literature on monetary policy in emerging economies that stresses the importance of central bank instruments other than the policy interest rate, indicating that many inflation targeting regimes are more accurately described as "inflation-targeting-cum-intervention" as suggested by Ostry et al. (2012). We also expand the block-exogenous SVAR literature on emerging economies in finding a relatively low importance of external shocks for output and price volatility in both Colombia and Brazil for the post-1999 inflation targeting period. This finding shows that the high susceptibility of emerging economies to external shocks found in studies over earlier time periods has likely been reduced in recent years, due to both higher exchange rate flexibility and an increased ability of emerging economies to intervene on the foreign exchange market.

The results in this paper imply that emerging economies must understand the dilemmas they face if they implement inflation targeting without full exchange rate flexibility and dispose of the necessary means to confront these dilemmas, i.e. a sufficient stock of international reserves and/or willingness to reduce their capital mobility. As for the US, we find that the Fed's interest rate setting behavior still has a strong, if reduced, impact on the domestic interest rates of small emerging economies. While Canova (2005) called for the Fed to internalize these effects, our findings indicate that central bankers from Colombia and Brazil have already chosen to approach the problem unilaterally, increasing their monetary independence from the US by an increased reliance on non-conventional instruments of monetary policy.

Data appendix

Country	Variable	Source	Datastream Mnemonic
World	US industrial production index	Federal Reserve	USIPTOT.G
	US consumer price index	Bureau of Labor Statistics	USCONPRCF
	Federal Funds rate	Federal Reserve	USPRATE.
	Oil price index	IMF Primary Commodity Prices	–
	Cereal price index	IMF Primary Commodity Prices	–
	Iron ore price index	IMF Primary Commodity Prices	–
Colombia	Industrial production index	Banco de la República	CBIPTOT.H
	Consumer price index	DANE	CBCONPRCF
	Foreign exchange balance	Banco de la República	CBFEBCURA
	Money stock M1	Banco de la República	CBM1....A
	Net foreign exchange interventions	Banco de la República	CBCIFEIT
	Intervention rate	Banco de la República	CBPRATE.
	Nominal exchange rate	WM/Reuters	CBXRUSD.
Brazil	Industrial production index	IBGE	BRIPTOT.G
	Consumer price index	IBGE	BRCONPRCF
	Current account balance	Banco Central do Brasil	BRCURBALA
	Money stock M1	Banco Central do Brasil	BRM1....A
	Net foreign exchange interventions	Banco Central do Brasil	BRFXOCBIA
	SELIC rate	Banco Central do Brasil	BRPRATE.
	Nominal exchange rate	Banco Central do Brasil	BRXRUSD.

DANE: Departamento Administrativo Nacional de Estadística (National Administrative Department of Statistics)
IBGE: Instituto Brasileiro de Geografia e Estatística (Brazilian Institute of Geography and Statistics)

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