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Flexible inflation targets, forex interventions and exchange rate volatility in emerging countries

Juan Carlos Berganza, Carmen Broto*

Banco de España, Alcalá 48, 28014 Madrid, Spain

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A B S T R A C T

Emerging economies with inflation targets (IT) face a dilemma between fulfilling the theoretical conditions of "strict IT", which imply a fully flexible exchange rate, or applying a "flexible IT", which entails a *de facto* managed-floating exchange rate with foreign exchange (forex) interventions to moderate exchange rate volatility. Using a panel data model for 37 countries we find that, although IT lead to higher exchange rate instability than alternative regimes, forex interventions in some IT countries have been more effective to lower volatility than in non-IT countries, which may justify the use of "flexible IT" by policymakers.

1. Introduction

Since New Zealand adopted an inflation target (IT hereafter) in 1990, an increasing number of countries have implemented this monetary policy framework. According to IMF (2005) and Little and Romano (2009), 18 emerging countries (EMEs onwards) have changed their exchange rate regime, from fixed to floating, and their nominal anchor, from exchange rate to inflation. See Table 1 for a summary of IT adoption dates in EMEs. Although the effectiveness of IT to lower the inflation level and volatility still remains controversial,[1] this framework has been more durable than other monetary policy strategies (Mihov and Rose, 2008). One of the main reasons for this is that IT countries have benefited

* Corresponding author. Tel.: +34 91 338 8776; fax: +34 91 338 6212.
E-mail addresses: jcberganza@bde.es (J.C. Berganza), carmen.broto@bde.es (C. Broto).

[1] See Ball and Sheridan (2005) or Brito and Bystedt (2010) for some empirical evidence against the positive role of IT in developed and emerging countries, respectively.

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Table 1
Adoption date of the formal IT in emerging markets and current target. Sources: IMF (2005), Little and Romano (2009) and national sources.

	IT adoption date	Point target (%)	Target range (%)
Israel	Jun. 1997	None	1–3
Czech Republic	Jan. 1998	3.0	±1.0
South Korea	Apr. 1998	None	3.5–4.0
Poland	Jan. 1999	2.5	±1.0
Brazil	Jun. 1999	4.5	±2.0
Chile	Sep. 1999	3.0	±1.0
Colombia	Sep. 1999	None	2–4
South Africa	Feb. 2000	None	3–6
Thailand	May 2000	None	0–3.5
Mexico	Jan. 2001	3.0	±1.0
Hungary	Jul. 2001	3.0	±1.0
Peru	Jan. 2002	2.0	±1.0
Philippines	Jan. 2002	None	4–5
Slovak Republic	Jan. 2005	None	None
Indonesia	Jul. 2005	5.0	±1.0
Romania	Aug. 2005	3.5	±1.0
Turkey	Jan. 2006	7.5	±2.0
Ghana	May 2007	None	6–8

Source: IMF (2005) and Little and Romano (2009); current IT point target and range target also obtained from national sources. Slovak Republic became non-IT in January 2009 after Euro adoption.

from the credibility gains from explicitly announcing the target, which helped to anchor and lower inflation expectations (Mishkin and Schmidt-Hebbel, 2007).[2]

A flexible nominal exchange rate constitutes, at least from a theoretical standpoint, a requirement for a well functioning full-fledged IT regime (Mishkin and Savastano, 2001). Its rationale is based on the policy dilemma of the “impossibility of the Holy Trinity”, as in a context of capital mobility, an independent monetary policy cannot be combined with a fixed exchange rate or a peg to another currency through interventions in the foreign exchange markets (forex interventions onwards); see Obstfeld et al. (2005). Some economists state that one of the costs of IT is precisely the higher volatility of exchange rates as a result of the floating exchange rate regime, which can entail negative effects of particular relevance for EMEs given their greater financial and real vulnerabilities (Cavoli, 2009). In fact, this is the basis of the “fear of floating” (Calvo and Reinhart, 2002), which is a phenomenon mostly associated to EMEs.[3] Accordingly, during economic booms EMEs also experience “fear of appreciation” given their concerns for their loss of competitiveness (Levy-Yeyati and Sturzenegger, 2007).

Thus, exchange rate monitoring under IT poses some challenges for EMEs that differ from those in advanced economies. This might justify the more active role of their exchange rate policies, particularly in those countries where the exchange rate has previously played a key role as nominal anchor, despite the theoretical reservations about it. Consequently, in practice, EMEs with IT generally have less flexible exchange rate arrangements, intervene more frequently in foreign exchange markets than their advanced economy counterparts and have a greater response to real exchange rate movements (see Aizenman et al., 2008; Chang, 2008).[4]

This adaptive way of implementing IT, also known as “flexible IT”, has generated an intense debate about its validity and viability in EMEs, compared with “strict or pure IT”, where the exchange rate does

[2] This effect is even stronger in EMEs, as their initial credibility is lower than that of developed countries (Gonçalves and Salles, 2008).

[3] According to Cavoli (2009), the main reasons to justify the “fear of floating” are: (i) trade contraction—higher exchange rate volatility will discourage other countries to engage trade—; (ii) a higher pass-through from exchange rate to domestic prices in EMEs than in developed countries; and, (iii) balance sheet effects provoked by currency mismatches (liability dollarization).

[4] In contrast to EMEs, the most common reason to perform forex interventions in IT advanced economies is to correct an exchange rate misalignment (Stone et al., 2009). In EMEs, there are other reasons to intervene, apart from moderating the exchange rate volatility (for instance, to influence on the exchange rate or to accumulate reserves).

not enter in the reaction function of central banks.[5] That is, implicitly there is a policy dilemma between fulfilling the theoretical requirements of IT and strictly following it, or applying a "flexible IT", in the sense of using forex interventions to reduce exchange rate volatility.

To this respect, there are different views in the literature. On the one hand, some authors like Bernanke et al. (1999) hold that attending to an IT and reacting to the exchange rate are mutually exclusive as forex interventions could confuse the public about the priorities of the central bank, which distorts expectations. On the other hand, other authors argue that central banks might interfere with the exchange rate volatility. According to this view, forex interventions would be fully justified, as far as EMEs need to maintain stable and competitive real exchange rates (Cordero, 2009). In fact, following Taylor (2000), some authors include the exchange rate in the policy reaction function arguing that it helps to mitigate the impact of shocks, by dampening exchange rate volatility (Kirnasova et al., 2006; Cavoli, 2008).

Other papers reach halfway conclusions about the role of exchange rates in IT regimes from a more theoretical point of view. Stone et al. (2009) show that it depends on the structure of the economy, the nature of the shocks, and the way in which the exchange rate enters the policy rule. In the same line, Parrado (2004) finds that the social loss is much higher under "flexible IT" than under "strict IT" for real and external shocks, while for nominal shocks the opposite holds. On the contrary, Yilmazkuday (2007) concludes with a calibrated model for Turkey that the welfare loss function is minimized under "flexible IT" for all types of shocks. Finally, Roger et al. (2009) estimate a DSGE model and find that financially vulnerable EMEs are especially likely to benefit from some exchange rate smoothing given the perverse impact of exchange rate movements on activity.

In line with this debate, the main objective of our paper is to empirically analyze the relationship between IT, forex interventions and exchange rate volatility. That is, we analyze if there is any difference in terms of exchange rate volatility between the use of forex interventions in IT and non-IT countries. In other words, we want to analyze if the "fear of floating" and "fear of appreciating" behavior of some central banks may justify halfway policies between the fixed and fully floating, such as the "flexible IT", which, in practice, is the most frequent way of EMEs to implement IT.

Our study of the link between these three variables is based on a panel data model for 37 IT and non-IT EMEs from 1995:Q1 to 2010:Q1. Note that we cover the last financial crisis, whose effects on the link between IT adoption, forex interventions and exchange rate volatilities have not been analyzed in detail yet (for an exception, see de Carvalho, 2010). This crisis constitutes a natural experiment to test these relations in turbulent periods (Habermeier et al., 2009), as the relatively more important role of the exchange rate policy in EMEs with IT than in developed ones became clear. Thus, once we analyze the panel for the whole sample period, we also replicate our analysis for the time previous to the onset of the financial crisis and the subsequent subsample. We date the beginning of the crisis in 2008:Q3, as from that moment the financial crisis translates to the exchange rates of almost all EMEs, which strongly depreciated.

We conclude that, although IT leads to higher exchange rate volatility than alternative regimes, the forex interventions performed by some IT countries, mainly in Latin America, have been more effective to lower the exchange rate volatility than those of non-IT countries, especially after the onset of the crisis. Thus, our results support the implementation of "flexible IT" by policymakers, as forex interventions under IT seem to be even more effective than those of non-IT countries in mitigating the exchange rate volatility. This outcome represents an additional argument in favor of IT, which have demonstrated to be sustainable during the crisis.

The paper is organized as follows. After the introduction, Section 2 briefly displays the empirical literature and Section 3 describes the data set, including our three main variables of interest, exchange rate volatility, forex interventions and a dummy variable that captures the fact of having an IT. Then, Section 4 presents the methodology that will be used to analyze the panel data set. In Section 5, we report the main empirical findings. Finally, Section 6 concludes the paper.

[5] The term "flexible", as defined in Svensson (2010), refers to IT central banks that look, not only for price stability, but also consider other variables, such as the output gap or the exchange rate.

2. Overview of the empirical literature

Previous empirical contributions on the analysis of the exchange rate volatility, IT adoption and forex interventions were mostly based on case studies for specific countries. For instance, Domaç and Mendoza (2004) analyze this link for two IT countries—namely, Mexico and Turkey—and conclude that negative forex interventions (foreign exchange sales) decreased their volatility, whereas Guimarães and Karacadag (2004), on the contrary, consider that these interventions had a limited effect on volatility.[6] For Brazil, Minella et al. (2003) highlight the importance of transparency of interventions to avoid a credibility deterioration of monetary policy as a result of misunderstandings about the policy objective. Geršl and Holub (2006) and Kamil (2008) analyze the role of forex interventions in two other IT countries—Czech Republic and Colombia, respectively–, and conclude that occasional interventions may be useful to stabilize the currency, although they are less effective when there is no consistency between monetary and exchange rate policy goals.

There are some empirical papers that separately analyze two of these three variables for a wide sample of EMEs. On the one hand, the literature on the effect of IT on the exchange rate volatility is not conclusive. Edwards (2007) studies if the exchange rate volatility is different in IT and non-IT countries and concludes that the volatility increases with IT as a result of their flexible exchange rate regime, but after controlling for this variable this link disappears. De Gregorio et al. (2005) find the same evidence for Chile. By contrast, Rose (2007) studies a panel data set for 45 emerging and developed countries and finds that, as a result of IT credibility gains, IT countries deliver the better outcomes in terms of exchange rate volatility, output growth and inflation than alternative regimes.

On the other hand, the empirical literature on the link between forex interventions and exchange rate volatility, without considering the role of IT, is not quite developed either. Most of these contributions fit GARCH models for specific countries (Domínguez, 1998; Edison et al., 2006 analyze developed countries). Finally, IMF (2007) studies five Asian managed-floating countries from 2000 to 2007 and finds limited evidence on interventions dampening the exchange rate volatility.

Our paper contributes to the previous literature in at least three directions. First, we analyze empirically the effect of forex interventions on the exchange rate volatility of IT and non-IT EMEs. To our knowledge, this is the first empirical application that combines the three variables for a panel of EMEs, and not for case studies on individual countries. Second, in our setting, interventions can be asymmetric, in the sense of allowing a different impact of positive and negative interventions (foreign exchange purchases or sales), which implies a novel contribution to this literature for panel data. Finally, we also analyze the period of the recent global crisis, which has not been much studied in this setting yet.

3. Data and explanatory variables

To test the implications in terms of exchange rate volatility of forex interventions in IT countries, we analyze a panel data set of 37 countries. We compare the group of 18 EMEs that have already adopted IT and a control group of 19 non-targeting countries, see Appendix A for the complete country list. In the control group we explicitly exclude those countries with a fixed exchange rate with the dollar or any other hard currency (like the euro) in the whole sample period, as their exchange rate volatility is zero.[7] We also omit fully dollarized countries as they relinquish any possibility of having an autonomous exchange rate policy.[8] Finally, for the sake of comparability of both groups and following Lin and Ye (2009), our control group consists of non-targeting EMEs that have a real GDP per capita and population at least as large as that of the poorest and smallest IT country, which guarantees their economic

[6] These two papers take into account asymmetric effects, that is, a different effect of positive or negative interventions on the exchange rate volatility.

[7] There are some relevant currencies, like the Chinese yuan, that are in our control group although China had a currency peg during most of the sample period. However, given its economic relevance and as its currency peg does not cover all the sample period, we include China in our sample.

[8] We use Carranza et al. (2009) to identify fully dollarized countries or with fixed exchange rates.

relevance. With these selection criteria our control group represents all emerging regions and covers a broad range of exchange rate regimes[9], namely, crawling pegs, crawling bands, other conventional fixed peg arrangements and managed-floating regimes with no pre-determined path for the exchange rate.[10]

Our sample runs from 1995:Q1 to 2010:Q1. The choice of the beginning of the sample period rested on avoiding the potential problems of extreme movements in the exchange rates of many EMEs until the mid-nineties, especially in Latin America, in a context of hyperinflation. We have also excluded some countries, such as Serbia, due to problems of data availability at the start of the sample period. If possible, we have obtained missing observations at the beginning or at the end of the sample with national sources, so that our panel is strongly balanced.

To measure the exchange rate volatility, $\sigma_{\mathrm{ER}t,}$ we calculate the quarterly standard deviation of daily returns. The percent return of the nominal exchange rate against the dollar for a country *i* follows this expression,

$$r_t = 100 \times (\Delta \log E_t), \quad (1)$$

where $\forall t = 1,\ldots,T$, E_t is the bilateral nominal exchange rate in t and Δ is the difference operator (a positive r_t implies a depreciation of the local currency against the dollar).[11] In the paper we use the nominal bilateral exchange rate against the dollar as it has advantages in terms of data availability and it is a rather intuitive choice as the dollar is used in most EMEs to borrow in Carranza et al. (2009).[12] In our setting, real exchange rates would have led to estimates of the exchange rate volatility very similar to those obtained using nominal exchange rates, as the price indexes needed to calculate r_t are only available at a monthly basis. Finally, our measure is less smooth than that proposed in Rose (2007), who uses the standard deviation over a four year window of monthly data.

To account for the fact of having an IT, we build a binary dummy variable for each EME, $\mathrm{IT}_{t,}$ that is one after formal IT adoption and zero otherwise (see Rose, 2007). To set this date, we follow IMF (2005) and Little and Romano (2009), see Table 1. Note that, as fixing the date of IT implementation is not straightforward, we consider that of the formal or explicit IT adoption for all countries, which may differ from the date of the IT announcement, when the IT could be combined with alternative objectives, such as the exchange rate or a money aggregate.

We approximate the forex interventions of a country with ΔRES, where RES is the ratio of foreign exchange reserves over GDP,[13] which hints at the pace of reserve accumulation or losses (a positive value indicates a net purchase of foreign currency). However, one weakness of ΔRES as proxy of forex interventions is that we cannot distinguish whether these reserve variations are linked to a real intervention in the exchange rate markets or to alternative reasons.[14]

In our analysis we are also interested in possible asymmetric effects of forex interventions. That is, we want to know if there is a different effect on the exchange rate volatility in the case of an accumulation or a loss of reserves (positive or negative forex interventions). For this analysis we use, for all

[9] According to the *de facto* classification of exchange rate regimes published by the IMF (see http://www.imf.org/external/np/mfd/er/2008/eng/0408.htm).

[10] In our control group it is worth highlighting the case of Singapore. In 1981 this economy adopted an intermediate exchange rate regime by targeting the Singapore dollar under a basket-band-crawl system. That is to say, Singapore follows a variant of the Taylor rule where the interest rate is replaced by the rate of currency appreciation (or depreciation). The reasoning for this policy framework is that in highly open and trade-dependent economies the exchange rate could be a more effective policy instrument to stabilize inflation than the short-term nominal interest rate. See Chow and McNelis (2010) for details.

[11] Following Harvey et al. (1994), we subtract the mean of $\Delta \log E_t$ to guarantee zero mean returns.

[12] Nominal effective exchange rates are available by JP Morgan only for a small number of EMEs. IFS data, available at a monthly frequency, which were used by Edwards (2007) and Rose (2007), also suffer from this limitation.

[13] To measure RES we tried to minimize the distortional effects of local currency depreciation on nominal GDP denominated in dollars. We have also tried to clean the effect of IMF disbursements and repayments on RES. Nevertheless, this process is not straightforward, so that we have just considered the two biggest repayments of our sample (Brazil, 2005:Q4, and Argentina, 2006:Q1).

[14] One alternative would be to estimate an unobservable threshold to disentangle those reserve variations that are truly linked to interventions (Kim and Sheen, 2002).

countries and periods, the interaction of ΔRES_{it} with a dummy variable, $D_{it,}$ that is 1 if the stock of reserves over GDP decreases and zero otherwise. That is, $\forall i = 1,\ldots,N$, and $\forall t = 1,\ldots,T$,

$$\begin{array}{ll} D_t = 1, & \textit{if } \Delta RES_t < 0 \\ D_t = 0, & \textit{otherwise}. \end{array} \quad (2)$$

Table 2 reports some summary statistics of $\sigma_{ER,}$ RES, the forex interventions as proxied by ΔRES, and the negative interventions, $D \times \Delta$RES, for IT and non-IT countries. We analyze the full sample and the period before and after the crisis. Regarding $\sigma_{ER,}$ the mean volatility is higher in IT countries, especially after the crisis, whereas non-IT countries exhibit a higher coefficient of variation than IT countries, which means that volatility jumps in these economies are more important. With respect to the stock of reserves, the mean RES in the pre-crisis period is similar in both types of countries, but after the crisis it is 0.29 in non-IT countries and 0.19 in IT countries. That is, once the more severe stage of the crisis is over, non-IT countries strongly accumulate reserves, whereas in IT countries this mean become rather stable. Regarding ΔRES, it is surprising that, on average, IT and not-IT countries implement a similar volume of forex interventions in the full sample, despite the requirements of a "strict IT". In the post-crisis period, IT countries have on average positive FX interventions, although IT countries did sell foreign reserves, violating the principles of "strict IT", as shown by the statistics for $D \times \Delta$RES.

Finally, for the robustness of our results, we also use five control variables (see Appendix B for more details). Specifically, we employ (1) the degree of trade openness, as higher openness increases the reaction to real exchange rate shocks (Cavoli, 2008); (2) current account (as percentage of GDP); (3) the natural logarithm of population, (4) the real GDP per capita and (5) one financial variable to measure global risk aversion, proxied by the implied volatility of the S&P index (VIX).[15] Table 3 shows the pairwise correlations of the five control variables and the main variables of our analysis.

4. Empirical model and econometric issues

4.1. The model

We fit nine panel data models that we denote as M1–M9, which are based on combinations between IT, RES, ΔRES and D. The estimation procedure is based on pooled OLS with time dummies. We fit the models for the full sample, and also for two subsamples: From 1995:Q1 to 2008:Q2, to characterize the period previous to the onset of the recent financial crisis, and from 2008:Q3 to 2010:Q1, to analyze its subsequent impact. Models M1–M3 are built out of this expression,

$$\sigma_{ERit} = \beta_0 + \beta_1 \sigma_{ERit-1} + \beta_2 IT_{it} + \beta_3 RES_{it} + \beta_4 RES_{it} \times IT_{it} + \sum_j \delta_j X_{jit} + \varepsilon_{it}, \quad (3)$$

where $\forall i = 1,\ldots,N$, and $\forall t = 1,\ldots,T$, the exchange rate volatility, σ_{ERit}, is a function of σ_{ERit-1}, which captures volatility persistence, IT_{it}, RES_{it}, the interaction between both variables and the set of five controls, $X_{it.}$

In models M4 and M5, we increase the number of drivers in (3) with $D_{it} \times RES_{it}$ and $IT_{it} \times D_{it} \times RES_{it}$, which will provide information about the possible different impact of reserve variations on the exchange rate volatility under an accumulation of reserves, where $D_{it} = 0$, or under a loss, where $D_{it} = 1$.

Finally, in models from M6 to M9 we include ΔRES_{it}, which approximates the pace of reserve accumulation or losses of country i. In particular, M6 follows this expression

$$\sigma_{ERit} = \beta_0 + \beta_1 \sigma_{ERit-1} + \beta_2 IT_{it} + \beta_3 \Delta RES_{it} + \sum_j \delta_j X_{jit} + \varepsilon_{it}, \quad (4)$$

[15] In previous versions we also considered other control variables, which we have omitted due to its lack of significance or multicollinearity problems. This is the case of the exchange rate regime as classified by Ilzetzki et al. (2008) given its severe multicollinearity problems with IT and the volatility of commodities prices (as measured by the CRB index).

Table 2
Summary statistics of σ_{ER}, RES, ΔRES and $D \times$ ΔRES for a sample of 37 countries (quarterly data, based on nominal exchange rates against the dollar). We date the beginning of the crisis in 2008:Q3.

		Mean		CV		Max		Min	
		IT	Non-IT	IT	Non-IT	IT	Non-IT	IT	Non-IT
σ_{ER}	Full sample	0.643	0.507	0.676	1.289	4.507	8.637	0.041	0.000
	Pre-crisis	0.565	0.501	0.561	1.331	2.818	8.637	0.041	0.000
	After crisis	0.971	0.575	0.676	0.861	4.507	4.251	0.141	0.000
RES	Full sample	0.167	0.186	0.444	0.984	0.505	1.026	0.036	0.006
	Pre-crisis	0.164	0.177	0.420	0.987	0.415	1.026	0.036	0.006
	After crisis	0.187	0.285	0.502	0.830	0.505	1.018	0.082	0.041
ΔRES	Full sample	0.002	0.002	7.311	6.916	0.086	0.080	−0.043	−0.101
	Pre-crisis	0.001	0.003	11.521	5.312	0.086	0.080	−0.043	−0.085
	After crisis	0.005	−0.003	3.550	−7.871	0.061	0.069	−0.028	−0.101
$D \times$ ΔRES	Full sample	−0.003	−0.004	−1.833	−2.162	0.000	0.000	−0.043	−0.101
	Pre-crisis	−0.003	−0.003	−1.848	−2.148	0.000	0.000	−0.043	−0.085
	After crisis	−0.004	−0.010	−1.743	−1.639	0.000	0.000	−0.028	−0.101

Summary statistics of the exchange rate volatility based on nominal exchange rates against the dollar (σ_{ER}), the stock of foreign reserves (RES); forex interventions (ΔRES) and negative forex interventions ($D \times$ ΔRES). CV: coefficient of variation (standard deviation/mean); Max: Maximum; Min: Minimum.

whereas in models from M7 to M9 we extend (4) by also regressing the interaction of ΔRES_{it} with IT_{it} and/or $D_{it.}$ Note that we omit RES_{it} in specifications from M6 to M9 for a clearer interpretation of the coefficients of ΔRES_{it}. The combination of these variables leads us to analyze if the effect of forex interventions in the exchange rate volatility in IT countries is different to that in non-IT countries. Moreover, we can also study if this effect is asymmetric, that is, if the impact of the purchases or sales of reserves on the volatility is different and to check whether there has been a punishment for these interventions under an IT regime in the form of higher exchange rate volatility than in non-IT countries.

Finally, we also estimate the panel model using a six-quarter rolling window. This time span has been chosen so as to coincide with the post-crisis sample size. This allows us to analyze the evolution of total effects of positive and negative interventions on IT and non-IT countries along the sample period. These time-varying coefficients let us know, for instance, if these links have changed during the last crisis.

4.2. Statistical inference

As mentioned, we distinguish between (i) countries with IT or not; and, (ii) countries that lose or accumulate reserves ($D = 1$ or $D = 0$, respectively). Their combination leads to four possible total effects of forex interventions on σ_{ER}, whose coefficients are useful for us to perform statistical inference (see Table 4). We calculate these four outcomes from the sum of the relevant coefficients in M9.

Table 3
Correlation matrix.

	σ_{ER}	IT	RES	ΔRES	$D \times$ ΔRES	Current account	Openness	Population	GDP per capita	VIX
σ_{ER}	1									
IT	0.10*	1								
RES	−0.14*	−0.05*	1							
ΔRES	0.00	−0.01	0.12*	1						
$D \times$ ΔRES	−0.05*	0.05*	−0.18*	0.74*	1					
Current account	−0.06*	−0.08*	0.65*	0.15*	−0.05*	1				
Openness	0.03	0.01	0.11*	−0.04	−0.02	−0.10*	1			
Population	−0.07*	0.08*	−0.14*	0.04	0.09*	0.12*	−0.20*	1		
GDP per capita	0.05*	0.36*	0.39*	−0.01	−0.10*	0.24*	0.16*	−0.38*	1	
VIX	0.25*	0.05*	0.02	−0.03	0.09*	−0.02	−0.02	0.01	0.05*	1

*Significant pairwise correlation at 5%.

Table 4
Coefficients of IT and non-IT countries under positive or negative interventions in M9.

	IT	Non-IT
Positive forex interventions ($D=0$)	ΔRES + ($D \times \Delta$RES)	ΔRES
Negative forex interventions ($D=1$)	ΔRES + (IT $\times$ ΔRES) + ($D \times \Delta$RES) + (IT $\times$ $D \times \Delta$RES)	ΔRES + (IT $\times$ ΔRES)

Statistical inference is useful to analyze more formally the significance of the effects of interventions on the exchange rate volatility depending on the IT adoption or on the intervention sign. To this end we propose two Wald-type tests. First, we analyze if the impact of negative interventions held on IT countries is different than that of non-IT countries. To confirm this hypothesis, as inferred from the coefficients in Table 4, we test this null,

$$H_0: \quad \beta_{IT\times\Delta RES} + \beta_{IT\times D\times\Delta RES} = 0, \tag{5}$$

where β_j denotes the coefficient of the explanatory variable j. If forex interventions performed by IT counties have a different effect on σ_{ER}, the null in (5) will be rejected. Second, we study if the effect of interventions in IT countries is significatively asymmetric, that is, whether negative interventions have a different effect on σ_{ER} than that of positive interventions or not, by testing this null hypothesis,

$$H_0: \quad \beta_{D\times\Delta RES} + \beta_{IT\times D\times\Delta RES} = 0. \tag{6}$$

If interventions are asymmetric, this null will be rejected. In Section 5 we interpret some of these statistics.

4.3. Econometric issues

As mentioned, our estimation procedure is based on pooled OLS with time dummies. This approach entails several problems. First, we cannot use country fixed effect dummies, as IT is time-invariant in certain subperiods, so that country fixed effects would translate to the intercept. However, the set of control variables allows us to control for the unobserved heterogeneity across countries.

Another difficulty of the analysis is the possibility of endogeneity biases as a result of reverse causality and omitted variables. Although the Generalized Method of Moments (GMM) estimator of Arellano and Bond (1991) is well-known to tackle endogeneity issues in a dynamic panel data framework, we must discard this procedure, as GMM is only consistent in short panels ($N \gg T$), but this is not our case ($T=61$ and $N=37$).

Reverse causality could be a concern when analyzing the link between our three main variables. For instance, with respect to the relationship between exchange rate volatility and forex interventions, one can interpret that these interventions help to manage market uncertainty but, on the other hand, it can be inferred that forex interventions might simply coincide with periods of higher uncertainty, which is precisely the reason to intervene. To further analyze this relation, we have also performed several Hausman-Wu tests (Hausman, 1983; Wu, 1973). According to these tests, we can consider ΔRES as exogenous to σ_{ER} in t, as all tests failed to reject the null of exogeneity, so that ΔRES would be independent of the errors in the models. These tests are available upon request.[16]

On the other hand, in the case of the exchange rate volatility and the IT adoption, their causality relation seems clearer. Edwards (2007) or Rose (2007) study the effect on the exchange rate volatility of following an IT. However, Gonçalves and Carvalho (2008) analyze the opposite causality relation and show that the volatility of the real exchange rate (as a proxy of adverse shocks) is not statistically

[16] As an additional robustness test of our pooled OLS estimates, we have also tried to address the possible reverse causality biases by also performing instrumental variables (IV) estimators using lagged forex interventions as instruments. We chose these lagged variables as instruments of ΔRES as they can be regarded as exogenous to the exchange rate volatility. However, the correlation between $\Delta \mathrm{RES}_t$ and $\Delta \mathrm{RES}_{t-h}$ is relatively low. This fact prevents identifying the effects of interventions in the IV estimates, where the effects of $\sigma_{\mathrm{ER}t-1}$ and IT dominate.

significant to explain the probability of IT adoption. Regarding possible omitted variable biases, the set of control variables helps to identify them.

5. Empirical results

5.1. The role of IT adoption and RES

Table 5 reports the estimates for models from M1 to M9 for the whole sample period (upper panel), as well as for the pre-crisis and post-crisis period (central panel and lower panel, respectively).

Table 5
OLS coefficient estimates from regressions of exchange rate volatility on IT dummy and foreign reserves.

	M1	M2	M3	M4	M5	M6	M7	M8	M9
Total sample									
$\sigma_{ER,\ t-1}$	0.53***	0.52***	0.51***	0.51***	0.51***	0.53***	0.53***	0.53***	0.53***
IT	0.07**	0.05	0.15**	0.15**	0.15**	0.07**	0.07**	0.07**	0.10***
RES		−0.45***	−0.40***	−0.39**	−0.39**				
IT × RES			−0.56**	−0.56**	−0.54**				
D × RES				−0.01	0.01				
IT × D × RES					−0.31*				
ΔRES						−0.57	−0.45	0.70	1.70
IT × ΔRES							−0.58		−3.32
D × ΔRES								−3.03	−4.85
IT × D × ΔRES									9.30**
N	2048	2039	2039	2039	2039	2036	2036	2036	2036
R^2	0.39	0.40	0.40	0.40	0.40	0.39	0.39	0.39	0.39
Pre-crisis									
$\sigma_{ER,\ t-1}$	0.52***	0.51***	0.51***	0.51***	0.51***	0.53***	0.53***	0.53***	0.52***
IT	0.06*	0.04	0.12*	0.12*	0.13*	0.06*	0.06*	0.07*	0.09**
RES		−0.48***	−0.44**	−0.44**	−0.44**				
IT × RES			−0.48*	−0.49*	−0.46*				
D × RES				0.01	0.02				
IT × D × RES					−0.35**				
ΔRES						−0.68	−0.82	1.11	1.61
IT × ΔRES							0.80		−1.96
D × ΔRES								−4.49	−6.05
IT × D × ΔRES									8.99**
N	1819	1810	1810	1810	1810	1807	1807	1807	1807
R^2	0.35	0.36	0.36	0.36	0.36	0.35	0.35	0.36	0.36
Post-crisis									
$\sigma_{ER,\ t-1}$	0.51***	0.51***	0.48***	0.48***	0.48***	0.51***	0.52***	0.52***	0.50***
IT	0.11	0.10	0.31**	0.32**	0.32**	0.13*	0.14*	0.12*	0.20**
RES		−0.15	−0.02	−0.05	−0.04				
IT × RES			−0.98**	−0.97**	−0.95*				
D × RES				0.08	0.10				
IT × D × RES					−0.28				
ΔRES						−1.53	−0.38	−2.50	2.19
IT × ΔRES							−3.49		−7.41*
D × ΔRES								1.95	−4.05
IT × D × ΔRES									15.82*
N	229	229	229	229	229	229	229	229	229
R^2	0.57	0.57	0.58	0.58	0.58	0.57	0.57	0.57	0.58

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; Pooled OLS estimations. Dependent variable: Exchange rate volatility proxied by the quarterly standard deviation of daily r_t (log difference of the bilateral nominal exchange rate against the dollar); IT: binary dummy, IT = 1 if countries have adopted IT; RES: Foreign reserves over GDP; D: binary dummy, $D = 1$ if $\Delta RES < 0$; Controls not reported but included: (1) Current account as percentage of GDP; (2) Trade openness; (3) Log of population; (4) GDP per capita; (5) VIX index; Intercept and time controls included but not reported; We date the beginning of the crisis in 2008:Q3.

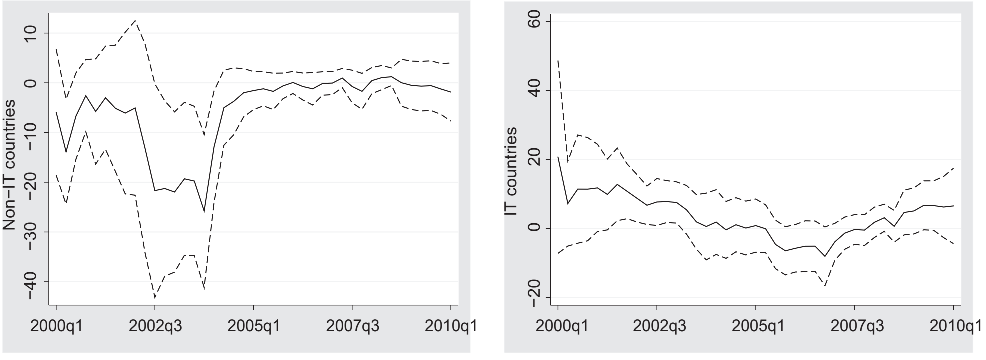

Fig. 1. Six-quarter rolling window estimates and confidence intervals at 95%. Total effect of negative forex interventions ($D = 1$) on the exchange rate volatility in non-IT (left), and IT countries (right).

Is IT associated with higher exchange rate volatility? As a first result, IT seems to be related to higher σ_{ER}, given the positive and significant coefficients of IT in Table 5. This link is robust across specifications and it is even higher and more significant after the crisis, when this relation exacerbated (as also reported in Table 2). This result is in line with De Gregorio et al. (2005) or Edwards (2007), and contrary to Rose (2007), who concludes that IT does not come at the expense of higher exchange rate volatility as a result of the credibility gains associated to this framework. This positive link could be mostly explained by its more flexible exchange rate regime. However, we explicitly exclude this control variable, the exchange rate regime, in the model as it is highly correlated with IT, which leads to serious multicollinearity problems.[17]

As shown in Table 5, RES and σ_{ER} are negatively related for the whole sample and the coefficients, around -0.4, are quite robust across specifications. It can be interpreted that higher stocks of reserves coincide with more stable exchange rates. The negative relation is even higher in IT countries, as shown by the estimates of IT × RES from M3 to M5. This might be a consequence of the higher flexibility of their exchange rates, which exacerbates the favorable effect of reserve accumulation on σ_{ER}. This negative association cannot be identified after the crisis in non-IT countries, as the estimates for IT countries—usually higher than in non-IT countries—dominate the relation between RES and σ_{ER}.

5.2. *The effect of forex interventions on the volatility*

As mentioned, we also distinguish periods of appreciatory pressures, in which the central bank buys reserves, from those of depreciatory pressures, in which the central bank sells reserves, with D as defined in (2). As shown by the estimates of IT × RES × D in M4 and M5 of Table 5, the negative link between RES and σ_{ER} seems to be different under appreciatory or depreciatory pressures for the whole sample and for the pre-crisis period in IT countries. That is, under depreciatory pressures, those IT countries with a higher buffer of foreign reserves have a lower exchange rate volatility. This is a result in favor of the role of foreign reserves as a buffer in times of crisis.

Models from M6 to M9 in Table 5 report the results that directly involve ΔRES. The analysis of the impact of forex interventions on the exchange rate volatility is particularly relevant given that, as already stated, EMEs intervene very frequently, even under IT, as a common way to stabilize the exchange rate. These are the three main results. First, forex interventions seem to lower the exchange rate volatility only in IT countries, whereas, surprisingly, in non-IT countries these interventions are not significant. This result is robust across subsamples. In fact, we clearly reject the null hypothesis in

[17] In previous versions, we have added as control variable the exchange rate regime as measured by the monthly coarse classification of Ilzetzki et al. (2008). This index labels countries from 1 to 6 in increasing order according to their degree of exchange rate flexibility. As expected, this control leads to non-significant IT coefficients and multicollinearity.

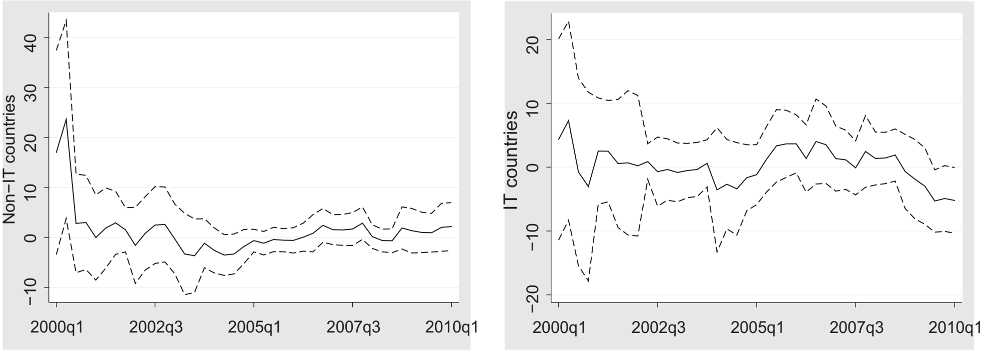

Fig. 2. Six-quarter rolling window estimates and confidence intervals at 95%. Total effect of positive forex interventions ($D = 0$) on the exchange rate volatility in non-IT (left), and IT countries (right).

(5), so that negative interventions in IT and non-IT countries have a different impact on the volatility.[18] One possible interpretation of this outcome is that it is a result of the credibility gains associated with IT.

Second, regarding the sign of interventions, the sales of reserves tend to be significant in IT countries in both subsamples (the estimates of $\text{IT} \times D \times \Delta\text{RES}$ are negative and significant).[19] After the crisis positive interventions are also significant. However, both effects are asymmetric in the sense that the impact of negative interventions is significatively different than that of positive interventions, as confirmed by the test of the null in (6).[20]

Finally, in IT countries, the total effect of lower reserves on the exchange rate volatility increases after the crisis, as shown by the sum of the coefficients $\Delta\text{RES} + (\text{IT} \times \Delta\text{RES}) + (D \times \Delta\text{RES}) + (\text{IT} \times D \times \Delta\text{RES})$ in both subsamples.

We complete this analysis with the study of the time-varying effect of negative and positive forex interventions on the exchange rate volatility in IT and non-IT countries. Figs. 1 and 2 represent the coefficients of the total effects of negative and positive interventions, respectively, obtained after fitting again the panel using a six-quarter rolling window. We also represent confidence intervals at 95%.[21] According to Fig. 1, in non-IT countries the effect of negative interventions is negative (that is, sales of foreign reserves are associated even with greater exchange rate volatility) or close to zero at the end of the sample. Meanwhile, since 2005 this link is increasingly positive in IT countries. Thus, Fig. 1 confirms previous results in the sense that negative interventions seem to be useful for IT counties to lower the exchange rate volatility, especially in the last part of the sample, whereas these interventions have a limited role in shaping the volatility in non-IT countries.

On the other hand, Fig. 2, that represents the coefficients of the rolling window estimates for IT and non-IT countries under positive interventions, illustrates that in non-IT countries this effect is around zero along the sample. Nevertheless, the total coefficient becomes negative in IT countries, especially since 2008. Again, these conclusions confirm our previous results.

All in all, our results support the role of forex interventions in IT countries, especially during crisis periods. Our outcomes also express some doubts about the effectiveness of the interventions performed by non-IT countries to reduce the exchange rate volatility. Finally, we do not identify any significant effect of interventions of IT countries in tranquil periods under appreciatory pressures.

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[18] The p-value associated with this joint Wald-type test for M9 is 0.008.

[19] Note that under a negative intervention $\text{IT} \times D \times \Delta\text{RES}$ is negative, so that a positive coefficient implies a negative effect on σ_{ER}.

[20] We reject the null hypothesis of symmetric effects on the exchange rate volatility of positive and negative interventions at 10%, and the p-value of the test for M9 is 0.081.

[21] We use the delta method to estimate the standard deviations of each sum of coefficients, which is needed to calculate the confidence intervals in Figs. 1 and 2.

5.3. Analysis by region

Finally, we also perform the same analysis by region, namely Latin America, Emerging Asia and Eastern Europe. Tables 6–8 report these estimates, respectively.

Regarding Latin America, the main result in Table 6 is that IT × ΔRES and IT × D × ΔRES are significant in the post-crisis period. That is, forex interventions carried out by IT countries during the crisis were associated with lower σ_{ER}, which is again a result favorable to the use of forex interventions during crisis times in IT countries. On the other hand, the positive link between IT and σ_{ER} is identified only in the post-crisis period. This could be a result of the extreme values of σ_{ER} in some non-IT and IT

Table 6
OLS coefficient estimates from regressions of exchange rate volatility on IT dummy and foreign reserves. Latin America.

	M1	M2	M3	M4	M5	M6	M7	M8	M9
Latin America: total sample									
$\sigma_{ER,\ t-1}$	0.50***	0.42***	0.42***	0.42***	0.42***	0.50***	0.50***	0.50***	0.49***
IT	0.03	0.11	0.04	0.04	0.04	0.02	0.02	0.03	0.08
RES		−2.40***	−2.60***	−2.59***	−2.63***				
IT × RES			0.56	0.57	0.69				
D × RES				−0.05	0.10				
IT × D × RES					−0.88				
ΔRES						−3.86	−4.94*	−1.64	−0.11
IT × ΔRES							4.45		−4.38
D × ΔRES								−4.97	−10.78
IT × D × ΔRES									22.96*
N	591	591	591	591	591	59	591	591	591
R^2	0.40	0.43	0.43	0.43	0.43	0.40	0.40	0.40	0.41
Latin America: Pre-crisis									
$\sigma_{ER,\ t-1}$	0.48***	0.41***	0.41***	0.41***	0.41***	0.48***	0.48***	0.48***	0.48***
IT	−0.01	0.07	−0.02	−0.02	−0.01	−0.01	−0.02	−0.01	0.02
RES		−2.42***	−2.66***	−2.66***	−2.69***				
IT × RES			0.71	0.72	0.75				
D × RES				−0.02	0.08				
IT × D × RES					−0.60				
ΔRES						−4.82*	−5.60*	−1.71	−1.07
IT × ΔRES							3.52		−1.99
D × ΔRES								−7.20	−10.32
IT × D × ΔRES									15.00
N	524	524	524	524	524	524	524	524	524
R^2	0.37	0.41	0.41	0.41	0.41	0.38	0.38	0.38	0.38
Latin America: Post-crisis									
$\sigma_{ER,\ t-1}$	0.44**	0.31*	0.24	0.20	0.21	0.43**	0.42**	0.43**	0.42**
IT	0.19	0.37**	0.91***	1.02***	0.95***	0.19	0.20	0.21	0.34*
RES		−2.64**	−0.46	−0.70	−0.83				
IT × RES			−3.60**	−4.04**	−3.28*				
D × RES				0.82	1.16				
IT × D × RES					−1.44				
ΔRES						3.21	1.34	−2.82	7.92
IT × ΔRES							4.20		−18.72*
D × ΔRES								9.95	−12.66
IT × D × ΔRES									45.73*
N	67	67	67	67	67	67	67	67	67
R^2	0.61	0.66	0.68	0.69	0.70	0.61	0.62	0.62	0.67

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; Pooled OLS estimations. Dependent variable: Exchange rate volatility proxied by the quarterly standard deviation of daily r_t (log difference of the bilateral nominal exchange rate against the dollar); IT: binary dummy, IT = 1 if countries have adopted IT; RES: Foreign reserves over GDP; D: binary dummy, $D = 1$ if ΔRES < 0; Controls not reported but included: (1) Current account as percentage of GDP; (2) Trade openness; (3) Log of population; (4) GDP per capita; (5) VIX index; Intercept and time controls included but not reported; We date the beginning of the crisis in 2008:Q3.

Table 7
OLS coefficient estimates from regressions of exchange rate volatility on IT dummy and foreign reserves. Emerging Asia.

	M1	M2	M3	M4	M5	M6	M7	M8	M9
Asia: total sample									
$\sigma_{ER,\ t-1}$	0.65***	0.62***	0.62***	0.62***	0.62***	0.66***	0.66***	0.66***	0.66***
IT	−0.17*	−0.24*	−0.36*	−0.36*	−0.36*	−0.16*	−0.14	−0.16*	−0.14
RES		−1.12*	−1.18*	−1.18*	−1.18*				
IT × RES			0.50	0.49	0.49				
D × RES				−0.01	−0.01				
IT × D × RES					0.21				
ΔRES						−2.38	−1.66	−2.96	−1.64
IT × ΔRES							−3.91		−4.25
D × ΔRES								1.44	−0.05
IT × D × ΔRES									2.15
N	415	415	415	415	415	415	415	415	415
R^2	0.64	0.65	0.65	0.65	0.65	0.64	0.65	0.64	0.65
Asia: Pre-crisis									
$\sigma_{ER,\ t-1}$	0.65***	0.63***	0.63***	0.63***	0.63***	0.65***	0.65***	0.66***	0.66***
IT	−0.18*	−0.24*	−0.45*	−0.45*	−0.45*	−0.18*	−0.17*	−0.18*	−0.18*
RES		−1.00	−1.01	−1.02	−1.02				
IT × RES			0.95	0.94	0.94				
D × RES				−0.03	−0.04				
IT × D × RES					0.21				
ΔRES						−1.71	−1.58	−2.37	−2.47
IT × ΔRES							−0.87		0.09
D × ΔRES								1.61	2.11
IT × D × ΔRES									−3.45
N	367	367	367	367	367	367	367	367	367
R^2	0.64	0.65	0.65	0.65	0.65	0.64	0.64	0.64	0.64
Asia: Post-crisis									
$\sigma_{ER,\ t-1}$	0.50**	0.22*	0.22*	0.22	0.21	0.47***	0.55**	0.47**	0.52**
IT	−0.19	−0.34	−0.40	−0.39	−0.36	−0.17	0.01	−0.17	0.11
RES		−2.46*	−2.55*	−2.54*	−2.49				
IT × RES			0.12	0.11	0.06				
D × RES				0.02	0.02				
IT × D × RES					−0.38				
ΔRES						−6.37	−3.72	−6.78	−2.34
IT × ΔRES							−8.71		−11.45
D × ΔRES								1.03	−1.13
IT × D × ΔRES									26.23
N	48	48	48	48	48	48	48	48	48
R^2	0.66	0.73	0.73	0.73	0.73	0.70	0.73	0.70	0.75

$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$; Pooled OLS estimations. Dependent variable: Exchange rate volatility proxied by the quarterly standard deviation of daily r_t (log difference of the bilateral nominal exchange rate against the dollar); IT: binary dummy, IT = 1 if countries have adopted IT; RES: Foreign reserves over GDP; D: binary dummy, $D = 1$ if ΔRES < 0; Controls not reported but included: (1) Current account as percentage of GDP; (2) Trade openness; (3) Log of population; (4) GDP per capita; (5) VIX index; Intercept and time controls included but not reported; We date the beginning of the crisis in 2008:Q3.

countries before IT adoption corresponding to different domestic crisis episodes (for instance, Argentine, Mexico or Brazil) before the crisis. Finally, in Latin America the negative relation between RES and σ_{ER} is stronger in IT countries, but only in the pre-crisis period, when a considerable amount of reserves was accumulated.

According to the estimates for Emerging Asia in Table 7, IT loses its significance in the post-crisis period. Besides, RES is only significant in the post-crisis period and its coefficient is higher than for the whole country sample and ΔRES plays no role either for IT or for non-IT countries. Finally, regarding Eastern Europe, the positive link between IT and σ_{ER} is only identified in the pre-crisis period, as reported in Table 8. However, we do not find any significant relation between RES and the exchange rate

Table 8
OLS coefficient estimates from regressions of exchange rate volatility on IT dummy and foreign reserves. Eastern Europe.

	M1	M2	M3	M4	M5	M6	M7	M8	M9
Eastern Europe: Total sample									
$\sigma_{ER,t-1}$	0.36***	0.36***	0.36***	0.36***	0.36***	0.37***	0.37***	0.37***	0.37***
IT	0.13**	0.11*	0.10	0.11	0.12	0.12**	0.12**	0.13**	0.12**
RES		−0.64	−0.65	−0.70	−0.70				
IT × RES			0.04	−0.04	−0.06				
D × RES				0.23	0.27				
IT × *D* × RES					−0.24				
ΔRES						−1.46	−2.04	−1.11	−2.04
IT × ΔRES							1.73		2.00
D × ΔRES								−0.87	−0.01
IT × *D* × ΔRES									−1.41
N	604	604	604	604	604	604	604	604	604
R^2	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
Eastern Europe: Pre-crisis									
$\sigma_{ER,t-1}$	0.36***	0.35***	0.35***	0.35***	0.35***	0.36***	0.36***	0.36***	0.36***
IT	0.12**	0.09	0.09	0.11	0.13	0.11*	0.11*	0.11**	0.11*
RES		−0.82	−0.82	−0.87	−0.88				
IT × RES			0.04	−0.11	−0.16				
D × RES				0.27	0.32				
IT × *D* × RES					−0.33				
ΔRES						−1.92	−2.91	−1.17	−2.03
IT × ΔRES							3.45		2.92
D × ΔRES								−2.01	−2.31
IT × *D* × ΔRES									1.90
N	532	532	532	532	532	532	532	532	532
R^2	0.26	0.26	0.26	0.27	0.27	0.26	0.26	0.26	0.26
Eastern Europe: Post-crisis									
$\sigma_{ER,t-1}$	0.35***	0.34***	0.31*	0.31*	0.31*	0.35***	0.36***	0.35**	0.35**
IT	0.19	0.16	−0.80	−0.91	−0.94	0.19	0.19	0.17	0.14
RES		−0.58	−4.04	−4.30	−4.31				
IT × RES			4.23	4.66	4.66				
D × RES				−0.32	−0.45				
IT × *D* × RES					0.66				
ΔRES						0.11	1.68	−1.36	−0.71
IT × ΔRES							−3.30		−0.59
D × ΔRES								3.31	3.89
IT × *D* × ΔRES									−9.31
N	72	72	72	72	72	72	72	72	72
R^2	0.53	0.53	0.54	0.54	0.54	0.53	0.53	0.53	0.53

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; Pooled OLS estimations. Dependent variable: Exchange rate volatility proxied by the quarterly standard deviation of daily rt (log difference of the bilateral nominal exchange rate against the dollar); IT: binary dummy, IT = 1 if countries have adopted IT; RES: Foreign reserves over GDP; D: binary dummy, $D = 1$ if $\Delta RES < 0$; Controls not reported but included: (1) Current account as percentage of GDP; (2) Trade openness; (3) Log of population; (4) GDP per capita; (5) VIX index; Intercept and time controls included but not reported; We date the beginning of the crisis in 2008:Q3.

volatility and, as in Emerging Asia, ΔRES is not significant in any specification, as far as these estimates seem to be led by the dynamics of σ_{ERt-1}. All in all, the full sample results for the post-crisis period regarding ΔRES reported in Table 5 seem to be driven by certain counties from our Latin American sample.

6. Conclusions

In this paper we have analyzed empirically the link between exchange rate volatility, IT and forex interventions. In practice most central banks with IT implement their monetary policy with some form of price stabilization objective, while managing their currency movements (“flexible IT”), so that these forex interventions might have implications for monetary policy and the use of policy rules. In this sense, "flexible IT" imply a departure from the corner solutions derived from the "impossibility Holy Trinity" of fixed exchange rates, independent monetary policy and perfect capital mobility and have several broad implications for the role of exchange rates in IT countries.

To analyze this question we estimate a panel data model for 37 IT and non-IT EMEs. We study the impact of IT adoption and foreign reserve movements—that we interpret as forex interventions—on the exchange rate volatility. We also perform this analysis for the period previous to the onset of the financial crisis and the subsequent subsample. This exercise is useful to disentangle if IT does make a difference in terms of the impact of forex interventions on the exchange rate volatility.

We confirm that exchange rates are more volatile under IT than under other regimes, in line with De Gregorio et al. (2005) and Edwards (2007), which is rather sensible given that, in principle, their exchange rate regime is more flexible. However, we also show that forex interventions in IT countries do play a useful role in containing the exchange rate volatility, especially negative interventions (sales of foreign reserves). This outcome is particularly significant after the onset of the recent financial crisis in Latin America. Surprisingly, this role of negative forex interventions in the moderation of the exchange rate volatility is not identified in non-IT countries.

All in all, we support the view that there is some scope for EMEs that have adopted IT to interpret the implementation of their IT mechanisms with certain degree of flexibility. Thus, "flexible IT" regimes are not only sustainable, but also forex interventions performed under this scheme are even more effective than those of non-IT countries in mitigating extreme volatility periods. However, there is still some room for future research to analyze if these episodes of heavy forex interventions have not undermined the credibility of these central banks.

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Appendix A. Country list

Inflation targeters		Non-inflation targeters	
Brazil	Peru	Albania	Guatemala
Colombia	Philippines	Algeria	India
Czech Republic	Poland	Argentina	Jamaica
Chile	Romania	Cambodia	Malaysia
Ghana	Slovak Republic	China	Morocco
Hungary	South Africa	Costa Rica	Russia
Indonesia	South Korea	Croatia	Singapore
Israel	Thailand	Dominican Republic	Ukraine
Mexico	Turkey	Egypt	Uruguay
			Vietnam

Appendix B. Definition of variables and data sources

- IT: Dummy variable that is one once the country adopts a formal IT in that quarter. Source: IMF (2005) and Little and Romano (2009).

- Reserves, RES_{it}: Foreign exchange reserves over nominal GDP in US dollars. Source: International Financial Statistics (IMF).
- Openness: Exports plus imports as a percentage of GDP. Source: International Financial Statistics (IMF), Datastream and national sources.
- Current account: Current account as a percentage of GDP. Source: International Financial Statistics (IMF), Datastream and national sources.
- Population: Logarithm of population (thousand persons). Source: World Economic Outlook (IMF).
- GDP per capita: Gross domestic product based on purchasing-power-parity (PPP) per capita. Source: World Economic Outlook (IMF).
- VIX: Implicit volatility of the S&P 500 index. Source: Datastream.

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