FOREIGN EXCHANGE INTERVENTION EFFECTIVENESS IN GUATEMALA UNDER INFLATION TARGETING

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Abstract

This study analyses the effectiveness of the foreign exchange interventions conducted by Bank of Guatemala to moderate domestic currency (quetzal to U.S. Dollar) volatility since the implementation of Inflation Targeting. The empirical analysis is based on an ACT-GARCH model and daily data for the 2005-2017 period. Results obtained allow us to conclude that foreign exchange interventions have been successful in moderating the exchange rate volatility, since the intervention amounts are relatively significant with respect to the amount of daily transactions carried out at the domestic foreign exchange market. We argue that such an exchange rate policy has contributed to achieve price stability in Guatemala.

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Keywords: buying foreign exchange intervention, selling foreign exchange intervention, effective intervention, exchange rate, and exchange rate volatility.

\textsuperscript{1} The opinions given in this document represent the authors’ own views and do not necessarily represent those from Bank of Guatemala’s authorities and fellow staff.

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I. INTRODUCTION

The global financial crisis of 2008-2009 gave rise to a worldwide tendency change to nominal exchange rate flexibility that was increasingly given by central banks to their domestic currencies in the previous decades. Since 2010, a greater amount of intervention from governments and central banks has been noticed in the foreign exchange markets, particularly those of emerging and developing economies (IMF, 2017). The most important justifications for such interventions are the following: i) to modify the exchange rate level; ii) to increase the level of international monetary reserves for caution-related reasons; iii) to moderate exchange rate volatility; iv) to reduce a currency’s appreciation (depreciation) pace; or vi) to amend misalignments concerning their long-term level (Domanski et.al., 2016).

In the Guatemalan environment, the involvement of the Central Bank in the exchange market has mainly pursued to moderate the exchange rate volatility and to accumulate international reserves. As a matter of fact, since the implementation of a flexible foreign exchange system in 1989, the monetary authorities have intervened regularly to moderate the volatility of the nominal exchange rate, which complementarily to the Inflation Targeting (IT) scheme, implemented in 2005, has generated steadiness to the nominal exchange rate, and also to the domestic pricing level, and has allowed to strengthen the country’s position overseas.

In this regard, this study is intended to carry out an analysis about the effectiveness of the foreign exchange interventions conducted by Banco de Guatemala on the volatility of the domestic currency (Quetzal) vis-à-vis the U.S. Dollar. The empirical analysis is conducted using an ACT-GARCH model similar to that used in the standard literature on this topic. Due to the lack of statistics on future-oriented foreign exchange contracts, a series of prospective indicators was developed; those indicators, $s_t$, measure the daily percent variation of the nominal exchange rate as a result of the immediate and lagged effects of the Central Bank’s interventions. Such indicators represent a measure of volatility and are constructed based on daily information about the exchange rate and the US dollar purchase/sale interventions performed by Bank of Guatemala since the IT implementation. The evidence obtained through the econometric analysis states that both types of foreign exchange interventions have significatively moderated the exchange rate fluctuations throughout the analyzed period, with this effect being greater prior to the international financial crisis of 2008-2009. This outcome is considered to be the result of the huge amounts of operations made by the Central Bank in the foreign exchange market, with respect to the average imbalance between the daily U.S. dollar supply and demand in the Guatemalan market. At the beginning, it was considered that the lack of a sterilization policy for the foreign exchange interventions in the monetary market, and the fact that the interventions were due to a foreign exchange rule independent from the position of the Central Bank’s monetary policy, could jeopardize the achievement of the inflation goal. However, the empirical evidence states that this has not been the case, since the Central Bank has managed well to maintain inflation around its predetermined target.

The discussion about the effectiveness of the foreign exchange interventions performed by Bank of Guatemala is arranged this way: a summary of the results obtained in previous studies on the topic is presented in Section II; in Section III, a brief description of how the foreign exchange policy has evolved in Guatemala is provided; the empirical evidence about the effects of the foreign exchange intervention in Guatemala since the implementation of the IT is discussed in Section IV; and the corresponding conclusions are presented in Section V.

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4 The lagging of the exchange rate intervention effects is up to one month.
II. FOREIGN EXCHANGE INTERVENTIONS: REVIEWING SOME LITERATURE

Literature related to interventions on the exchange market is usually broken down into two large topics: transmission mechanisms of the foreign exchange intervention and the monetary authority’s justifications to perform an intervention. Some relevant results concerning both subjects are presented in the following sections.

A. TRANSMISSION MECHANISMS OF FOREIGN EXCHANGE INTERVENTION

Based on the relevant literature on economy, the two main transmission mechanisms of foreign exchange intervention towards the exchange rate level are the portfolio balance channel and the signaling channel (Adler and Tovar, 2011; Sarno and Taylor, 2001; and Canales-Kriljenko, 2003). The portfolio balance channel states that the exchange rate is determined by the interaction between supply and demand of financial assets issued in domestic and foreign currency. It is assumed that the financial assets issued in different currencies are not perfect substitutes (which allows investors to discriminate between their risks and their returns) and that investors are opposed to risk (they prefer to maintain a diversified portfolio of assets issued in diverse currencies). Therefore, the (sterilized) interventions of a central bank have no impact on the monetary base or on the interest rates, but they do affect the composition of the portfolio of the economic agents. Evans and Lyons (2002 and 2005), Chutasripanich and Yetman (2015), Abbuy (2018) have found significant evidence about the effect of the foreign exchange interventions according to this channel.

The second channel through which the exchange rate intervention impacts on the exchange rate is the signaling channel or channel of exchange expectations. Based on this mechanism, the (sterilized) intervention impacts on the performance of the nominal exchange rate, since it provides privileged information to the markets about the Central Bank’s position towards the monetary policy. Therefore, the mere action of intervening modifies the exchange expectations and influences the current economic decisions of the economic agents (that means, consumption, investment, or portfolio composition), which in turn impact the foundations of the exchange rate and, therefore, cause changes on its current value. Bonser-Neal, Roley, and Sellon (1998), and Guimarães and Karacadag (2006) present some empirical evidence about this transmission channel. Based on these studies, the central bank’s intervention in the exchange market significantly impacts the exchange rate level and the effect is statistically more relevant when the exchange rate intervention is coordinated, due to the credibility generated in the markets by those interventions. However, other studies like Canales and Kriljenko (2003) have an opposite view about the weakness of this channel in developing economies, since the central banks in those economies are poorly responsible for the macroeconomic management, which generates a low level of institutional and political credibility. Therefore, investors find it difficult to establish a stable, foreseeable link between the current and the future interventions in the exchange market.

B. REASONS FOR INTERVENING THE EXCHANGE MARKET

When analyzing the determining factors that compel the central banks to intervene the exchange market, Adler and Tovar (2011), Basu and Varoudakis (2013), and Chutasripanich and Yetman (2015) agree upon that the two main reasons for the central banks to intervene the exchange market is to prevent a significant misalignment of the exchange rate concerning its long-term level, and to moderate eventual episodes of exchange rate volatility.\(^5\) Additionally, though

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\(^5\) Tsen (2014) points out that the exchange rate volatility may decrease the direct foreign investment flows, as well as the international trading amounts due to the uncertainty caused around the Return on Investment rate and in connection with the profitability of transactions. In this regard, Lim and Sek (2014), and Adjasi (2008), find evidence of a negative relation between the exchange rate volatility and
to a lesser extent, the central banks also intervene the exchange market to gather international monetary reserves and to provide the domestic market with foreign currency. Daude and Yeyati (2014) find some evidence for 18 emerging economies about the effectiveness of interventions in the exchange market for the 2003-2011 period, mainly when there are large deviations of the exchange rate concerning its balance value. On the other hand, Broto (2012) concludes that, for a group of Latin American countries, the central banks’ interventions reduce the volatility of the exchange rate when a participation rule is first implemented, but thereafter such measure loses effectiveness due to a signaling effect of the interventions.

It is worth mentioning that the reasons that give rise to foreign exchange interventions are independent from the position of economy in the economic cycle. According to Reinhart (2000), a country, under favorable conditions, can experience inflows of external capitals that would increase the supply of foreign currency and lead to the appreciation of the exchange rate. In these cases, a central bank could intervene to prevent a decrease in exports or to prevent a country’s loss of external competitiveness. On the other hand, and under adverse economic conditions that could be noticed by massive capital outflows, a central bank could intervene to avoid the unfavorable effects of an exchange rate depreciation in terms of inflation, service of the external debt, and institutional credibility.

Moreover, a relevant aspect of the effectiveness of foreign exchange interventions, regardless of the central bank’s reasons to conduct it, is its transparency degree. A transparent intervention in the exchange market exists when a central bank announces the intended effects of its actions to the participants in the market and accounts for its measures to them. Chui (2003) states that a transparent exchange rate intervention contributes to steer the agents’ expectations towards the direction foreseen by the monetary authority, and to minimize the number of speculative transactions of the markets that could be developed by the intervention, which leads to a greater effectiveness of the central bank as to its participation in the exchange market. On the other hand, Sarno and Taylor (2001) state that the signaling market is more effective when the exchange rate intervention is announced to the markets and accounted for to their participants. In this regard, Kenen (1988) states that a transparent foreign exchange intervention is more effective, which in turn contributes to strengthening the credibility of a central bank.

III. FOREIGN EXCHANGE POLICY IN GUATEMALA (2005-2017)

In 2005, Guatemala established an Inflation Targeting (IT) scheme as a framework for the monetary policy, and thus became the 6th Latin American country in implementing this type of scheme. Jointly with the implementation of the IT, the central bank (Bank of Guatemala) established a rule to intervene the exchange market; it was intended to moderate the volatility of the nominal exchange rate. This rule is still in operation, although it has experienced some amendments throughout the 2005-2017 period. The foreign exchange interventions carried out by Bank of Guatemala during this period have been characterized by the following: i) They are implemented in U.S. Dollars through an auction mechanism in the National Electronic Foreign Currency System (Sistema Nacional Electrónico de Divisas, SINEDI); ii) They are based on a predetermined, public intervention rule intended to moderate the exchange rate volatility; and iii) They have not been totally sterilized in the monetary market.

the return on investment rate in the stock markets. Therefore, a high exchange rate volatility could cause a price increase of financial assets and imported goods, as well as a higher inflation rate.

6 For an overview of the foreign exchange policy prior to that date, see Castillo (2010).

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Concerning the first aspect, interventions have been performed in U.S. Dollars, since most of the international transactions in the country are carried out using this currency, which in turns is due to the fact that the American economy is the main commercial partner of Guatemala and of the remaining economies in the region. Additionally and for the explicit purposes of the intervention, an electronic system was developed and is managed jointly by Bank of Guatemala and the National Stock Exchange (Bolsa de Valores Nacional); this system is called SINDI, and can be accessed by any financial institution legally established in the country; through this system, such institutions can place offers both to buy and to sell foreign currencies. Bank of Guatemala intervenes in the exchange market by means of a U.S. Dollar auction system, in which the central bank determines the closing price of the negotiation, the amount to be placed in the auction, and a maximum number of daily auctions. These factors are announced at the beginning of each calendar year; therefore, all the agents participating in the exchange market are aware of them. In this regard, the second aspect typical to the interventions performed by Bank of Guatemala in the exchange market is that such interventions are carried out upon the activation of a rule established to allow for some degree of exchange flexibility, but at the same time to moderate the fluctuations of the exchange rate. The establishment of such a rule could seem to contravene the recommendations made by the academia as a pre-requisite for the implementation of an IT. However (as discussed below), the foreign exchange steadiness noticed through the implementation of such a rule has contributed to the stability of prices. Regarding the third aspect, even though the central bank daily takes over the excess of liquid funds existing in the financial market by means of open market operations, such operations do not match the amounts, in Quetzals, that correspond to the foreign exchange intervention performed. This means that a portion of the resources in the possession of the financial institutions (as a result of buying/selling foreign currency generated by the central bank’s intervention) could be transferred to other activities, such as financial brokerage operations, which have effects on the real economy sector, and therefore (although not necessarily), on the level of prices.

The intervention rule has experienced changes since it was conceived in 2005, in order to accommodate the foreign exchange management to both the internal and external macroeconomic conditions. Particularly, the amendments made to the foreign exchange rule prior to the international financial crisis of 2008-2009 were carried out to favor a greater symmetry (intervening both the buying and the selling of U.S. Dollars) and to grant the nominal exchange rate of the Quetzal a greater degree of flexibility. On the other hand, those changes made after the crisis (particularly the change made in 2011) extended the coverage of the exchange rule to inter-day operations and continued favoring the moderation of the exchange rate volatility, while gradually encouraged a greater degree of flexibility to the nominal exchange rate.
Table 1 summarizes the changes made to the Bank of Guatemala’s foreign exchange intervention rule during the period being analyzed. The original rule established that the central bank would intervene the exchange market to moderate the exchange rate volatility; however, the secondary objective was moderating the appreciation of the Quetzal which was occurring since 2004, and which could adversely affect exports (which were already experiencing a low growth since 2003) and also affect the economic activity at large. Such rule established three intervention areas called thresholds (1st threshold, 2nd threshold, and 3rd threshold), which were demarcated by predetermined exchange rates. The intervention criterion varied in each threshold, so that the
interventions were more frequent as the exchange rate continued its appreciation (as it moved from the 1\textsuperscript{st} to the 3\textsuperscript{rd} threshold).\textsuperscript{7} Additionally, the monetary authority maintained permanent positions on the buying of U.S. Dollars, even though the exchange rate behavior during short periods of time would be oriented to depreciation.

In January 2007, Bank of Guatemala amended the rule to participate in the exchange market in order to provide a more flexible exchange rate. In this 2nd intervention rule (see Table 1), the explicit goal of the central bank was to moderate the exchange rate volatility without impacting its tendency. For such a purpose, a kind of exchange rate fluctuation range was established for those values included between Q/$7.60 and Q/$8.05; this range was in turn broken down into two areas, which were demarcated by a central value (Q/$7.815). The degree of allowed exchange rate fluctuation was lower in the bottom of the range, as the Quetzal experienced a greater appreciation concerning the U.S. Dollar.\textsuperscript{8} Additionally, Bank of Guatemala set forth participation criteria concerning the sale of U.S. Dollars and removed the permanent intervening positions in the SINEDI. In spite of the amendments performed, the rule restricted the Quetzal fluctuation to a very narrow value range, which caused that the intervention mechanism would be activated on a frequent basis each time the exchange rate experienced values beyond the fluctuation range. Moreover, just like using the previous rule, Bank of Guatemala’s way of acting was independent from the monetary policy position; particularly, the narrow margin of allowable fluctuation jointly with the asymmetric design of the rule, which suggested a greater intervention from the monetary authority when the exchange rate would experience an appreciation-oriented behavior, compromised the achievement of the central bank’s inflation goal.

Again, in June 2008, Bank of Guatemala amended the rule to participate in the exchange market, but kept the goal pursued by such rule unchanged. The third exchange rate intervention rule eliminated the values that delimited the exchange rate fluctuation range and amended the design asymmetry of the previous rule (see Table 1). In this regard, the amendments performed favored a greater flexibilization of the exchange rate for the Quetzal \textit{vis-à-vis} the U.S. Dollar. The fourth intervention rule in the exchange market, which was created after the international financial crisis, intended to provide a greater exchange rate flexibility, this with purpose of acting as a buffer for the crisis effects. Such rule was in effect up to late 2010, and it allowed to extend the exchange rate fluctuation margin by 0.75%, both for buying and for selling. For the next 2 years, the rule to participate in the exchange market included a section of discretionary participation for unusual exchange rate volatility, this with the purpose of being able to have some broadness to handle the foreign exchange policy upon an eventual huge shock. Additionally, the number of daily auctions was increased from 3 to 4; therefore, the maximum participation amount increased to USD32 million. The exchange rate fluctuation margin in this participation rule was located at 0.60% symmetrically. It is important to point out that since 2011, the participation criterion in the exchange market was based on the inter-day exchange rate fluctuations. By 2013, the participation rule in the exchange market included an extension of the fluctuation margin from 0.60% to 0.65%; such change was mostly based on the guiding principle of providing greater flexibility to the exchange rate, thus reducing the central bank’s participation in the foreign exchange market. In 2014 and 2015, the current participation rule was amended, thus extending the variation margins for the exchange rate (0.70%), in pursuit of greater flexibility to it; additionally, the policy for accumulation of International Monetary Reserves was officially implemented in 2015. By 2016, the limits of participation in the exchange market were extended

\textsuperscript{7} An intervention criterion based on the exchange rate volatility also existed, but it was never implemented.

\textsuperscript{8} The allowable fluctuation degree was also reduced, but to a lesser extent, as the exchange rate was above the upper limit of the range.
to 0.75%, both for buying and for selling, and additional to it, the number of daily auctions was increased from 4 to 5 for the next year; therefore, the daily maximum amount of participation increased to USD40 million. It is important to point out that the exchange rate experienced a noticeable appreciation that year, as a result of a deceleration of the fuel prices, which decreased the demand for foreign exchange, and also due to an increase of the revenue inflows from family remittances. During that period of time, the exchange rate experienced its lowest historical value since 2001, being at Q/$7.27 in August 2017.

To sum up, one can notice that, from the implementation of the IT up to this date, the foreign exchange policy has been intended to provide greater flexibility to the exchange rate; in this regard, the allowable fluctuation margin for the currency, prior to the implementation of the foreign exchange intervention rule, did increase during the study period, from 0.50% up to 0.75%, reducing the central bank’s participation in the exchange market, and thus pursuing that the exchange rate would be able to buffer the shocks coming from the external sector and to contribute to the fulfillment of the inflation-related goal, within the IT framework.

IV. EMPIRICAL ANALYSIS

This section introduces the results of an empirical analysis of the effects of Bank of Guatemala’s interventions on the level and volatility of the exchange rate. The econometric analysis is derived from the methodology used by Guimarães and Karacadag (2006) to determine the effect that foreign exchange interventions conducted by the central banks in Mexico and Turkey have on the level and volatility of their respective local currencies relating to the U.S. Dollar.

A. DATA

This study intends to determine the behavior of the Quetzal – US dollar nominal exchange rate based on the implementation of IT. Accordingly, in order to analyze the effect of the foreign exchange interventions over the nominal exchange rate, the empirical analysis of this job is based on the daily information about the reference exchange rate from the first business day of 2005 to the last business day of 2017. It is worth mentioning that such period is subdivided in two parts, where the demarcated date, December 2008, separates the behavior of the exchange rate and the foreign exchange interventions before and after the international financial crisis of 2008-2009.

Figure 1 illustrates the behavior of the Quetzal nominal exchange rate vis-à-vis United States Dollar since the implementation of IT, as well as the daily amounts of foreign exchange interventions by the central bank in millions of dollars. During the first part of the sample, which comprises from January 4th, 2005 to December 31, 2008, it can be observed a relative exchange rate stability; subsequently, since the international financial crisis of 2008, the main objective of the interventions by the central bank was to moderate the exchange rate volatility that was being produced as a consequence of this; the exchange rate experienced a moderate trend toward appreciation at the beginning of 2008, and then it was depreciated since September 2008 until January 2010, period in which the exchange rate was depreciated in 12.9%, going from Q/$7.43 to Q/$8.39. At this stage, there is a volume of participations by Bank of Guatemala in the

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9 The international financial crisis, called The Great Recession, occurred during the period between August 2007 and March 2009.

10 This behavior is explained partly because of the outflows of capital to pay the external debt denominated in dollars due to the reduction of the interest rates, as a result of the international financial crisis originated in the United States of America (USA). In addition, there was a drop in the exports value of the domestic economy which reduced the inflow of foreign currency by way of exports.
exchange market that were mainly oriented to dollar selling. In fact, approximately one third of the total amount of dollar selling-oriented interventions during the period of study occurred between September 2008 and January 2010.

Figure 1. Foreign exchange interventions by Bank of Guatemala, Jan 05 – Dec 17

Subsequently, during the remainder of the analyzed period, the exchange rate showed a slight trend toward appreciation, which was intensified since 2015. The exchange rate achieved the lowest value observed since July 2008 (Q/$7.38), positioning in Q/$7.27 in August 2017. In that sense, Bank of Guatemala continued with intervention in order to limit Quetzal fluctuations. In fact, 94.5% of central bank interventions between January 2015 and December 2017 were oriented to buy dollars.

Figure 2 illustrates the daily participation that central bank interventions represent in the daily total number of transactions in the country (right vertical axis, from bottom to top), as well as in the net demand (left vertical axis, from top to bottom) of exchange market. The total number of transactions in the exchange market, so as the net demand of foreign exchange in such market are calculated based on the average of the last five business days of the total of buying + selling and selling – buying, respectively, in the foreign exchange market. On average, for the period 2005-2017, such amounts come up to USD139.2 million and USD11.2 million, respectively. For the whole period of the sample, the daily average proportion that represented the intervention amounts by Bank of Guatemala over the daily total transactions of the exchange market was 9.7%, which is relatively high when it is compared to the daily average proportion of the interventions for the period 1995-2011 for economies with flexible exchange rate (1.0%) or economies with exchange rate with bands (5.2%).

It is important to mention that such proportion is higher in the

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11 The experienced appreciation in the exchange rate was due to factors of internal and external nature. On the internal level, a slowdown was observed in the growth of monetary aggregates, particularly M1, as a consequence of a drop in the government expenditure. In turn, the external sector showed a significant increase in the variation rate of family remittances. Additionally, the observed reduction in the oil prices diminished the oil bill of the national economy because fuel imports.

12 See Fratzsch, Gloede, Menkhoff, Sarno and Stohr (2017).
second part of the sample, following the international financial crisis (10.4%), period in which the nominal exchange rate experienced a trend toward exchange rate appreciation; such participations reflect the monetary authority’s solid intent to regulate exchange rate fluctuations over the last years. As stated, central bank average participation in the total number of transactions of the foreign exchange market (buying + selling) in the second term came up to 10.4%, while since the implementation of IT until before the international financial crisis of 2008, such proportion was 6.8%.

FIGURE 2. Central bank average participation in the total number of transactions (buying + selling) and exchange market net demand (buying – selling), Jan 2005 – Dec 2017.

Bank of Guatemala’s intent to moderate foreign exchange volatility is more obvious when looking at the daily average proportion that central bank’s intervention amounts represent over the net demand of the exchange market which is an indicator of the central bank capacity to handle the daily imbalance between foreign exchange supply and demand of the market. In accordance with the estimates done, the daily average intervention amount doubles the daily net demand of the exchange market and, even though the highest values for this indicator are experienced during the first term of the sample, the average value is slightly higher during the second term thereof. The estimated proportions for the whole period of the sample, as well as the ones for the two periods in which the sample is subdivided, come up to 111.4%, 95.5%, and 115.5%, respectively.
B. EFFECTS OF AN INTERVENED EXCHANGE RATE

1. The Model\(^{13}\)

The econometric analysis of the foreign exchange intervention effect on the nominal exchange rate is based on the behavior of the variable called variation of exchange level, \(s_t\), that represents a measure of nominal exchange rate volatility, which is built as the percentage difference between the bilateral Quetzal – US dollar exchange dollar considered at the time of the intervention, \(e_t\), and the weighted average of the exchange rates experienced in two terms after Bank of Guatemala’s intervention in the foreign exchange market:

\[
s_t = e_t - \left( \lambda e_{pi} + (1 - \lambda) e_{pm} \right)
\]

(1)

Where:

\(s_t\) : variation of exchange level in period t;

\(e_t\) : nominal exchange rate at the time of intervention;

\(e_{pi}\) : immediate average;

\(e_{pm}\) : average after one month;

\(\lambda \in [0, 1]\) : weight coefficient

The weighted average of the exchange rates which corresponds to the parenthesis on the right side of the Equation (1) is calculated over two expressions. The first is called immediate average, \(e_{pi}\), and is equal to the simple average of the exchange rates experienced 10 business days immediately after the intervention. The second expression is called average after one month, \(e_{pm}\), and represents the simple average of the exchange rates experienced during the 10 business day term that begins 30 days after the central bank intervention has occurred. Therefore, \(s_t\), considers the immediate effect as well as the short term effect (after one month) of the foreign exchange intervention in the exchange rate level. The weight coefficient, \(\lambda\), shows the relative importance granted to the immediate effects of the intervention. Three alternate series of \(s_t\) were made that change according to the values granted to \(\lambda\) (0.1, 0.5, and 0.9).

The empirical analysis is based on an ACT-GARCH model with effects on the mean similar to the one used by Guimarães and Karacadag (2006);\(^{14}\) therefore, as opposed to the original model, the consequences of foreign exchange intervention are considered, simultaneously, in the level and volatility of \(s_t\) (and not \(e_t\)) which helps to estimate the dynamic effects of the intervention in two terms after such intervention. The econometric specification of the model to be estimated consists of the following system of equations,

\[
s_t = \beta_0 + \beta_1 l^i_t + \beta_2 l^v_t + \sum_{j=1}^{10} \beta_j r^j_t + \beta_{13} d_l + \epsilon_t
\]

(2)

\[
h_t = q_t = \alpha (e_{t-1}^2 - q_{t-1}) + \tau (e_{t-1}^2 - q_{t-1}) z_{t-1} + \mu (h_{t-1} - q_{t-1}) + \gamma_1 l^i_t + \gamma_2 l^v_t + \sum_{j=1}^{10} \gamma_j r^j_t + \gamma_{13} d_l
\]

(3)

\[
q_t = \omega + \rho (q_{t-1} - \omega) + \varphi (e_{t-1}^2 - h_{t-1}) + \delta_{1} l^i_t + \delta_{2} l^v_t + \sum_{j=1}^{10} \delta_{j} r^j_t + \delta_{13} d_l
\]

(4)

\(^{13}\) It is worth mentioning that the exchange rates used for the calculation of the multiple expressions, within this section as well as in the next one, are expressed in logarithms and multiplied by 100 in order to ease its interpretation.

\(^{14}\) Asymmetric Component Threshold GARCH with mean effects, in English.
where $s_t$ refers to the variation in the exchange level; $I_t^C (I_t^P)$ refers to the amount of buying (selling) of foreign currency by the central bank (expressed in millions of United States dollars) resulting from interventions in the exchange market; $dl_t$ is the interest rate differential;15 while, $r_{ct}^j, \forall j = 1, 2, \ldots, 10$; are dummy variables that represent the multiple foreign exchange intervention rules established by Bank of Guatemala, since the implementation of IT in 2005 until 2017.

$$
\text{TABLE 2. Statistic proofs of explicative variables for model ACT-GARCH.}
$$

Table 2 illustrates a set of descriptive statistics for $e_t$, $s_t$ and $dl_t$. The results of the unit root tests using the Augmented Dickey-Fuller (ADF) test, point out that multiple modalities of $s_t$ as well as $dl_t$ are stationary. Additionally, Jarque-Bera tests, bias, and kurtosis show that series move away from the assumption of normality (these are biased, leptokurtic, and their volatility is concentrated in small terms of the sample); however, we consider that it was not necessary to carry out additional transformations of data, since these could have an adverse effect on the intuitive understanding of the results.

In Equation (2) $s_t$ is estimated based on the Bank of Guatemala’s foreign exchange intervention (buying and selling), the participation rules in the foreign exchange market, and the interest rate differential. In front of a scenario of effectiveness of the intervention rules established by the Central Bank, it would be expected that coefficients $\beta_1$ and $\beta_2$ were statistically significant because the goal of the aforementioned intervention rules is to moderate the exchange rate volatility. In particular, the expected sign for $\beta_1$ is negative, because a buying intervention would

15 It is equal to the difference between the weighted average interest rate of three-month repo transactions within the banking system of Guatemala (which in turn it is used as proxy of the interest rates in certificates of deposit issued by the central bank to the aforementioned term) and the interest rate in three-month US Treasury Bills. Interest rate differential is expressed in terms of its gap regarding the trend component which value was obtained by means of the Hodrick-Prescott filter.
contribute to moderate fluctuations toward the appreciation of the nominal exchange rate; on this matter, Central Bank intervention would generate negative values of \( s_t \), given that \( e_{pi} \) and \( e_{pm} \) will have a higher value than the value presented by \( e \). In turn, the expected sign for \( \beta_2 \) is positive because one selling intervention would contribute to moderate the exchange rate fluctuations toward depreciation; in this case, the involvement of Bank of Guatemala in the foreign exchange market would generate positive values of \( s_t \), given that \( e_{pi} \) and \( e_{pm} \) will have a lower value than the value presented by \( e \). The intervention rules are included in order to determine if they generate an additional impact in the exchange rate behavior. Therefore, if the intervention rules are neutral (they do not have impact on \( s \) nor on \( e \)), it is expected that the coefficients \( \beta_3, \ldots, \beta_1, \ldots, \beta_{12} \) are not statistically significant. Finally, the interest rate differential would be considering the effect of the monetary policy and the relative conditions of the domestic financial market on the exchange rate. It is expected that \( \beta_{13} \) is positive because an increase of the interest rate differential in term \( t \) would produce, in the short term, an increase of the foreign capital flow to the country, which in turn, would contribute to generate a nominal exchange rate appreciation and, therefore, would lead to values of \( e_{pi} \) and \( e_{pm} \) below the value showed by \( e \) (hence, \( s_t > 0 \)).

In Equation (3), \( h_t \) and \( q_t \) represent the short-term and the long-term conditioned variance of \( s_t \), respectively, while \( z_t \) is a dummy variable representing a non-expected appreciation of the nominal exchange rate, which value depends on the error term. The type of ACT-GARCH models allows for estimating the short-term conditioned volatility, \( h_t \), based on its long-term value, \( q_t \) (which is variable across the time); on the unexpected, lagged shocks relating to the long-term lagged volatility, \( (\varepsilon^2_{t-1} - q_{t-1}) \); on its net lagged value of the long-term lagged volatility, \( (h_{t-1} - q_{t-1}) \), as well as on the set of exogenous variables included in the Equation (2); that means, the variables representing the foreign exchange intervention of the central bank, the foreign exchange rules, and the interest rate differential. The relative value of the unforeseen, lagged shocks relating to long-term volatility is included in the equation in order to catch high-volatility episodes, which tend to build up in short time intervals throughout the sample.

Long-term conditioned volatility, \( q_t \), is calculated by means of Equation (4) and its value is not steady along time. Like both previous equations, an estimation of \( q_t \) is found based on the variables representing the central bank’s foreign exchange intervention, the foreign exchange rules, and the interest rate differential. Additionally, lagging of long-term volatility, \( q_{t-1} \), and of the error term, \( \varepsilon^2_{t-1} \) is also included. Although \( q_t \) varies on a time-related basis, it is considered that it converges at a steady value, \( \omega \).

There are some characteristics of the ACT-GARCH model used in the estimation, that are worth mentioning. Initially, the model allows for the inclusion of asymmetric shocks in the short-term conditioned volatility equation, by means of the expression \( \tau(\varepsilon^2_{t-1} - q_{t-1})z_{t-1} \). Particularly, when the estimated \( \tau \) value is higher than zero, the unforeseen depreciations of the nominal exchange rate (\( \varepsilon_t > 0 \), which implies that \( z_t < 0 \)) cause an increase of the foreign exchange volatility higher than the increase produced by an unforeseen appreciation thereof. Second, the impact of foreign exchange interventions conducted by the central bank and of the remaining exogenous variables on short-term volatility (measured by the value of \( \gamma_{\cdot} \)) can differ from the impact of such variables on the long-term exchange rate volatility (measured by the value of \( \delta_{\cdot} \)). Finally, this type of models allows to include in Equation (2), the effects of the conditioned variance of \( s_t \) in its mean value.\(^{16} \)

\(^{16} \)The variance logarithm was used to model the effects on the mean nominal exchange rate. It is worth mentioning that the errors of the referenced equation were modeled through the Student’s \( t \)-distribution, in order to consider the kurtosis level of the data.
2. Results

A total of nine estimations separate from the equation system (2)-(4) were carried out, which are described in Table 3. Particularly, 3 different versions of the $s_t$ were calculated, one for each $\lambda$ value (0.1, 0.5, and 0.9) and, for each one of these series, estimations for 3 different sample periods (R1, R2 y R3) were conducted, where R1 encompasses the complete data period (January 4, 2005 through December 31, 2017); R2 covers the period prior to the international financial crisis, which occurred from January 4, 2005 through December 31, 2008; while R3 includes the period after the crisis, which goes from January 1, 2009 through December 31, 2017.

As to the effect of the exchange rate intervention on the exchange rate volatility, the main conclusions derived from the empirical evidence are as follows: i) during the 2005-2017 period, the foreign exchange interventions have significantly moderated the Quetzal fluctuations. Particularly, an amount of USD10 million in buying interventions has caused, in average, an increase (depreciation) of 0.34% ($e_t < \lambda e_{pm}+(1-\lambda)e_{pm}$ in 0.34%), while a similar amount in selling interventions has caused, in average, a decrease (appreciation) of 0.55% ($e_t > \lambda e_{pm}+(1-\lambda)e_{pm}$ in 0.55%); ii) both in buying and selling interventions, the statistical significance of the coefficients estimated for $\beta_1$ is independent from the $\lambda$ value used in calculating the $s_t$; that means, the effect of this type of exchange rate intervention has persistent effects on the value of the Quetzal exchange rate, since it tends to be reflected since the days right after the intervention, thus impacting the immediate average, $e_{pm}$, and continues prevailing 30 working days after the intervention, affecting the average subsequent to the month, $e_{pm}$; iii) during the period prior to the international financial crisis, both types of intervention (buying and selling) tend to generate greater effects on the exchange rate fluctuations represented by $s_t$ than it was experienced in the second period of the sample; iv) the foreign exchange intervention rules during the study period had a direct effect on $s_t$, that means, they contributed to moderate the exchange rate volatility; however, evidence was found about a negative effect of the third intervention rule, which was in effect in 2008; this would be denoting that the implementation of such rule generated a bias favoring a depreciation (it contributes to avoid appreciation) in an amount of up to Q/USD0.03; and, v) the interest rate differential has a persistent effect -which is positive, but no significant- on the exchange rate fluctuations; its effect was greater during the first period of the sample (January 2005 through December 2008).

Regarding the effect of the foreign exchange intervention on the acceleration of the exchange rate volatility, it was determined that: i) buying interventions caused a marginal decrease in the long-term acceleration of the exchange rate volatility, particularly prior to the international financial crisis; subsequent to this crisis, buying interventions contributed to increase such acceleration, although on a limited basis; ii) selling interventions, in turn, caused a significant increase in the long-term acceleration of the exchange rate volatility; this effect occurred particularly during the second period of the sample and for $\lambda$ values tending to one; iii) evidence on the establishment of foreign exchange intervention rules to moderate the referenced short-term acceleration denotes an orientation to its reduction, mainly for $\lambda$ values close to zero; on the long run, in turn, the foreign exchange intervention rules contributed to increase the referenced volatility acceleration, with a greater significance prior to the international financial crisis; iv) the interest rate differential reduced the long-term volatility acceleration for the

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17 Their effect on the short-term exchange rate volatility is ambiguous and irrelevant. It is important to point out that, in the first period of the sample, the decrease of the long-term volatility is reflected both immediately after the intervention and after one month of the central bank’s intervention.

18 However, on the short term, such interventions did cause an immediate decrease of the exchange rate volatility, mostly in the second period of the sample.
exchange rate only during the first period of the sample, and the empirical evidence ($\tau > 0$ and significant value) suggests that unforeseen depreciations of the nominal exchange rate ($\varepsilon_\tau > 0$, which implies that $z_\tau < 0$) cause a greater increase on the acceleration of the exchange rate volatility than the one caused by the unforeseen appreciations of the exchange rate.

<table>
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<tr>
<th>Table 3: Effectiveness of the foreign exchange intervention on the exchange rate level and volatility</th>
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<td><strong>Regression Equations</strong></td>
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<td>Exchange Rate Level</td>
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**: significant at 10%
***: significant at 5%
****: significant at 1%

R1: period from 06-Jan-2005 to 31-Dec-2017
R2: period from 06-Jan-2009 to 31-Dec-2008
R3: period from 06-Jan-2009 to 31-Dec-2017

Therefore, it is possible to infer that the exchange rate reacts with a certain lagging degree, and not on an immediate basis, to changes in the interest rate differential (in this case, within a 3-month term).
V. CONCLUSIONS

According to the empirical analysis, the foreign exchange interventions conducted by the central bank have successfully managed to significantly moderate the Quetzal exchange rate fluctuations during the sample period, regardless of whether they represented U.S. Dollar buying or selling interventions. This result is due to the increased proportion represented by the intervention amounts (which are not sterilized) over the total transactions of the market and over the net demand of foreign currency. It is important to point out that the selling interventions have had a greater effect on the exchange rate than the buying interventions have. As to the effectiveness of the foreign exchange interventions during the IT implementation period, the empirical analysis proves that they were effective, since Bank of Guatemala successfully managed to moderate the exchange rate volatility.
REFERENCES


Banco de Guatemala. “Evaluación y Propuesta de la Política Monetaria, Cambiaria y Crediticia”. Multiple years.


