The Impact of Different Types of
Foreign Exchange Intervention:
An Event Study Approach

Por: Juan José Echavarría
Luis Fernando Melo Velandia
Mauricio Villamizar

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Abstract

To date, there is still great controversy as to which exchange rate model should be used or which monetary channel should be considered, when measuring the effects of monetary policy. Since most of the literature relies on structural models to address identification problems, the validity of results largely turn on how accurate the assumptions are in describing the full extent of the economy. In this paper we compare the effect of different types of central bank interventions using an event study approach for the Colombian case during the period 2000-2012, without imposing restrictive parametric assumptions or without the need to adopt a structural model. We find that all types of interventions (international reserve accumulation options, volatility options and discretionary) have been successful according to the smoothing criterion. In particular, volatility options seemed to have the strongest effect. We find that results are robust when using different windows sizes and counterfactuals.

Key Words: Central bank intervention, foreign exchange intervention mechanisms, event study

JEL Classification: E52, E58, F31

I. Introduction

In the context of discretionary central bank intervention, monetary authorities systematically react to informative variables when setting their policy decisions, i.e. the timing and magnitude of interventions are driven by market behavior in order to meet explicit or implicit policy objectives. As such, researchers usually assume functional forms of both the policy rule and the process determining the economy in order to estimate causal effects. However, since most of these studies purely rely on structural models to address identification problems (see Christiano et al. 2011) then the validity of results largely depends on how accurate the assumptions are in describing the full extent of the underlying economy.

To date, there is still great controversy as to which exchange rate model should be used (stock, monetary, microstructure-based, etc...) or which monetary channel should be considered (signaling, portfolio, or expectations), when measuring the effects of policy. Moreover, the Colombian case poses additional methodological challenges since there have been multiple mechanisms of exchange rate intervention. These consist of: international reserve accumulation and volatility options in the first part of the 2000s, discretionary (dirty) interventions during 2004-2007 and day-to-day constant and preannounced interventions during 2008-2012. A better understanding of these mechanisms and their effects is hence warranted, without imposing restrictive parametric assumptions or without the need to adopt a full-blown structural model.

In this paper we compare the effects of international reserve accumulation, volatility options and discretionary interventions, [3] using an event study approach. This paper is complementary to Echavarría et al. (2013) which only analyzes preannounced interventions. Following Fatum and Hutchison (2001), we define four criteria to evaluate a successful intervention: 1) Direction (Frankel, 1994); 2) Reversal (Fatum and Hutchison, 2001); 3) Smoothing (Humpage, 1996); and 4) Matching. Results show that all types of interventions were successful according to the smoothing criterion. In particular, volatility options seemed to have the strongest effect according to several criteria. Results are robust when using different windows sizes and counterfactuals.

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[3] Preannounced interventions were not used given the few events available.

This paper is organized as follows: Section II provides a general overview of the Colombian foreign exchange rate intervention. Parts of this section are taken from Echavarría et al. (2013) without explicit acknowledgement. Section III describes the event study methodology and Section IV presents the results. Finally, section V concludes.

II. Foreign Exchange Interventions

Foreign exchange intervention for the Colombian case during the period 2000-2012 can be summarized by Graph 1. Average yearly purchases were close to US$ 2,200 million, much larger than average sales (US$ 571 millions). Purchases were especially high in 2005 and 2007, and also during 2010-2012[4] . Yearly purchases represented 0.12% of (yearly) market transactions in 2003, and 4.06% in 2005, with an average of 1.70% in 2000-2012. They represented 1.0% of the average stock of international reserves in 2003 and 33% in 2005, with an average of 11.86% in 2000-2012[5].

Graph 1
Colombian Central Bank Interventions

2012: January-August

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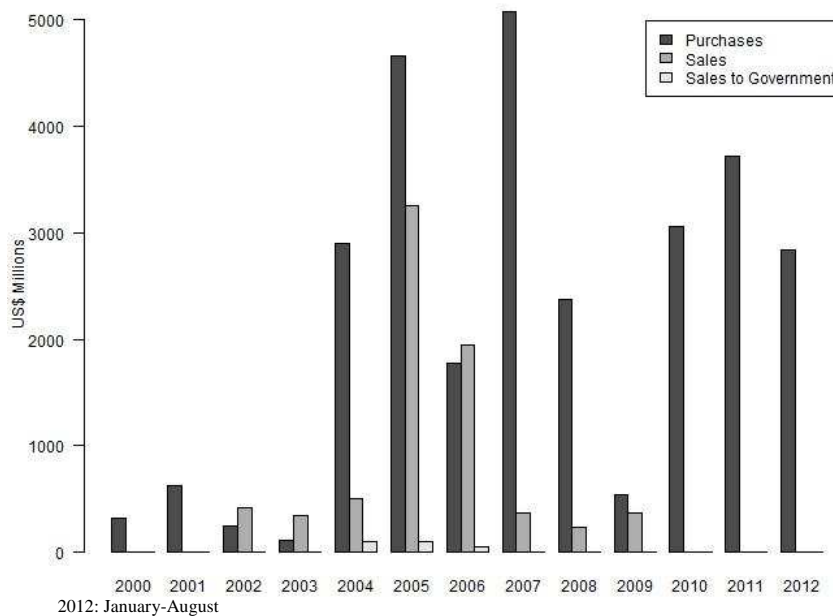
[4] There were some sales of US$ dollars to the government in 2004-2006, intended to repay external debt.
[5] Daily transactions in the market were close to US$ 1000 million at the end of the sample, and to US$ 320 million in 2001-2004 (average). The stock of international reserves was close to US$ 33,000 million at the end of the sample and to US$ 10,611 in 2001-2004 (average).

Table 1 shows the relative importance of the different mechanisms of intervention: options for reserve accumulation, options for the control of volatility, discretionary interventions and fixed (close to) US$ 20 million per day interventions.[6] Put options for reserve accumulation, partially implemented to replenish the strong reduction of international reserves observed in 1997-2000, accounted for all purchases in 2000-2003, while discretional interventions explained a large part of purchases in 2004-2007. The amounts and periods of interventions were initially announced, but that practice changed later on when periods and amounts became indefinite.

Volatility options were used to buy and (mainly) sell foreign currency in some days in 2004, 2006, 2007, 2008 and 2009. Options were auctioned automatically whenever the difference between the exchange rate of the previous day (the TRM) and the moving average of the last twenty days was higher or lower than 5%. This percentage changed to 4% in December 2001; to 2% in February 6, 2006; to 5% in June 24, 2008; and to 4% in October 13, 2011. However, volatility options have not been used during the last years, partially because there are doubts about their impact, and partially because they could conflict with the effect of the US$ 20 million purchases (the central bank could be selling and buying dollars during the same day).

Put/call options for reserve accumulation were auctioned monthly and agents had the right to exert them (totally or partially) during the next month, as long as the exchange rate was lower than the average of the last 20 days. This meant that international reserves were bought at a "low" price (opposite for sales). The Board of the Central Bank could announce a new auction during the month even if the previous auction had not yet expired.

Ramírez (2005) considers that exchange rate interventions in Colombia have been relatively transparent. Options are announced on the same day that they are exerted (the name of the firm remains secret) and the amount of intervention is announced each week. Very often the Board of Directors pre-announced the total amount of dollars to be bought/sold during the next months. For example, the Board announced an intervention of US$ 1 billion during the last three months of 2004,[7] and in June 20, 2008 the Board announced the new US$ 20 million daily interventions, with an amount of US$ 2.4 billion to be bought between July and December.

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[6] Next day purchases accumulate when there is a holiday in the United States or when t-1 auctions are not fully exercised.
[7] But in December 2004 the Board announced additional undefined interventions and periods.

Table 1
Colombian Central Bank Interventions, 2000-2012

|	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012[*]
PURCHASES (US $)	319	629	252	106	2905	4658	1781	5082	2381	539	3060	3720	2840
Participation(%)													
Options Put	100	100	100	100	54	0	33	11	41	100	0	0	0
International Reserve Accumulation	100	100	100	100	48	0	0	0	19	0	0	0	0
Volatility Options	0	0	0	0	6	0	33	11	22	100	0	0	0
$20 million/day aprox.	0	0	0	0	0	0	0	0	59	0	100	100	100
Discretional Intervention	0	0	0	0	46	100	67	89	0	0	0	0	0
SALES (US $)	0	0	414	345	500	3250	1944	369	235	369	0	0	0
Participation (%)													
Options Call	0	0	100	100	0	0	49	100	100	100	0	0	0
International Reserve Reduction	0	0	0	100	0	0	0	0	0	0	0	0	0
Volatility Options	0	0	100	0	0	0	49	100	100	100	0	0	0
Sales to National Government	0	0	0	0	100	100	51	0	0	0	0	0	0
NET PURCHASES	319	629	-163	-238	2405	1408	-164	4713	2147	171	3060	3720	2840

*January- august

Graphs 2 and 3 show the evolution of the different types of intervention and the nominal exchange rate (S_t), for both Colombia and Brazil during 2000-2012. Discretional interventions I_{disc}^p and preannounced interventions of US$ 20 million I_{20}^p are shown in Graph 2 and reserve accumulation $I_{res\_opt}^p$ and volatility options $I_{vol\_opt}^p$ in Graph 3. There were 723 days of discretionary purchases, with an average of US$ 20 million and a maximum of US$ 723 million (on March 390, 2007); 437 days of US$ 20 million interventions distributed in four episodes; 80 days of reserve accumulation (purchases) with an average of US$ 41 million and a maximum of US$ 200 million; and 41 days of volatility option purchases with an average of US$ 51 million and a maximum of US$ 170 million.

Graph 2
Different Types of Intervention and the Nominal Exchange Rate in Colombia and Brazil
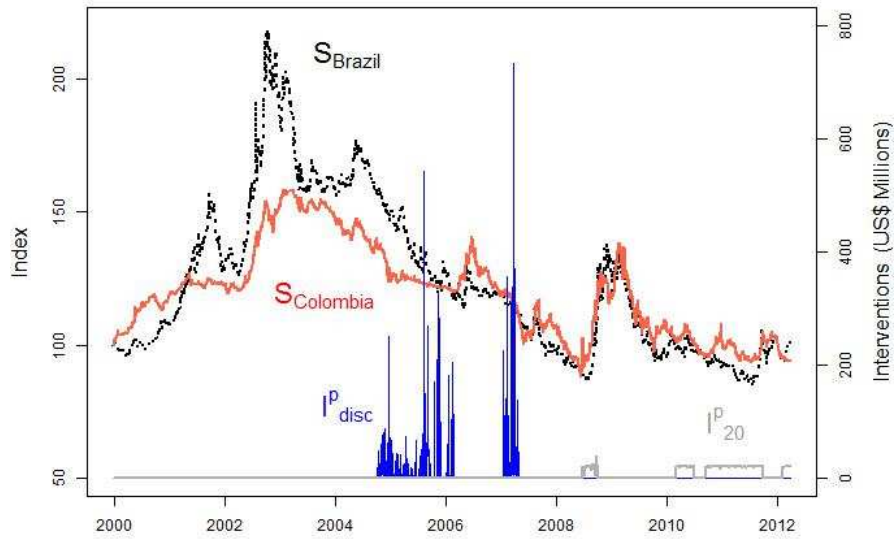
Graph 3
Different Types of Intervention and the Nominal Exchange Rate in Colombia and Brazil
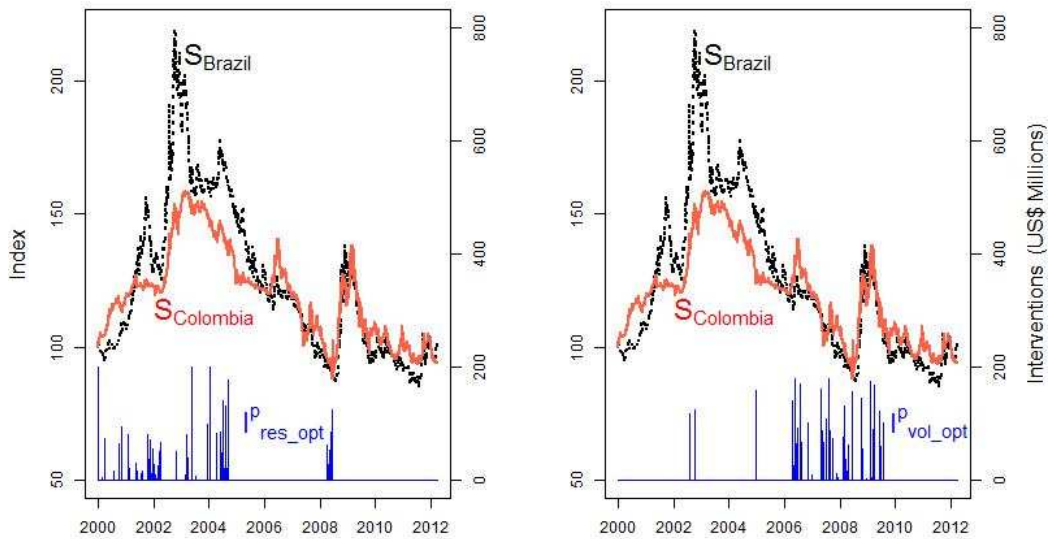
III. Methodology: An Event Study Approach

Event studies were originally applied in the area of finances (MacKinlay, 1997), but in recent years they have also been used in areas as diverse as: the impact of different local factors on financial crisis (IMF, 2007, pp.124-132), the relationship between the development of capital markets and the environment in emerging countries (Dasgupta, Laplante, and Mamingi, 1997), the effects of fiscal policy in the process of disinflation (Celasum, Gelos, and Pratti, 2004), and even the impact of the merits of the Central Bank Governor on financial markets (Kuttner and Posen, 2007).

Humpage (1996), Fatum and Hutchison (2001), Fatum and Hutchison (2008) and Fratzscher (2012) used event studies to analyze the effect of interventions on the exchange rate. All of them conclude that interventions produce the desired results, even when considering a 15 day window (the longest period considered by most of them). For Fratzscher (2012, pp.739) "overall, there is overwhelming evidence that both actual and oral intervention events for the G3 economies have been successful", and the success rate remains relatively stable when extending the time window to 40 days.

In this section we compare the cumulative effect of different types of intervention. We exclude day-to-day constant and preannounced interventions from our analysis given the few events available. The methodology starts with the definition of the event window, comprised by: a) the estimation window; b) purchases-sales of foreign exchange (the event); and c) the post event period.

Following Fatum and Hutchison (2001), Hutchison (2002) and Fratzscher (2012), we consider a sensitivity analysis for pre and post events of 2, 5, 10 and 15 days. Moreover, we define a cluster of intervention as the event in which the Central Bank did not stop intervening during 2, 5, 10 or 15 days, respectively. We then define four alternative criteria to evaluate a successful intervention: 1) Direction (Frankel, 1994); 2) reversal (Fatum and Hutchison, 2001); smoothing (Humpage, 1996); and 4) Matching. Formally, the four criteria can be expressed in the following way for the case of purchases (vice versa for sales):

Direction: Success if:

$$I_t^p > 0 \cap \Delta s_+ > 0$$

Reversal: Success if

$$\Delta s_- < 0 \cap I_t^p > 0 \cap \Delta s_+ > 0$$

Smoothing: Success if

$$\Delta s_- < 0 \cap I_t^p > 0 \cap \Delta s_+ > \Delta s_-$$

Matching (see below)

Where "-" and "+" correspond to pre and post intervention periods, and I_t^p to foreign exchange purchases by the central bank. The direction criterion considers a successful event when the exchange rate rises after purchases, without any regard about the trend of the exchange rate before intervention. As Frankel (1994) argues, a successful intervention means that the exchange rate moves in the direction wanted by the central bank. However, the direction criterion does not take into account the behavior of the exchange rate before the intervention. The central bank could simply be following a *leaning with the wind* policy, with the behavior of the exchange rate probably dictated by market conditions rather than by exchange rate interventions. The reversal criterion is more demanding, and success requires that the exchange rate rises after purchases (like direction) but also that the exchange rate was falling before intervention. Finally, the smoothing criterion also considers the pre-intervention period, but it is less demanding. This criterion defines success when the revaluation is lower after intervention (i.e. it includes devaluation after intervention like in the case of reversal).

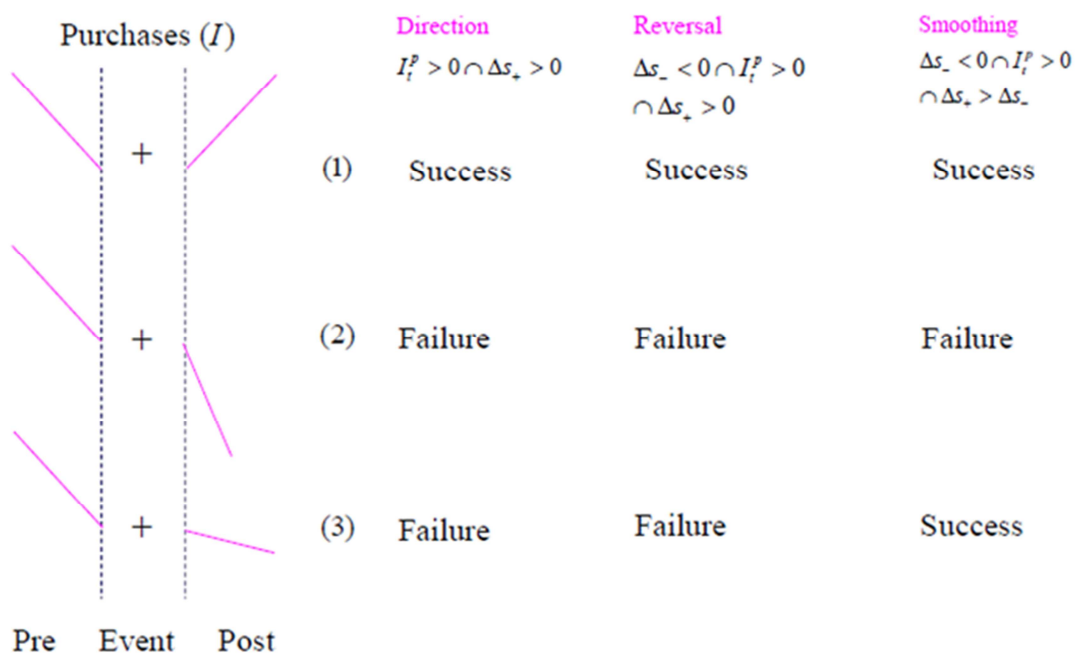Overall, reversal is a more demanding criterion than direction (it does not consider the pre-intervention pattern), and also more demanding than smoothing (it does not require the exchange rate to rise after purchases by the central bank).

Graph 4 shows the behavior of the exchange rate under three hypothetical cases before and after purchases of foreign currency. The direction criterion is successful in case (1) since the

exchange rate rises after purchases, but it is a failure in cases (2) and (3). Results are similar for the reversal criterion. The smoothing criterion is successful in cases (1) and (3), since the exchange rate is falling at a lower rate after the event, something that does not happen in case (2).

The statistical analysis consists of counting the number of successful events (how many times was intervention successful according to each criterion) and comparing it with the total number of events. In particular, the direction, reversal and smoothing criteria are evaluated using a sign t-test, based on a binomial distribution, to check if the probability of a "successful event" (p) is greater than 0.5 (or a given probability value).

Graph 4

Evaluation of direction, reversal and smoothing criteria for three hypothetical cases

Purchases (I)		Direction $I_t^p > 0 \cap \Delta s_+ > 0$	Reversal $\Delta s_- < 0 \cap I_t^p > 0$ $\cap \Delta s_+ > 0$	Smoothing $\Delta s_- < 0 \cap I_t^p > 0$ $\cap \Delta s_+ > \Delta s_-$
+	(1)	Success	Success	Success
+	(2)	Failure	Failure	Failure
+	(3)	Failure	Failure	Success

Pre   Event   Post

A different test to evaluate the effectiveness of interventions (considers magnitudes instead of direction) is the matched sample test. This test considers the magnitude of daily devaluations. The matched sample test consists of verifying whether the behavior of the

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exchange rate experienced a significant variation between the pre and post-estimation periods. To do so we computed the matched difference between the corresponding pre and post event observations. Assuming that the variation of the exchange rate of both subsamples is normally distributed, we derive the following t-test with n-1 degrees of freedom ("n" being the number of matched pairs):

$$\frac{D - \mu_d}{S_d} \sim t(n-1).$$

IV. Results

Table 2 presents the results when the estimation window, the pre, and the post-event periods correspond to five days. Column (1) presents the different types of intervention (including combinations like t_2 and t_3), column (2) distinguishes sales from purchases, and columns (4) - (6) present the total and the successful number of cases. Columns (7) – (10) consider the p-value associated with the sign test for different values (probability of success): 0.5, 0.6, 0.7 and 0.8. Highlighted values correspond to p-values less than 0.10.[8]

The results confirm that all types of intervention are successful, when considering $H_0 : p \leq 0.5$ (column 7) meaning that exchange rate revaluation will be less intense after purchases of foreign currency by the central bank (vice versa for sales). However, only the volatility options are successful when considering a more rigorous null hypothesis $H_0 : p \leq 0.6, 0.7$ or 0.8 (and t_3 in some cases).

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[8] Tables 2 – 5 only considered event, pre and post periods of five days, but results for the other combinations yield similar results. We report in the Appendix the case of 10 days. Obviously, the longer the event windows are defined, the fewer the events within the sample. Also, the longer the pre and post estimation windows, the more likely the probability that other external and domestic shocks (different from the intervention) affect the exchange rate.

Table 2
Sign Test, Smoothing (5 days)

Type of Intervention	Purchases/ sales	window	Total Cases	Favorable Cases	% Success	H₀: p≤0.5 P-value	H₀: p≤0.6 P-value	H₀: p≤0.7 P-value	H₀: p≤0.8 P-value
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A. Discretionary	Purchases	5	11	8	72.7	0.03	0.12	0.31	0.62
	Sales	5	0	-	-	-	-	-	-
B. Options int. reserves	Purchases	5	19	12	63.2	0.08	0.31	0.67	0.93
	Sales	5	1	1	100.0	.	.	.	.
C. Options volatility	Purchases	5	11	10	90.9	0.00	0.00	0.02	0.09
	Sales	5	9	9	100.0	0.00	0.00	0.00	0.00
t2=(A)+(B)	Purchases	5	30	20	66.7	0.02	0.18	0.59	0.94
	Sales	5	1	1	100.0	.	.	.	.
t3=(A)+(B)+(C)	Purchases	5	38	28	73.7	0.00	0.03	0.26	0.78
	Sales	5	8	8	100.0	0.00	0.00	0.00	0.00

The results of Table 3 suggest that t_3 and volatility options were successful according to the direction criterion ($H_0 : p \leq 0.5$). The former, with p-values of 0.02 for sales, and 0.11 for purchases. The combined effect of volatility options, "purchases + sales" is also significant at the 10% level (not reported). The stronger effect of volatility options also appears in Table 4 for reversals (t_3 is not significant in this last case) and in Table 5 for matching. We also report in the next Section the results of the same tests, controlling for two alternative scenarios. Scenario (a) considers the evolution of the exchange rate in Brazil; and Scenario (b) considers what happened in those cases in which volatility options should have been applied if the rule were in place.

Table 3
Sign Test, Direction (5 days)

Type of Intervention	Purchases/ sales	Window	Total Cases	Favorable Cases	% Success	H₀: p≤0.5 p-value
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. Discretionary	Purchases	5	11	6	54.5	0.27
	Sales	5	0	0	.	.
B. Options int. reserves	Purchases	5	19	11	57.9	0.18
	Sales	5	1	1	100.0	
C. Options volatility	Purchases	5	11	7	63.6	0.11
	Sales	5	9	7	77.8	0.02
t2=(A)+(B)	Purchases	5	30	17	56.7	0.18
	Sales	5	1	0	-	-
t3=(A)+(B)+(C)	Purchases	5	38	23	60.5	0.07
	Sales	5	10	8	80.0	0.01

Table 4
Sign Test, Reversal (5 days)

Type of Intervention	Purchases/ sales	Window	Total Cases	Favorable Cases	% Success	H_0: p≤0.5 p-value
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. Discretionary	Purchases	5	11	5	45.5	0.50
	Sales	5	0	0	.	.
B. Options int. reserves	Purchases	5	19	6	31.6	0.92
	Sales	5	1	0	-	.
C. Options volatility	Purchases	5	11	7	63.6	0.11
	Sales	5	9	7	77.8	0.02
t2=(A)+(B)	Purchases	5	30	11	36.7	0.90
	Sales	5	1	0	-	.
t3=(A)+(B)+(C)	Purchases	5	38	17	44.7	0.69
	Sales	5	10	8	80.0	0.01

Table 5
Matching Test (5 days)

Type of Intervention	Purchases/ sales	Window	Total Cases	Average Difference	P-value H_0: D≤0 or H_0: D≥0[*]
(1)	(2)	(3)	(4)	(5)	(6)
A. Discretionary	Purchases	5	11	0.06	0.42
	Sales	5	0	.	.
B. Options int. reserves	Purchases	5	19	0.05	0.39
	Sales	5	1	-0.16	.
C. Options volatility	Purchases	5	11	1.08	0.11
	Sales	5	9	-0.72	0.02
t2=(A)+(B)	Purchases	5	30	0.05	0.41
	Sales	5	1	-0.10	.
t3=(A)+(B)+(C)	Purchases	5	38	0.30	0.32
	Sales	5	10	-0.67	0.04

* D≤0 for purchases and D ≥0 for sales.

IV.a Counterfactuals

The Colombian exchange rate could have increased after an intervention for a variety of reasons, including the effects of other countries like Brazil (See Section II). For this reason, Table 6 presents the same exercise of Tables 2-5 (for volatility options) but for the case of Brazil. In other words, we consider the evolution of the exchange rate in Brazil in periods corresponding to pre and post Colombian volatility interventions. This provides a counterfactual experiment that allows us to test for possible bias that might have been introduced by predetermined variables. Table 6 suggests that the interventions under this counterfactual were not successful according to direction, reversal and the matched criteria. However, the case of Brazil casts some doubts on

our strong results when considering the impact of intervention on smoothing the exchange rate in Colombia (it also happened in Brazil).[9] It is worth noting that smoothing was the weakest criteria.

Table 6
Control I: Sign tests for volatility options using Brazil as counterfactual

Criterion	Window	Total Cases (Purchases+ Sales)	Favorable Cases	%Success	H_0: $p \leq 0.5$, p-value	H_0: $D \leq 0$, p-value
Smoothing	5	20	17	85	0.00	-
Direction	5	20	12	60	0.13	-
Reversal	5	20	9	45	0.58	-
Matched	5	20	-	-	-	0.26

The second counterfactual we considered was related to the behavior of the Colombian exchange rate in those periods in which volatility options should have been applied if the rule was in place, but was not, simply because the board of the Central Bank decided to suspend interventions in that particular period. As explained in Section II, auctions for volatility options were conducted whenever the exchange rate was above or below its last 20-day moving average by a specific threshold. Market participants could then purchase an option and then exercise it up to one calendar month after its purchase, as long as conditions that triggered the auction remained the same. In other words, our "control event" only considers the period when the central bank decided not to intervene through volatility options, and when no intervention of any other type took place, so that the movements of the exchange rate are not contaminated by the effect of other interventions.

A caveat however, is the small number of control events available. For this reason, we were forced to consider only the case of 2 days (event window, pre and post event). Table 7 shows, once again, that our results are not biased by pre-existing differences. Tables 6 and 7 thus suggest that the counterfactual experiments for volatility options are robust for direction, reversal and for the matched test, but not for smoothing.

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[9] We are assuming that Brazil was not intervening in those same periods, or that the pattern of intervention during the whole period was very different.

Table 7
Control II: Sign tests for volatility options considering different conditions to
trigger the auction

| Criterion	Window	Total Cases (Purchases+ Sales)	Favorable Cases	%Success	H_0: p≤0.5, p-value	H_0: D≤0, p-value
Smoothing	2	10	7	70	0.05	-
Direction	2	10	7	70	0.58	-
Reversal	2	10	6	60	0.17	-
Matched	2	10	-	-	-	0.40

IV.a Robustness Checks

Graphs 5-8 show additional robustness checks for our proposed criteria: Smoothing (Figure 5), Direction (Figure 6), Reversal (Figure 7) and Matching (Figure 8). For each type of intervention, we computed the % of successes and p-value of the evaluation test[10] for different window sizes. Two main results can be seen: 1) volatility options are successful according the four criteria and for all window sizes that are considered, and 2) the rest of intervention types are successful when considering only the smoothing criteria and for window sizes that are less than 12 days.
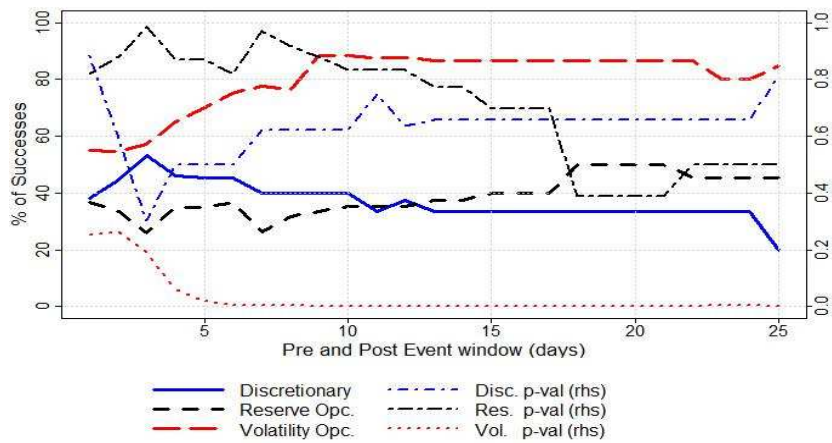
Graph 5
Robust exercise-Smoothing Criteria
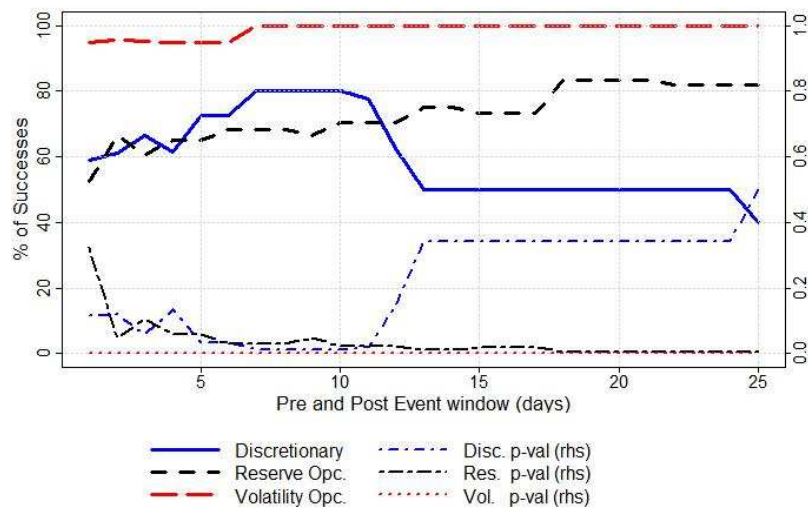
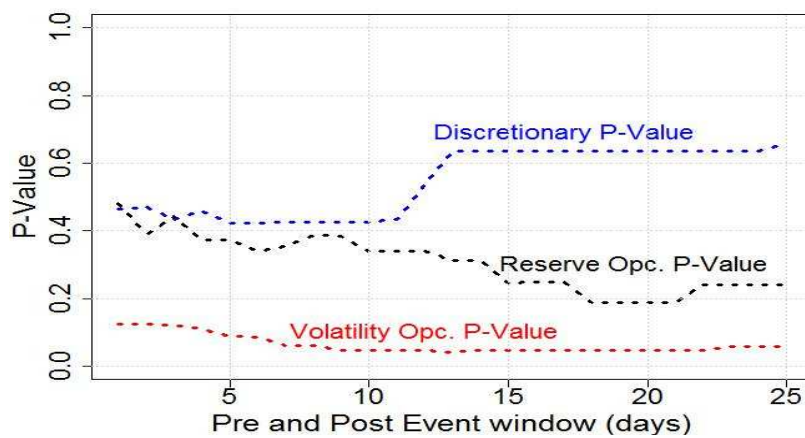[10] For the match test only the p-value is presented.

Graph 6
Robust exercise –Direction Criteria
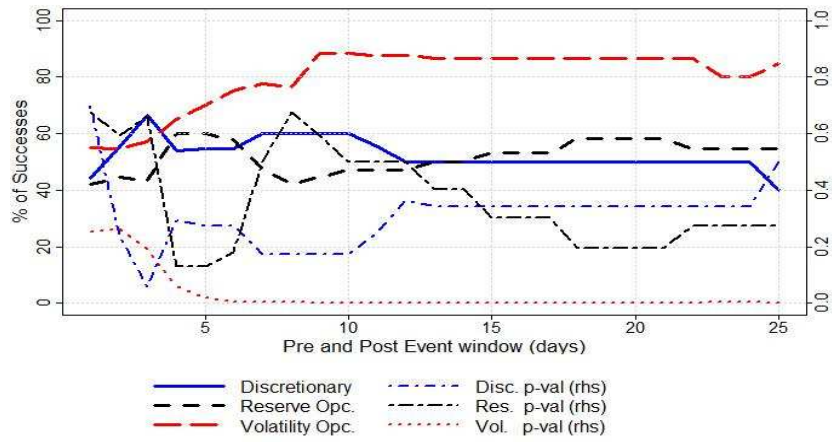
Graph 7
Robust exercise – Reversal Criteria

Graph 8
Robust exercise – Matched Test

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V. Conclusions

We compare the effects of international reserve accumulation options, volatility options and discretionary interventions for the Colombian case during the period 2000-2012, using an event study approach. Following Fatum and Hutchison (2001), we define four different criteria to evaluate a successful intervention: 1) Direction, 2) Reversal, 3) Smoothing, and 4) Matching.

We also conduct two counterfactual exercises: 1) we consider the evolution of the Brazilian exchange rate in periods corresponding to pre and post Colombian volatility interventions and 2) we consider periods in which volatility options should have been conducted if the intervention rule was in place, but was not, because the board of the Central Bank decided to suspend interventions in that period. Finally, we conduct robustness checks by allowing for various event window sizes.

Results show that all types of interventions were successful according to the smoothing criterion. In particular, volatility options seemed to have the strongest effect according to the four criteria that were considered. Results are robust when using different windows sizes and counterfactuals.

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VII. Appendix

Table A. 1
Sign Test, Smoothing (10 days)

Type of Intervention	Purchases/ sales	Window	Total Cases	Favorable Cases	% Success	H₀: p≤0.5 p-value
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. Discretionary	Purchases	10	6	4	67	0.11
	Sales	10	0	0	.	.
B. Options int. reserves	Purchases	10	14	10	71	0.03
	Sales	10	1	1	100	.
C. Options volatility	Purchases	10	10	10	100	0.00
	Sales	10	5	5	100	0.00
t2=(A)+(B)	Purchases	10	18	12	67	0.05
	Sales	10	1	1	100	.
t3=(A)+(B)+(C)	Purchases	10	24	19	79	0.00
	Sales	10	6	6	100	0.00

Table A. 2
Sign Test, Direction (10 days)

Type of Intervention	Purchases/ sales	Window	Total Cases	Favorable Cases	% Success	H₀: p≤0.5 p-value
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. Discretionary	Purchases	10	6	3	50	0.34
	Sales	10	0	0	.	.
B. Options int. reserves	Purchases	10	14	9	64	0.09
	Sales	10	1	1	100	.
C. Options volatility	Purchases	10	10	8	80	0.01
	Sales	10	5	4	80	0.03
t2=(A)+(B)	Purchases	10	18	11	61	0.12
	Sales	10	1	1	100	.
t3=(A)+(B)+(C)	Purchases	10	24	18	75	0.00
	Sales	10	6	5	83	0.02

Table A. 3
Sign Test, Reversal (10 days)

Type of Intervention	Purchases/ sales	Window	Total Cases	Favorable Cases	% Success	H_0: $p \leq 0.5$ p-value
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. Discretionary	Purchases	10	6	2	33	0.66
	Sales	10	0	0	.	.
B. Options int. reserves	Purchases	10	14	7	50	0.40
	Sales	10	1	0	0	.
C. Options volatility	Purchases	10	10	8	80	0.01
	Sales	10	5	4	80	0.03
t2=(A)+(B)	Purchases	10	18	9	50	0.41
	Sales	10	1	0	0	.
t3=(A)+(B)+(C)	Purchases	10	24	16	67	0.03
	Sales	10	6	4	67	0.11

Table A. 4
Matching Test (10 days)

Type of Intervention	Purchases/ sales	Window	Total Cases	Average Difference	P-value H_0: $D \leq 0$ or H_0: $D \geq 0$[*]
(1)	(2)	(3)	(4)	(5)	(6)
A. Discretionary	Purchases	10	6	-0.05	0.58
	Sales	10	0	.	.
B. Options int. reserves	Purchases	10	14	0.06	0.30
	Sales	10	1	-0.01	.
C. Options volatility	Purchases	10	10	0.62	0.07
	Sales	10	5	-0.63	0.05
t2=(A)+(B)	Purchases	10	18	0.04	0.41
	Sales	10	1	-0.01	.
t3=(A)+(B)+(C)	Purchases	10	24	0.28	0.24
	Sales	10	6	-0.53	0.11

* $D \leq 0$ for purchases and $D \geq 0$ for sales.