ARE CAPITAL CONTROLS AND CENTRAL BANK INTERVENTION EFFECTIVE?

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ABSTRACT

Intervention in the foreign exchange market and capital controls are two controversial policy options that many countries have adopted in order to influence the exchange rate and moderate capital flows. The objective of this paper is to examine their effectiveness for a representative Emerging Market economy. The main findings indicate that neither central bank intervention nor capital controls used separately were successful for depreciating the exchange rate but have the side effect of augmenting its volatility. Nonetheless, during a period when both policies were used simultaneously, they were effective to impact the exchange rate, without increasing its volatility.

Keywords: Capital controls (Tobin tax), foreign exchange intervention, exchange rate return, effectiveness, GARCH.
JEL Classification: C52, E58, F31, F32, F38.

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¿SON EFECTIVOS LOS CONTROLES DE CAPITAL
Y LA INTERVENCIÓN DEL BANCO CENTRAL?

RESUMEN

La intervención en el mercado cambiario y los controles de capital son dos instrumentos de política controversiales que muchos países han utilizado para influir sobre la tasa de cambio y moderar los flujos de capital. El objetivo de este artículo es evaluar su efectividad para una economía emergente representativa. Los principales hallazgos indican que ni la intervención cambiaria ni los controles de capital utilizados por separado tuvieron éxito en afectar la tasa de cambio, pero sí tuvieron un impacto no deseado como fue aumentar su volatilidad. Sin embargo, durante el periodo en el que ambas políticas se usaron simultáneamente, fueron efectivas en impactar la tasa de cambio sin incrementar su volatilidad.

Palabras clave: controles de capital (impuesto Tobin), intervención cambiaria, retorno de la tasa de cambio, efectividad, GARCH.

Clasificación JEL: C52, E58, F31, F32, F38.

1. INTRODUCTION

The objective of this paper is to examine the effectiveness of foreign exchange intervention (FXI) and capital controls (CC) policies for depreciating the local currency, reducing its volatility, and moderating the exchange rate vulnerability to external shocks. To accomplish this objective the paper uses daily data from an Emerging Market (Colombia) for the period 1993-2018, and a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model for the exchange rate return of the local currency (peso).

The rationale for using FXI and CC differ. As far as FXI, it is in principle an instrument directed towards accumulating international reserves. Nevertheless, in this process it may affect the level and return of the exchange rate through different channels. In the case of a non-sterilized intervention, the level of the exchange rate will be affected by the change in the relative supplies of domestic and foreign money, similarly as with any other open market operation. The effects of a sterilized intervention are less direct, and occur through different channels: Signaling

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(Domínguez, 1998), portfolio (Sarno and Taylor, 2001), microstructure channel (Evans and Lyons, 2002), and coordination (Sarno and Taylor, 2001; Reitz and Taylor, 2008). This paper does not seek to identify which of these channels explains the effects that foreign exchange intervention may have on the exchange rate. Its objective is just to verify if those effects exist, how significant they are, and if they differ through time as economic circumstances change.

The rationale of capital controls is to dampen capital inflows either by imposing administrative restrictions, or as in the case of Colombia, by introducing an unremunerated reserve requirement (URR) that increases the cost of bringing capital into the country. As a result, capital controls could alleviate exchange rate pressures and enhance the autonomy of monetary policy. Capital controls could also modify the structure of capital inflows by discouraging short-term (speculative) capital and boosting medium and long-term capital. As was argued by Eichengreen, Tobin, and Wyplosz (1995), by throwing "sand in the wheels", capital controls constrain speculative inflows helping to stabilize the exchange rate and reducing its short-term volatility.

As stated by Blanchard, Dell'Ariccia, and Mauro (2013) and Liu and Spiegel (2015), FXI and CC can be both complements and substitutes: Complements because CC reduce the elasticity of flows with respect to relative rates of return, thereby making FXI more powerful; substitutes because they can affect the exchange rate by their own. Furthermore, CC introduce a market friction that limits arbitrage so that FXI can become effective (Blanchard, Adler, and de Carvalho Filho, 2015). According with these hypotheses, the complementarity of sterilized FXI and CC is tested in this paper by examining the interacted effects of those two policies on the exchange rate return of the Colombian peso.

In the case of Colombia several efforts for empirically assessing the effectiveness of FXI and CC policies have been done in the past, with differing conclusions. Overall, it has been shown that effectiveness of FXI is at most short-lived and, in certain instances, it increases exchange rate volatility. Notice that the literature review on Colombia, as well as the appendixes of the different sections, will not be reported in the text but they are available upon request. The appendixes will be called in the text as "complementary files". Regarding CC, the research carried out in Colombia has found that they are generally able to reduce short-term

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flows and induce a shift from short-term to long-term capital inflows (complementary files).

The contribution of this paper is somewhat different from the previous literature, both in Colombia and in elsewhere. To begin with, rather than evaluating CC and FXI as separate policies, as it is the tradition in the literature, this paper assesses the effectiveness of CC and FXI as a combined policy, whenever authorities use them simultaneously, as it was the case during several instances in Colombia over the last years. A second contribution is to show the time-variation in the relationship between policy actions and outcomes. Over the last quarter of a century, Colombia has been subject to all kinds of domestic and external shocks; changes of monetary and exchange regimes, and large swings in inflation; exchange rates; interest rates; economic growth and other macroeconomic variables. A long daily sample that spans for 26 years include all these events and permits to conveniently split the sample in several subsamples to allow for structural changes or to focus on episodes. A third contribution is to build and to use a measure of capital controls that takes into account its intensity and variation through time, which differs from standard approaches that mostly rely on dummy variables to assess the effects of capital controls. A final and no minor contribution is to apply this non-standard battery of indicators to a large and representative emerging economy like Colombia.

The remaining of this paper is organized as follows. The second section presents the regression model, discusses its main characteristics and describes the data. The third section introduces a measure of capital controls, which quantifies its presence and intensity. The fourth presents the results of the estimations. The last section summarizes the conclusions and draws the main lessons from the Colombian experience with CC and FXI.

2. DATA AND THE REGRESSION MODEL

We used daily information for the entire period between 1993:01:04 and 2018:12:31 on the nominal exchange rate of the peso with respect to the US dollar (E) so that the total sample size reached 6,781 observations (complementary files provides a detailed description of the time series and their respective sources).

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The regression model is an augmented version of the return of the domestic currency derived from the uncovered interest parity condition, under imperfect substitutivity between domestic and foreign assets, for a small open economy —it has similarities to those estimated by Edwards and Rigobon (2009) for the Chilean case and Clements and Kamil (2009) for Colombia. Since CC may introduce a market friction that limits arbitrage and affects the exchange rate return, as stated in the introduction, we condition its behavior by a capital control measure.

The AR(1)-GARCH(1,1) regression model in logarithms for the mean of the short-term return of the exchange rate, indexed by time *t*, is the following (the expected signs are in parenthesis):

$$\begin{aligned}\Delta e_t = {} & \beta_0 + \underset{(+)}{\beta_1 \Delta e_{t-1}} + \underset{(+)}{\beta_2 \Delta spread_t} + \underset{(+)}{\beta_3 vix_t} + \underset{(-)}{\beta_4 \Delta Dif_t} + \underset{(+)}{\beta_5 TAX_t} + \underset{(+)}{\beta_6 I_t} + \underset{(-)}{\beta_7 \Delta pc_t} + \\ & \underset{(-)}{\beta_8 Dq_{t-1}} + \underset{(-)}{\beta_9 TAX_t * \Delta spread_t} + \underset{(+)}{\beta_{10} TAX_t * I_t} + \underset{(+)}{\beta_{11} TAX_t * \Delta Dif_t} + u_t \end{aligned} \quad [1]$$

Where the dependent variable Δe is the peso/US dollar exchange rate return [$\Delta e_t = (lnE_t - lnE_{t-1})*100$, the constant β_0 represents the expected long term mean return and *u* is the unexpected short term return, that is initially assumed to be normally distributed *i.i.d.* (identically and independently) with a mean of zero and conditional *h* variance. Later, we will evaluate if the assumed normality and independence of the errors are supported by the data. Δ is the first-difference operator. β_5, β_6, and β_{10} the coefficients we are mostly interested in, measure the short-run effects on the mean return of the exchange rate of CC or/and central bank's FXI respectively. If these policies were effective, they would increase the future spot exchange rate relative to the expected spot rate in such a way that would reduce the incentives for international capitals to come in. In terms of the uncovered interest parity hypothesis this implies that the yield of the local asset —measured in dollars— relative to the yield of the foreign asset would be reduced, thus discouraging capital inflows.

The explanatory variables of the model are, *spread*: Measures the risk in the financial sector of Emerging Markets; *Vix*: Measures the volatility (risk) in the financial markets of the industrialized countries; *Dif*: Differential between the domestic rate and the foreign rate; *TAX*: The

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tax equivalent to the URR on capital inflows as a measure of the CC, which is defined below; *I*: Central bank's FXI measure. Since it cannot be ruled out that authorities may decide to intervene as a reaction to the behavior of the exchange rate, a simultaneity problem in Equation [1] may emerge that could bias the estimations. In order to prevent this problem, we instrument the intervention variable as shown below. *Pc*: Commodity prices; *Dq*: Misalignment measure of the real exchange rate. *TAX**Δ*spread*, *TAX***I*, *TAX**Δ*Dif* are interaction variables. The lagged dependent variable stands for the persistence of the peso depreciation/appreciation. Notice that we included the interaction variables between *TAX* and *spread*, in order to assess whether the CC helped to isolate the domestic forex market from international shocks to Emerging Markets; between *TAX* and *I*, to see if the combination of the CC and FXI had an impact on the exchange rate return beyond each policy taken separately; between *TAX* and ΔDif_t to evaluate whether the CC helped the central bank to gain autonomy.

The logarithmic exchange rate series, the logarithm of the *spread*, the interest differential and the logarithm of prices of commodities were differentiated once to obtain stationary series. The short-term conditional variance or conditional volatility for the exchange rate return of the peso, indexed by time *t*, is given by (the expected signs are in parenthesis):

$$h_t = \alpha_0 + au_{t-1}^2 + bh_{t-1} + \underset{(+)}{\alpha_1}\left|\Delta spread_t\right| + \underset{(+)}{\alpha_2} vix_t + \underset{(+)}{\alpha_3}\left|\Delta Dif_t\right| + \underset{(-)}{\alpha_4} TAX_t + \underset{(-)}{\alpha_5} I_t + \underset{(+)}{\alpha_6}\left|\Delta pc_t\right| + \underset{(-)}{\alpha_7} TAX_t * \Delta spread_t + \underset{(-)}{\alpha_8} TAX_t * I_t + \underset{(-)}{\alpha_9} TAX_t * \Delta Dif_t \quad [2]$$

Where α_0 is the constant term, *h* the conditional variance of the return ($b \geq 0$), u^2 is the unexpected squared return ($a \geq 0$). Note that *h* is stationary if and only if $a + b < 1$. The variables defined above, some of which are introduced into Equation [2] in absolute value, explain the changes with respect to the long-term variance. The coefficients we are mainly interested in are α_4, α_5, or/and α_8, which measure, respectively, the effects of the CC or/and FXI on the volatility of the peso/US dollar exchange rate return. We will conclude that the CC or FXI were effective in the short term if it made possible to reduce the volatility of the return.

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The instrument for the variable *I* (henceforth *IVI*) was calculated using a generalized instrumental variable procedure. Thus, we estimate it as the fitted value of the random reaction function of the central bank —the expected signs are in parenthesis—, which is the monetary and foreign exchange authority:

$$I_t = \underset{(+)}{\theta_0 + \theta_1 I_{t-1}} + \underset{(-)}{\theta_2 gape_{t-2}} + \underset{(-)}{\theta_3 INFS_{t-1}} + \upsilon_t \qquad [3]$$

Where υ_t is a stochastic shock to the forex intervention policy, which is assumed to behave as a white-noise. The lagged *I* variable in Equation [3] captures the possible intervention persistence and the *gape* variable the reaction of the central bank to the misalignment of the nominal exchange rate of the peso: If it is depreciated, the central bank sells US dollars and *vice-versa*. Notice that we lagged the *gape* variable twice to avoid introducing biasedness and simultaneity into Equation [1]. The last term, the *INFS* variable, captures the FXI response of the central bank to inflationary surprises: If the observed inflation was above (below) the target during the previous period, the authorities would be expected to purchase fewer (more) US dollars in period *t*.

3. THE TAX EQUIVALENT TO THE URR

The tax equivalent to the capital controls calculated and incorporated in the regressions that is our measure of CC is the version used by Cárdenas and Barrera (1997) for evaluating the effectiveness of capital controls in the case of Colombia and De Gregorio, Edwards, and Valdes (2000), and Edwards and Rigobon (2009), for the Chilean case. According to these authors, the equivalent tax of the URR on capital inflows for a credit for *tc* periods is given by (we changed the authors' original notation simply to adjust it to the notation used in this document and, for simplification, we eliminate the time index):

$$TAX = \left(\varepsilon / 1 - \varepsilon\right)\left(i^f tm / tc\right) \qquad [4]$$

ε is the percentage of the reserve requirement set by the central bank, the Colombian institution that is authorized to establish and modify the

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control; i^f is the foreign interest rate, which measures the opportunity cost of the URR; and *tm* is the time (in months) that an URR on foreign debt had to be kept in the central bank. Finally, *tc* is the loan period (in months). Notice that under the tax definition given by Equation [4], if *tm* is assumed constant and given, *TAX* is a decreasing function of *tc* so that the longer the loan term *tc*, the lower the equivalent tax imposed by the control. *TAX* is calculated as an average on the different values of i^f, *tm*, and *tc*, which are directly observable from the statistics and the regulation on foreign capital flows issued by the central bank. In order to get a single measurement of *TAX*, we took a simple average for all of *tc* values, that is, *tc* = 3, 6, 9, 12, 18, 24, 36, and 60 months.

4. THE ESTIMATIONS

In this section, we estimate the AR(*m*)-GARCH(1,1) model represented by Equations [1] and [2] simultaneously where we assume for presentation that *m* = 1. We carry out different diagnostic and specification tests (see complementary files) and present the estimates for the entire sample 1993:01:04 - 2018:12:31. As will be seen, the model that adjusts best to the data is an integrated GARCH (IGARCH) model.

Due to the size of the sample analyzed, we use two criteria to split it: First, stability or perseverance test of the parameters in the model and structural break tests. Second, the changes of the monetary and foreign exchange regimes that occurred during the sample. Third, strong international or local macroeconomic shocks.

The first sub-sample covers the period when the exchange rate was controlled through a crawling-peg and an exchange rate band, the monetary policy was guided by money aggregates (1993:01:04 to 1999:09:30) and the economy faced a sudden stop at the end. The second covers the period with a flexible exchange rate and an inflation targeting monetary regimes (1999:10:01 to 2018:12:31). We categorized these sub-samples by following what was suggested by Gómez, Uribe, and Vargas (2002) in the first two cases. The third sub-sample (2004:01:01 to 2010:07:30) covers a period of a very active forex intervention policy, which coincides with capital controls, the consolidation of the inflation targeting regime, and the economy recovery trend from the 2007-2009 international financial crisis. Finally, the fourth sub-sample includes exclusively the period of

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preannounced intervention (2008:01:01 to 2010:07:30), for the reason mentioned before, and the peak of the international financial crisis.

4.1. Total sample: 1993:01:04-2018:12:31

4.1.1. Diagnostic and specification tests

First, we carried out the Kleibergen-Paap (2006) *rk* statistics of under- and-weak identification. The tests showed that the null hypothesis of under-identification was rejected, which means that the model is identified. The null hypothesis of the equation being weakly identified was also rejected. Then, we identified the structure of the lags for the autoregressive process of the return or, in other words, the *m* value of the AR process in Equation [1], which, according to Akaike's information criteria, corrected for degrees of freedom (called CAIC criterion), and Schwarz's is equal to 2. Afterward, we corroborated the presence of at least one ARCH component in the data through the Engle's test.

Second, we found a fat tail distribution and a failure of the unexpected returns in Equation [1] to fulfill normality, so that we used the Kolmogorov-Smirnov test to evaluate their distribution. The tests reported that the distribution was neither normal nor *t-student* so that we used a Generalized Error Distribution (GED). Castaño Vélez, Gómez Portilla, and Gallón Gómez (2008) and Echavarría, Vásquez, and Villamizar (2010) also use this type of distribution to estimate models of the GARCH family for the exchange rate of the Colombian peso.

The first estimates showed that the constant term in the variance equation turned out to be negative. Secondly, the estimated coefficients *a* and *b* for Equation [2] turned out to be larger than one, which could indicate that the conditional variance is not stationary. The non-stationarity of peso volatility is not strange to the trend of the exchange rate for other currencies around the world as has been documented by Baillie, Bollerslev, and Mikkelsen (1996) and Davidson (2004). For instance, Davidson (2004) found that at least ten European countries' foreign exchange rates with respect to the US dollar, before the Euro zone existed, behaved like IGARCH processes. In the Colombian case, Castaño Vélez, Gómez Portilla, and Gallón Gómez (2008) found a similar result. The implications of this finding are that volatility could become explosive

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and the standard GARCH model is non-stationary and, therefore, it may be inappropriate for analyzing the data. Therefore, and based on the statistical findings, we use an AR(2)-IGARCH(1,1) model which imposes the $a + b = 1$ restriction on Equation [2].

4.1.2. Estimations

The estimates indicate, in the first place, that the effect of FXI is nil and statistically non-significant for the mean return equation for all models (see Table 1). In other words, the FXI has not helped to prevent the appreciation/depreciation of the Colombian peso. However, FXI significantly raises volatility in most of the cases; its impact is almost zero, though.

The coefficient that measures the impact of the CC is also very small and statistically non-significant in most cases. As for the variance of the return, the CC have no effect on it. The coefficient of the *TAX*Δspread* interaction variable is small but turned out to be significant in the mean equation and with the expected sign. This provides evidence that the control helped to stem depreciation pressures during episodes of external risk shocks. The *TAX*IVI* and *TAX*ΔDif* interaction variables were non-significant in the mean and variance equations. When the former is statistically significant in the variance equation, it increases in some degree the return volatility. Notice that the finding that the CC is not effective to stem domestic currency appreciation does not coincide with those found by Edwards and Rigobon (2009) for the Chilean peso, but it does coincide with that of Clements and Kamil (2009) for the case of Colombia. As for the effect of the CC on the volatility of the exchange rate return, both papers find that they increase it, contrary to our results.

The other regressors such as the measure of risk perception in Emerging Markets, the prices of commodities and the misalignment of the real exchange rate are statistically significant and with the expected signs in the equation for the mean of the return. These show that, together with the lagged self-comportment of the return, those variables are fundamental determinants of the daily average behavior of the exchange rate return of the peso. As for the variance equation, the risk perception in global markets and the volatility of the interest rate differential seem to be the determinants of the return volatility of the peso, but the size of their impact is small.

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4.2. Estimations for the sub-samples

In this section, we will examine the results of the estimations of the AR(2)-IGARCH(1,1) models for the mean and variance of the exchange rate return for the previously mentioned sub-samples. As before, we carried out the different diagnostic and specification tests, which yielded similar results. Just like with the whole sample, we estimated a regression for the FXI and CC measures and five specifications of the model. To guarantee comparability with previous results, we kept the same assumptions regarding the distribution and behavior of the unexpected returns, the method of estimation and optimization, and the specification of the FXI reaction function (Equation [3]).

Table 2 summarizes the results of the individual regressions (complementary files). First, like for the total sample and without ambiguity, FXI does not have any effect on the mean of the return in any of the sub-samples but it raised the return volatility in the first sub-sample and reduced it in the second one.

Second, the CC coefficient turned out to be nil and statistically non-significant for the mean of the return in all the sub-samples, and neither affects the return volatility. Thus, we find that the foreign exchange policy does not seem to benefit from the capital control when it acted separately in most of the sub-samples.

Now, the interaction between CC and FXI does not affect the volatility of the return in any sub-sample nor the mean return on the first three sub-samples. However, the interaction between CC and FXI delivered an important result for the last sub-sample (complementary files). When the CC and the FXI policies were used simultaneously, the coefficient of the interaction variable turned out to be not only statistically significant, but also sizable and positive, making the return higher. What was the role of the signaling or other channels of transmission of the FXI and the CC explaining these findings? Unfortunately, we have no answer and leave this as a topic for future research.

It is worth noting that the CC and FXI interaction policy lasted 75 working days during this period. Several weeks before the beginning of this combined policy, important events were happening in the world financial markets that started to put upward pressure on risk perception. In particular, risk measures like the Emerging Markets Bond Index

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Table 1. Effect of the capital control and forex intervention on the peso/US dollar exchange rate mean return and its volatility (whole sample: 1993:01:04-2018:12:31)

Variables	Model 1			Model 2			
	Coeff.	*t*	Sig.	Coeff.	*t*	Sig.	
Equation for the mean of the return							
Constant	0.002	0.16		0.001	0.07		
Δe_{t-1}	0.168	15.05	***	0.167	14.97	***	
$\Delta spread_t$	0.011	7.96	***	0.016	9.89	***	
vix_t	0.001	1.37		0.001	1.52		
ΔDif_t	0.000	0.06		0.000	0.12		
TAX_t	0.000	1.38		0.000	1.71	*	
IVI_t	0.001	−1.50		−0.001	−1.25		
Δpc_t	−0.057	−12.78	***	−0.057	−12.74	***	
Dq_{t-1}	−0.001	−3.71	***	−0.001	−3.56	***	
$TAX_t{}^*\Delta spread_t$	–	–		0.000	−5.26	***	
$TAX_t{}^*IVI_t$	–	–		–	–		
$TAX_t{}^*\Delta Dif_t$	–	–		–	–		
Equation for the variance of the return							
a	0.166	17.07	***	0.167	17.21	***	
b	0.834	85.80	***	0.833	86.05	***	
$\lvert\Delta spread_t\rvert$	0.001	2.01	**	0.001	2.80	***	
vix_t	0.000	1.16		0.000	0.80		
$\lvert\Delta Dif_t\rvert$	0.000	1.89	*	0.000	1.85	*	
TAX_t	0.000	−0.64		0.000	−1.27		
IVI_t	0.000	2.47	**	0.000	2.55	**	
$\lvert\Delta pc_t\rvert$	0.001	0.56		0.001	0.45		
$TAX_t{}^*\Delta spread_t$	–	–		−0.000	−1.32		
$TAX_t{}^*IVI_t$	–	–		–	–		
$TAX_t{}^*\Delta Dif_t$	–	–		–	–		
Shape	1.725	55.66	***	1.721	55.31	***	
Observations	6,778			6,778			
LogLikelihood	−3,474			−3,463			

Note: The symbols ***, **, * indicate a statistical significance of 1%, 5% and 10%, respectively. The mean equation only reports one lag of the dependent variable.

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	Model 3			Model 4			Model 5		
	Coeff.	*t*	Sig.	Coeff.	*t*	Sig.	Coeff.	*t*	Sig.
	0.002	0.16		0.002	0.15		0.000	0.01	
	0.168	15.03	***	0.168	15.00	***	0.168	14.99	***
	0.011	8.00	***	0.011	7.99	***	0.016	9.91	***
	0.001	1.34		0.001	1.38		0.001	1.59	
	0.000	0.08		0.000	0.18		0.000	0.15	
	0.000	1.13		0.000	1.22		0.000	1.15	
	–0.001	–0.79		–0.001	–1.59		0.000	–0.61	
	–0.056	–12.68	***	–0.057	–12.82	***	–0.056	–12.69	***
	–0.001	–3.76	***	–0.001	–3.72	***	–0.001	–3.67	***
	–	–		–	–		0.000	–5.75	***
	0.000	–0.91		–	–		0.000	–0.83	
	–	–		0.000	–1.61		0.000	–1.19	
	0.167	16.99	***	0.166	17.02	***	0.165	17.17	***
	0.833	84.96	***	0.834	85.49	***	0.835	86.93	***
	0.001	2.27	**	0.001	2.18	**	0.001	3.23	***
	0.000	0.93		0.000	1.04		0.000	0.52	
	0.000	1.84	*	0.000	1.88	*	0.000	1.80	*
	0.000	0.00		0.000	–0.16		0.000	0.21	
	0.000	0.68		0.000	2.20	**	0.000	0.64	
	0.001	0.60		0.001	0.53		0.000	0.42	
	–	–		–	–		–0.000	–1.16	
	0.000	2.04	**	–	–		0.000	2.46	**
	–	–		0.000	0.55		0.000	1.24	
	1.725	54.93	***	1.726	55.13	***	1.717	55.46	***
	6,778			6,778			6,778		
	–3,471			–3,473			–3,459		

Source: Authors' calculations.

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Table 2. Summary of the findings on the effect of CC and FXI on the mean return of the peso and its volatility

Variable	Equation for the mean of the return	Equation for the variance of the return
Controlled exchange rate and monetary policy guided by money aggregates (1993:01:04-1999:09:30)		
IVI_t	NS	S and volatility increases
TAX_t	NS	NS
TAX_t*$\Delta spread_t$	NS	NS
TAX_t*IVI_t	NS	NS
TAX_t*ΔDif_t	NS	NS
Floating exchange rate and inflation targeting monetary regime (1999:10:01-2018:12:31)		
IVI_t	NS	S and volatility decreases
TAX_t	NS	NS
TAX_t*$\Delta spread_t$	S and return increases	NS
TAX_t*IVI_t	NS	NS
TAX_t*ΔDif_t	S and return increases	NS
Secret and preannounced forex intervention (2004:01:01-2010:07:30)		
IVI_t	NS	NS
TAX_t	NS	NS
TAX_t*$\Delta spread_t$	S and return increases	NS
TAX_t*IVI_t	NS	NS
TAX_t*ΔDif_t	S and return increases	NS
Preannounced forex intervention (2008:01:01-2010:07:30)		
IVI_t	NS	NS
TAX_t	NS	NS
TAX_t*$\Delta spread_t$	S and return decreases	NS
TAX_t*IVI_t	S and return increases	NS
TAX_t*ΔDif_t	NS	NS

Note: NS: No significance at 1%, 5% or 10% level. S: Significance at 1%, 5% or 10% level.
Source: Authors' calculations, based on complementary files ("Model 5").

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(EMBI+), our measure of risk in Emerging Markets, the Credit Default Swaps (CDS) on 5-year corporate Colombian debt, and the High Yield Spread were all increasing. As a result, days before the outset of the preannounced intervention, the Colombian exchange rate had ceased to appreciate, and was beginning to show an incipient depreciation trend. As argued by Fratzscher *et al.* (2019, p. 134), one of the "major conditions" for FXI becoming more effective is that "intervention goes with the prevailing trend on the market."

In addition, supporting the complementarity hypothesis (Blanchard, Dell'Ariccia, and Mauro, 2013; Liu and Spiegel, 2015), it is found that the interaction of control and intervention since June 24 gave a boost to the ongoing depreciation trend: The central bank started to buy dollars and sell pesos in order to reinforce the outgoing depreciation of the local currency. The exchange rate even overshoots during the first few days of intervention, and then maintained a depreciation trend all along the interaction period. This is reflected in the statistical significance effect of the interaction of control-intervention for increasing the exchange rate return within this sub-sample.

Another fact to highlight is that before the interaction period the CC had been progressively reinforced, by extending the URR to a larger number of operations (imports financing; several modalities of foreign credit), while at the same time the regulation regarding the minimum permanence period of foreign direct investment in Colombia was extended from one to two years. This upgrading of capital controls together with the preannounced intervention at the right moment seem to have been the key factors that helped to achieve the desired effect of depreciating the exchange rate, without increasing volatility.

Therefore, the effectiveness of the interaction of intervention and control in these particular circumstances is related to a situation of 'lean with the wind' as opposed to 'lean against the wind.' This means that the FXI and CC policies were able to provide an impulse to a depreciation process that was already on its way. In contrast, under circumstances where all economic forces were pushing for an appreciation, even the interaction between intervention and control were insufficient for modifying the appreciation trend. That is, interventions tend to be more effective if executed in line with a longer run fundamental equilibrium (Fratzscher *et al.*, 2019).

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To evaluate the robustness of this important result we carried out joint significance tests for the capital control, intervention and the interaction coefficients. The χ^2 and F statistics showed that the null hypotheses of non-significance could not be rejected except for the joint test for the forex intervention and interaction coefficients in the last sub-sample. This means that the CC does not affect the exchange rate return by itself, as was displayed by the *t*-statistics along outputs of the different samples, but it does when it interacts with the FXI, which was also supported by the statistical significance of the interaction partial regression coefficient in the last sub-sample.

Regarding the other two interaction variables, they have no effect neither on the mean return nor on the variance in the first sub-sample. During the second and third sub-samples, the interaction between the CC and the spread unambiguously increased the return but did not increase its variance. This result suggests that during these years CC was unable to isolate the exchange rate return from shocks to the international risk. However, in the fourth sub-sample this interaction variable acted as expected by reducing the return without increasing its volatility, which means that CC contributed to isolate the economy from external risk variations. This is a meaningful result, since this fourth sub-sample corresponds with the period of the international financial crisis.

As for the interaction between the CC and the interest differential, during the second and third sub-samples it clearly increased the return but did not rise its variance. This result suggests that the CC was capable to isolate the exchange rate return from pressures arising from positive interest rate differentials, which means that controlling capital inflows allowed monetary authorities to gain some autonomy since they could increase interest rate without putting additional appreciation pressure on the exchange rate. During the fourth sub-sample, interaction between CC and ΔDif ceased to play that role.

The rest of the explanatory variables change their sign and statistical significance depending on the sample that was analyzed (complementary files). The spread resulted significant but with an opposite sign to what was expected in the equation for the mean of the return in the first sub-sample. This indicates that an increase in the risk in emerging countries reduced the exchange rate return for the peso during the period of exchange rate band, aimed at managing the nominal exchange rate,

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and monetary aggregates as policy instruments. This can be explained by the reaction function of the central bank during that policy regime, which led them to tighten monetary policy and increase the interest rate to defend the exchange rate band during periods of negative external shocks, thus inducing a peso appreciation. During this period, the spread did not affect the return volatility. In the other sub-samples, the spread has the expected positive sign and is statistically significant in the mean return equation, rising the volatility of the returns in the second sub-sample only.

The measure of risk in the financial markets of the industrialized countries (*vix*) resulted significant and with the expected positive sign in the equation for the mean of the return in the first sub-sample; besides, it did not affect its volatility. In contrast, since 2004 up to the end of the sample, it has no effect neither on the return nor on its variance and lose its importance as determinant of the peso return.

Contrary to what was expected, the innovations in the interest differential (ΔDif) did not have any statistically significant effect on the mean of the return in any of the sub-samples, while —in the first sub-sample— its variations unambiguously induced a greater volatility of the return. This result might have to do with the fact that during the first sub-sample, especially during the second part, the risk perception abroad on the Colombian economy was relatively high, due to an unsolved fiscal situation and a high public debt, which discouraged foreign capitals different from direct investment to come in despite of positive interest rate differentials.

The price of commodities plays a fundamental role in determining the exchange rate return of the peso as shown by the size, sign and statistical significance of their coefficients. Its importance and robustness are missed during the first sub-sample, which may corroborate the miss-functioning of the different monetary and exchange rate channels during that period. Regarding the misalignment of the real exchange rate, its role as an error correction mechanism is missed overall. As for the volatility of the return, the volatility of the price of commodities plays no role.

Finally, it is important to observe two things: The high persistence of the exchange rate return, independently of the subsample analyzed, which coincides with the findings for the entire sample, and that volatility of

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the return is mostly determined sub-sample by sub-sample by its own volatility and by the term capturing the clustering property of the return.

5. CONCLUSIONS

The policy debate on how to manage the international capital inflows and the resulting effects on exchange rates is commonly a crucial issue in many Emerging Markets. To prevent the possible damage that excessive movements of exchange rates could cause on their economies, authorities intervene in the foreign exchange market, and some of them impose capital controls. Intervening in the foreign exchange market and/or imposing restrictions on capital mobility may be costly policies, in terms of market efficiency. On this regard, the key question is whether these policies are effective for influencing the exchange rate.

In this paper, we examined the effectiveness of central bank intervention in the foreign exchange market and capital controls for depreciating the exchange rate, reducing its volatility, and diminishing the exchange rate vulnerability to external shocks. For this purpose, the paper used high frequency data for an Emerging Market and a GARCH model of the local currency exchange rate return.

The main contributions of this paper are, first, assessing the effectiveness of capital controls and FXI as a combined policy. Second, we show the time-variation in the relationship between policy actions and outcomes through a long daily sample that spans for 26 years. Third, the paper builds and uses a measure of capital controls that considers its intensity and variation through time. Fourth, it applies this non-standard battery of indicators to a large and representative emerging economy like Colombia.

The key general finding indicates that neither central bank interventions nor capital control used separately were successful for inducing a currency depreciation. In addition, as a side effect, these policies increased the exchange rate volatility, at least in some periods. Nonetheless, when they were used simultaneously, as during the period of the international crisis between 2008 and 2010, the impact of the interaction of both policies turned out to be sizable and statistically significant for increasing the exchange rate return (depreciate the peso), with no effect on the volatility of the exchange rate return. The policy implication of

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this finding is obvious: More than one instrument may be needed at the time of strong external shocks. Avenues for future research are readily available: Identify and evaluate which of the transmission channels of the FXI and CC explains our findings. ◄

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