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Effectiveness of Foreign Exchange Interventions: Evidence and Lessons from Chile*

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Abstract

In this article we evaluate the effectiveness of the last two foreign exchange interventions (FXI) of the Central Bank of Chile (BCCh), dated 2019 and 2022. Using data with daily and intra-daily frequency for the nominal exchange rate, results show through different empirical methods that both intervention episodes have significant effects in the expected direction on the level and volatility of the exchange rate. The effects associated with the 2019 and 2022 interventions are appreciations of an average of 2% and 6%, respectively. The estimated decrease in volatility is also greater in the 2022 intervention. The results support the implications of the different mechanisms that have been proposed in the literature to understand the effectiveness of FXI. Simultaneously, these results suggest that intervening the forward market seems just as effective as intervening into the spot market.

Resumen

En este artículo se realiza un ejercicio de evaluación de la efectividad de las últimas dos intervenciones cambiarias del Banco Central de Chile (BCCh), en 2019 y 2022. Utilizando datos con frecuencia diaria e intra-diaria para el tipo de cambio, y mediante diferentes métodos empíricos, los resultados muestran que ambos episodios de intervención poseen efectos significativos y en la dirección esperada sobre el nivel y volatilidad del tipo de cambio. Los efectos asociados a las intervenciones de 2019 y 2022 son del orden del 2% y 6% de apreciación en promedio, respectivamente. La disminución estimada en volatilidad es también mayor en la intervención de 2022. Los resultados apoyan las implicancias de diferentes mecanismos que se han planteado en la literatura para entender la efectividad de las intervenciones cambiarias, y a la vez estos resultados sugieren que, al parecer, intervenir el mercado forward es igual de efectivo que intervenir el mercado spot.

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1 Introduction

Foreign exchange interventions (FXI) are part of the set of tools that Central Banks possess to achieve their objectives. Naturally, in contexts with a fixed exchange rate or within a band, the monetary authority must dedicate a large part of its work to maintaining the promised level by constantly intervening in the exchange market.

Likewise, in regimes with floating exchange rates, such interventions have been popular in developing economies. They are motivated by a wide range of objectives such as accumulation of reserves, management of inflationary pass-through, mitigation of financial stability risks and control of exchange rate volatility (Chamon *et al*., 2019).

Recently, the Central Bank of Chile (BCCh) intervened in the exchange market on two occasions, in 2019 and 2022.[1] Although Chile has had a floating exchange rate system since 1999, the BCCh reserves the right to intervene in parity exchange. This is done through foreign currency purchase or sale operations and it is carried out on exceptional occasions that compromise the proper functioning of the financial market. In particular, these last two episodes of intervention were preceded by strong depreciative pressures on the exchange rate, causing excess volatility.

In this article we empirically evaluate the effectiveness of these intervention episodes using different econometric approaches.

One way to theoretically justify the effectiveness of sterilized FXI is through certain frictions that induce the famous *impossible trinity* to default.[2] On the one hand, mechanisms have been proposed that allow these interventions to have effects on the exchange rate even under perfect capital mobility. For example, in the portfolio channel, the imperfect substitution between assets in national and foreign currency makes it possible for these interventions to have an effect on the exchange rate by moving the relative supply of foreign currency (Kouri, 1976). Other frictions are of the informational type, so if a misalignment between the exchange rate and its fundamentals occurs as a result of said frictions, the monetary authority could use FXI to correct information asymmetries (Frankel and Froot, 1990). On the other hand, non-instantaneous movements in capital flows also make it possible to justify the effectiveness of these interventions (Chamon, Ghosh, and Ostry, 2016).

However, the signalling channel suggests that FXI have an effect on the exchange rate by providing information on future monetary policy, without violating the *impossible trinity* (Mussa, 1981).

Note that these mechanisms are not mutually exclusive, and it is very likely that in practice they will be present simulatenously during an intervention episode.

Regarding the empirical evidence on the effectiveness of FXI, there is a vast literature that tries to verify and quantify this effect, facing the related endogeneity problems (Sarno and Taylor, 2001; Menkhoff, 2010; Adler, Blanchard and Carvalho, 2015; Fratzscher *et al*., 2019; Chamon, García and Souza, 2017; Chamon *et al*., 2019). In general, it seems that these interventions have a significant effect in the expected direction, both on the level and on the volatility of the exchange rate. However, the magnitude of the effects is rather small. In a recent meta-analysis of 74 empirical articles covering a period of five decades (1970 - 2020) for 19 countries, it is found that, on average, the exchange rate moves 1% in the face of an intervention of $ 1 billion USD, while its volatility decreased by 0.6% for the same amount of intervention (Arango-Lozano *et al*., 2020).

Although the event study methodology is one of the most common in empirical exercises of this type (Contreras, Pistelli, Sáez, 2013; Echavarría, Melo-Velandia, Villamizar-Villegas, 2014; Durán-Vanegas, 2016; Larraín Saravia , 2019), other strategies have also been used that exploit the availability of data and some rules of intervention specific to each country. For example, panel data strategies (Adler, Lisack, Mano, 2019), regression discontinuity designs (Cardozo, Vargas, Villamizar-Villegas, 2019), instrumental variables (Adler Tovar, 2014; Domanski, Kohlscheen, Moreno, 2016), synthetic controls (Chamon, García and Souza, 2017) and autoregressive vector models (Adler, Blanchard and Carvalho, 2015).

As for the heterogeneity of the effect of FXI, it has been documented that a greater degree of financial openness (Adler and Tovar, 2014; Arango-Lozano *et al*., 2020), or independence of the monetary authority (Arango-Lozano *et al*., 2020), seems to decrease the effect. The latter is consistent from a theoretical perspective with the presence of frictions that weaken the *impossible trinity*.

[1] Both interventions were sterilized, that is, the counterpart of operations in national currency was neutralized in order to keep the monetary policy rate (or monetary base, in other policy schemes) constant. In what follows, we only speak of exchange rate interventions, referring to sterilized interventions, unless otherwise mentioned.

[2] The *impossible trinity* refers to the theoretical impossibility of having an independent monetary policy along with exchange rate objectives, in a context of perfect capital mobility.

On the other hand, the larger the amounts to be traded in each intervention, the greater its effectiveness (Adler y Tovar, 2014; Fratzscher *et al*., 2019; Arango-Lozano *et al*., 2020). This supports one of the implications of the portfolio channel. According to this mechanism, the more the relative supply of foreign exchange is displaced, the greater the effect.

With respect to the way that FXI are communicated, the evidence for Latin American countries suggests that the more transparent the information provided to the public about the intervention, the smaller the effect (Adler and Tovar, 2014). However, for episodes in which the start of an FXI is announced, the magnitude of the effect of the announcement is greater than that of the intervention itself (Tapia and Tokman, 2004; Echavarría, Melo-Velandia and Villamizar-Villegas, 2018). The latter can be considered as evidence in favour of the signalling channel, due to agents taking these announcements as hints of the direction of future monetary policy.

Empirical evidence for Latin America has focused on those countries with a higher frequency of FXI episodes, such as Brazil, Colombia and Peru. For the case of Brazil interventions largely use forward instruments for operations (Walker, 2019). Chamon, Garcia and Souza (2017) use a synthetic control methodology to estimate the effects of a pre-announced FXI programme in Brazil in 2013. They find effects in the expected direction and significant on the level and volatility of the exchange rate, although of short duration. Instead, Viola *et al*. (2019) document effects on volatility in both directions in different intervention episodes in Brazil.

In Peru FXI are more frequent. They are characterized by being rather discretionary and using, to a greater extent, the *spot* market for operations. Evidence suggests that FXI in Peru have been effective in reducing exchange rate volatility (Durán-Vanegas, 2016; Castillo *et al*., 2019).

A 2019 study by the Bank for International Settlements uses a regression discontinuity design to estimate the effect of interventions between 2002 and 2012 in Colombia. The study finds that the exchange rate moves on average 2% in the first week of intervention. It also emphasizes the degree of market uncertainty, which can amplify the former effect by up to 2 percentage points (Cardozo, Vargas and Villamizar-Villegas, 2019).

One of the characteristics of FXI in Colombia is that they have had episodes in which FXI have been discretionary (2004 - 2007), and others in which they have been well publicized and pre-announced (2008 - 2014). The evidence shows that the magnitude of the effect of interest is greater when the interventions are pre-announced, and at the same time this effect is amplified when the monetary authority has greater credibility (Echavarría, Melo-Velandia and Villamizar-Villegas, 2018; Pinzón-Puerto and Villamizar -Villegas, 2023).

FXI in Chile have been rather exceptional. Since the floating exchange regime began in 1999, the BCCh has intervened in the foreign exchange market by selling foreign currency four times, and buying foreign currency in three episodes.[3] On the evidence of the effectiveness of these interventions, significant effects in the expected direction on the level and volatility of the exchange rate have been found (Tapia and Tokman, 2004; Larraín and Saravia, 2019; Jara and Piña, 2022). A highlight of the literature is that the effect of the intervention announcements have greater effects than the interventions themselves (Tapia and Tokman, 2004), and that foreign currency purchase programmes have greater effects than sales programmes (Larraín and Saravia, 2019).

In this article we carry out different empirical exercises to evaluate the effectiveness of the last two FXI of the BCCh, the one that began in 2019, and the more recent intervention in 2022. Using data with a daily frequency for the exchange rate, we estimate event study models, local projection models (Jordà, 2005), and also control for the fundamental determinants of the exchange rate. In addition, for the 2022 intervention, we use intra-day data to estimate the effect of five events of interest related to different announcements on the start, operational details, and end of the 2022 FXI, using the interrupted time series approach (Moraffah *et al*., 2021).

The results indicate that the effects of both interventions are significant and negative, both on the level and on the volatility of the exchange rate. These results are to be expected since foreign currency was sold in both intervention programmes. The magnitude of the results is greater for the 2022 intervention than for the 2019 intervention, with average values of 6% and 2% decrease in the exchange rate, respectively. In terms of volatility, the magnitude of the decrease in the 2022 intervention is almost four times that of the 2019 intervention.

Furthermore, these results support the presence of both channels through which FXI have the potential

[3]The foreign currency selling episodes were in August 2001, October 2002, December 2019 and July 2022. While in March 2008, January 2011 and January 2021 the BCCh bought foreign currency to increase its international reserves (García, 2022).

to affect the exchange rate, the portfolio channel and the signalling channel. On the one hand, the portfolio channel predicts that the magnitude of the effect of the intervention is greater the larger the amounts to be traded. Thus, a larger effect associated with the 2022 intervention is interpreted as evidence in favour of this mechanism because the traded amount was almost double that of the 2019 episode.

On the other hand, it is also found that intervention announcements have a greater effect than the intervention itself, which is consistent with the signalling channel premise. In addition, controlling for the fundamental determinants of the exchange rate, the results indicate that it is not possible to reject the null hypothesis that the effect of operations in dollars *spot* is different from the effect of operations in contracts non-deliverable forward (*NDF*).

These results contribute to the literature on the effectiveness of FXI by providing evidence on a recent intervention (2022), distinguishing different mechanisms that could be behind this effect, together with opening the discussion towards the effectiveness of the different FXI instruments (dollars *spot* and contracts *NDF*).

In what follows, Section 2 presents how FXI are framed in inflation targeting schemes. Section 3 explains the case of Chile and its FXI. The data used are detailed in Section 4. Section 5 presents and discusses the results of different empirical exercises to assess the effectiveness of the last two FXI of the BCCh. Finally, Section 6 concludes and discusses the lessons learned from the results.

2 FXI in Inflation Targeting Regimes

An independent monetary policy tends to require a flexible exchange rate in order to adjust and absorb the effects of various shocks. This allows a local monetary policy to respond differently than other countries with larger financial markets' monetary policies in order to achieve its objectives, primarily with regard to inflation (BCCh, 2020a).

However, excessive volatility in exchange rates can be detrimental to the economy by distorting the formation of market prices and disrupting the proper allocation of resources. Such volatility can lead to inflationary effects, heightened uncertainty, and reduced confidence among economic agents (García, 2022). To prevent these adverse outcomes, it is vital to have a well-regulated financial system and a credible monetary policy that can manage volatility effectively. In addition, tools like FXI can be implemented to address issues of excessive volatility.

The theory of uncovered interest rate parity (UIP) highlights that sterilized FXI do not have a direct impact on the exchange rate, which depends exclusively on the interest rate differential and depreciation expectations.[4] That is,

$$e_t = \mathcal{E}_t(e_{t+1}) + i_t^* - i_t,$$

where e_t is the logarithm of the nominal exchange rate, i_t is the domestic interest rate and i_t^* is the foreign interest rate.

To gauge the potential effectiveness of FXI, one way is to justify the non-fulfilment of UIP resulting from the presence of specific frictions.

One of the arguments supporting the potential effectiveness of FXI is the portfolio channel. The existence of imperfect substitution between domestic and foreign assets permits portfolio adjustment by investors, as changes in the relative supply of these assets through FXI by the monetary authority can affect risk premia (Chamon and Magud, 2019). This channel states that changes in the risk premium can explain the effectiveness of FXI, and has been discussed in earlier literature (Kouri, 1976; Tapia and Tokman, 2004).

One of the key implications of this mechanism is that the effectiveness of FXI relies on the size of the trading volumes relative to the market. In other words, the relative supply of these assets must move sufficiently in order to produce an impact. Empirical evidence supports this notion, as the effectiveness of FXI tends to increase with larger trading volumes during the intervention (Adler and Tovar, 2014; Fratzscher *et al.*, 2019; Arango-Lozano *et al.*, 2020).

Other types of frictions have also been studied to justify the effectiveness of sterilized interventions, such as capital flows with non-instantaneous movements (Chamon, Ghosh, and Ostry, 2016) or frictions in price formation (Frankel and Froot, 1990).

Furthermore, mechanisms have been proposed to explain the effectiveness of these interventions without resorting to a violation of the UIP. One of the most extensively studied mechanisms is the signalling

[4] Furthermore, given that we are discussing sterilized interventions, there are no movements in the monetary policy rate.

channel (Musa, 1981; Adler, Blanchard, and Carvalho, 2015). This mechanism is based on the premise that Central Banks have superior information compared to other market agents regarding fundamental variables. Therefore, interventions can be seen as signals of future monetary policy. As a result, market agents adjust their portfolios of national and foreign currency, which can lead to changes in the exchange rate (Tapia and Tokman, 2004). The signalling channel is consistent with the UIP since it suggests that movements in future rates could impact the exchange rate through the expectations of future exchange rates (Chamon and Magud, 2019).

It should be noted that the signalling channel requires Central Banks to have better information about fundamental variables than the rest of the market or a longer-term fundamental-based view. Additionally, the credibility component of Central Banks is necessary for these signals to have an effect. At the same time, an open communication strategy for announcements and details of FXI are required.

It is worth noting that the mechanisms mentioned above are not mutually exclusive, and some studies have partially documented the presence of both. However, it appears that the signalling channel has a more significant impact on the exchange rate (Tapia and Tokman, 2004; Fuentes *et al*., 2014; Echavarría, Melo-Velandia, and Villamizar-Villegas, 2018).

3 The case of Chile

Since 1999, Chile has had a free-floating exchange rate system, which is considered necessary for managing an independent monetary policy under an inflation targeting regime.

The exchange rate policy of the Central Bank of Chile (BCCh) reflects the option to intervene in the market when there is an overreaction in the exchange rate, meaning when the exchange rate experiences sharp increases or decreases without significant changes in its fundamental determinants over a short period of time (BCCh, 2020a).

Making the decision to intervene in the foreign exchange market is not an easy task. First, it is essential to have a deep understanding of the determinants of the exchange rate in order to identify abnormal trends in this price that are not explained by movements in these fundamental variables. Garcia (2022) mentions global and local factors that determine the volatility of the nominal exchange rate. The correlation between the exchange rate and the multilateral dollar, the interest rate differential between Chile and the US, variables related to the internal savings-investment balance (current account), and local uncertainty indicators are highlighted. Moreover, according to the model used by the Macroeconomic Analysis Department (GAM) of the Central Bank of Chile, variables such as copper and oil prices, and the spread of credit default swaps of Chilean government bonds, are also determinants of the nominal exchange rate (BCCh, 2020b).

However, the above is not enough, as it is complex to determine precisely significant deviations of the exchange rate in relation to its fundamentals, so any decision to intervene is extensively analysed by the BCCh.

Since the implementation of the floating exchange rate system, the BCCh has intervened on seven occasions: in August 2001, October 2002, March 2008, January 2011, December 2019, January 2021, and July 2022. However, only the interventions in 2001, 2002, 2019, and 2022 were motivated by the need to correct problems of volatility in the foreign exchange market, and in those cases the direction of the intervention was the sale of currencies. In the episodes of 2008, 2011, and 2021, the objective was the accumulation of international reserves, so the BCCh bought currencies.

In Tapia and Tokman (2004), an analysis of the effectiveness of exchange rate interventions between 1998 and 2003 is carried out. Using time-series estimates, they find that the announcements of interventions have a greater impact on the level of the exchange rate, while the interventions themselves have insignificant effects (Tapia and Tokman, 2004). This supports the signalling channel as the relevant mechanism behind the effectiveness.

Regarding the interventions in 2008 and 2011 (in which the BCCh bought foreign currencies), Fuentes *et al*. (2014) concluded that the announcements of these interventions had significant and persistent effects on the exchange rate level, while Broto (2013) documented an increase in exchange rate volatility associated with these two episodes of intervention.

Larraín and Saravia (2019) use event study models to evaluate the effectiveness of interventions in 2001, 2002, 2008, and 2011. Similar to Tapia and Tokman (2004) and Fuentes *et al*. (2014), they find larger effects on the level of the exchange rate for intervention announcements, and they also observe greater effects on

the exchange rate return for currency purchase programmes (in 2008 and 2011) compared to currency sale programmes (in 2001 and 2002) (Larraín and Saravia, 2019)

Jara and Piña (2022) recently employed autoregressive heteroscedasticity models for the exchange rate volatility. Using the local projections method (Jordà, 2005), they find that the 2019 intervention had a significant negative effect on the currency volatility.

3.1 2019 and 2022 Interventions

This study analyses the FXI announced by the BCCh in 2019 and 2022. Since both interventions were preceded by sharp depreciations of the exchange rate, the operations consisted of selling foreign currency.

The interventions share the same operational structure as well as communication strategy. In terms of the sale operations, both interventions offered a programme of *spot* dollar sales and non-deliverable forward (*NDF*) instruments. *Spot* dollar transactions involve the exchange of currency at the current market rate, while *NDF* transactions are made through contracts that adjust the *spot* price by the differential between CLP/USD exchange rates (de Ramón, 2020).

Regarding communication policy, the BCCh announces the start of each intervention through public statements on its website several days prior to the start of operations. These statements detail the sale modality (*spot* dollars and *NDF* instruments), the maximum trading amounts, and the start date of operations. Additionally, from the beginning of the intervention, the amounts to be traded for the next week are reported at the end of each week. It should be noted that both interventions were duly sterilized.

The details of each intervention are shown in Table 1. In terms of duration, the intervention initiated in 2019 lasted for over a year due to the arrival of the Covid-19 pandemic, which again caused a sharp depreciation of the exchange rate and an increase in volatility. Thus, the BCCh decided to extend the duration of this intervention until January 2021. On the other hand, the 2022 intervention had the originally agreed-upon extension, from July 15th to September 30th, 2022.

FXI	Announcement	Start	Finish	*Spot* amounts (million USD)		*NDF* amounts (million USD)	
				Max. announced	Total traded	Max. announced	Total traded
2019	28-nov-19	02-dec-19	09-jan-21	10,000	2,550	10,000	4,875
2022	14-jul-22	18-jul-22	30-sep-22	10,000	6,150	10,000	9,950

Table 1: FXI details.

In Figure 1, the daily accumulated stock of the amounts of each intervention is shown over the days during which the market was intervened. It can be observed that in the 2022 intervention, the daily accumulated stock of traded amounts was higher than in 2019. Therefore, the total amount traded during the entire intervention period was also higher. A total of 2.55 billion *spot* dollars had been sold in the 2019 intervention as of January 3rd 2020. Conversely, the 2022 intervention lasted until September 30th of said year and amounted to 6.15 billion USD.

As for *NDF* contracts, the 2019 intervention reached a total of 4.88 billion USD, and since June 2020, these contracts have been liquidated at a rate of 50 million USD per day. For the 2022 intervention, a total stock of 9.95 billion USD in *NDF* contracts was reached. To date, these contracts have not yet been liquidated, and according to the latest statement from the BCCh, they will be renewed until June 2023.[5]

Something interesting about these two intervention episodes is that they were announced on a Thursday, after the closing of the market, but the start of sales operations began on the following Monday. This allows for the evaluation of the effect of the announcement itself, and to distinguish this effect from that associated with the actual sales. Hence, the following sections analyse what happened on the Friday following the announcement of the start of each intervention, as well as what happened when sales operations were active.

3.2 Background of each FXI

This section provides a brief analysis of the exchange rate behaviour in the months leading up to each intervention episode.

[5]See *Central Bank of Chile extends the renewal of forward operations*, December 27th, 2022, https://www.bcentral.cl/contenido/-/detalle/banco-central-de-chile-extiende-la-renovacion-de-operaciones-forward.

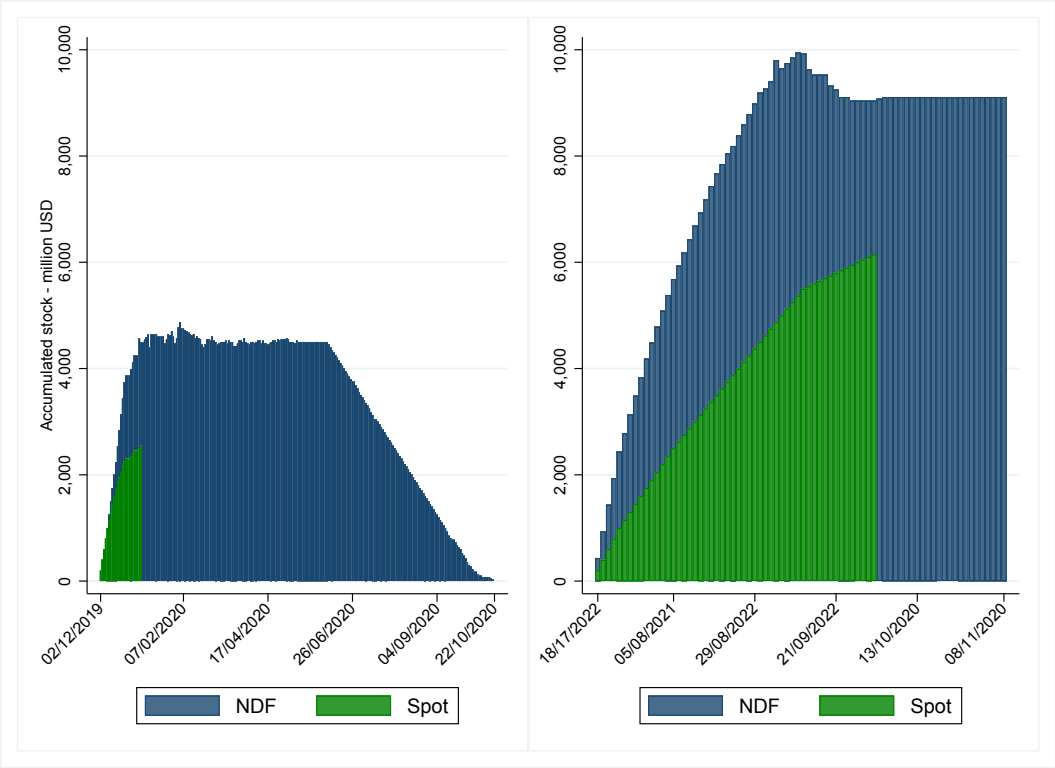

Figure 1: Daily accumulated stock of selling dollars *spot* and instruments *NDF*.

Figure 2 illustrates the exchange rate trend in chilean pesos per dollar (CLP/USD) and the total daily amount traded through *spot* and *NDF* operations. We observe significant exchange rate depreciations in the weeks leading up to each intervention, reaching 820 CLP in November 2019 and 1,040 CLP in July 2022.

In response to these upward pressures, the BCCh intervened in the foreign exchange market by selling currencies and acting as a counterparty for banks and other financial actors. This was done to address the inability of these intermediaries to manage the flows directed towards purchases (de Ramón, 2020).

These depreciation trends in the exchange rate also led to a rise in volatility. Figure 3 depicts the daily exchange rate return evolution alongside a measure of exponential smoothing volatility.[6] An increase in volatility in the return series can be observed in the days prior to the announcement of each intervention. This is also reflected in the substantial increases of the estimated volatility of the return series.

Figures 2 and 3 also show that, after each intervention was announced, the exchange rate began to fall, reversing its depreciating trend. Likewise, the volatility of the exchange rate followed a similar pattern, with daily returns and volatility becoming more stable in the days following the start of each intervention. The following section attempts to evaluate the effectiveness of these interventions and quantify their effects.

4 Data

The dataset used to carry out the effectiveness evaluation exercises for both FXI consists of daily data on the nominal exchange rate series CLP/USD, as well as fundamental control variables considered crucial for this exchange rate. The data ranges from January 1st 2019, to November 8th 2022. Exchange rate data was obtained from the BCCh website, while fundamental control variable data was obtained from Bloomberg.

[6]Considering e_t as the exchange rate level on day t, daily return is defined as $\Delta \ln(e_t) = \ln(e_t/e_{t-1})$. As for volatility, an exponentially weighted moving average (*EWMA*) model of daily return squares is used. The volatility of day t is defined as

$$\sigma_t^2 = 0.94\sigma_{t-1}^2 + (1 - 0.94)\left(\Delta \ln(e_{t-1})\right)^2 .$$

For further details, please refer to Section 5.3.

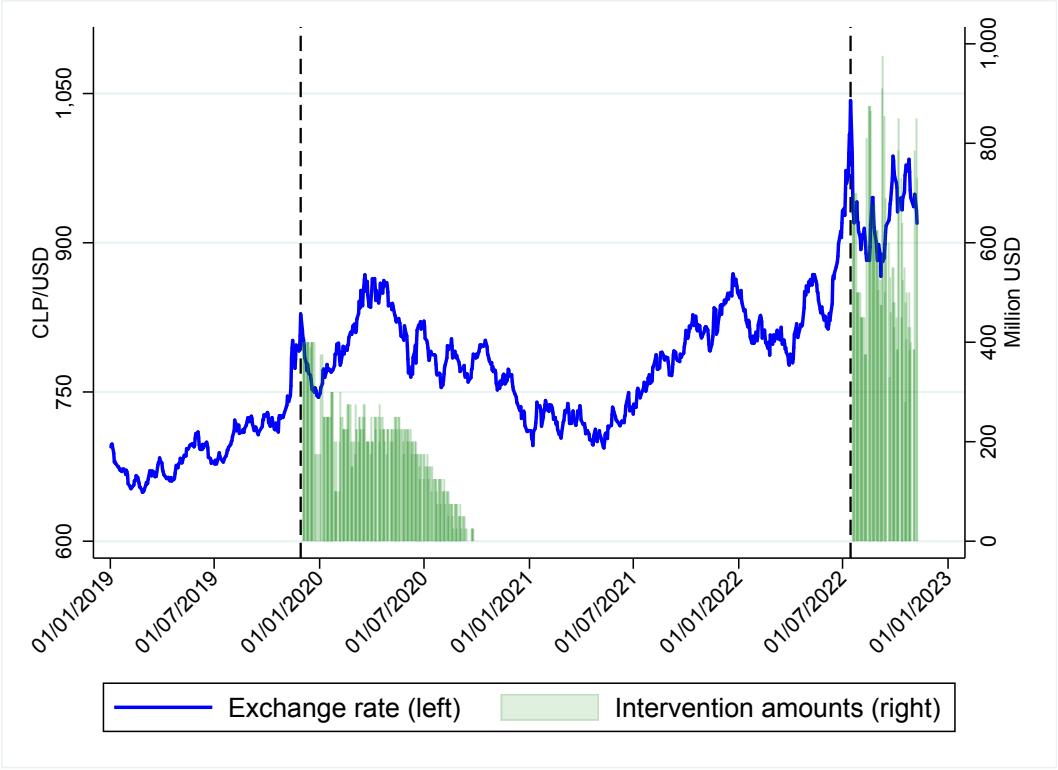

Figure 2: Evolution of the exchange rate and total daily amounts of intervention (*spot* + *NDF*). Dotted vertical lines indicate the announcement of each intervention.

Table 2 presents descriptive statistics of the exchange rate and its daily returns. In the full sample, the average exchange rate was 778, with a daily return of 0.029%. Taking a 30-day window around the start of each intervention, it is observed that, on average, the exchange rate falls during the intervention, albeit in very small magnitudes.

However, the daily return does show considerable changes during the interventions. On average, daily depreciations of around 0.6% and 0.9% were observed in the month prior to the 2019 and 2022 interventions, respectively. Nevertheless, one month after the start of the operations, these averages become appreciations of around 0.5% and 0.8%, respectively. Table 2 also shows that the standard deviation of the exchange rate decreases after one month of each intervention. The next section evaluates whether these trends in the exchange rate, daily returns, and volatility can indeed be associated with intervention episodes.

For the exercise in Section 5.4, intra-day exchange rate data on relevant dates of the 2022 intervention are used. This data provides information on the exchange rate at different points during the day (minutes, seconds) when the market is open, allowing for better identification when using classical methods of effectiveness evaluation due to the higher frequency of observations. These data are available between May 3rd 2022 and October 28th 2022, and were obtained through the Macroeconomic Analysis Department (GAM) of the BCCh.

Thus, using the dataset described above, the following section presents the different exercises for evaluating the effectiveness of FXI and their results.

5 Effectiveness evaluation

This section presents several empirical exercises aimed at evaluating the effectiveness of FXI. The primary econometric challenge is to address various identification problems that are prevalent in this context and have been well-documented in the literature (refer to Adler, Blanchard, and Carvalho, 2015; Chamon *et al.*, 2019).

In what follows, we rely on both high-frequency (daily and intra-daily) data and event study

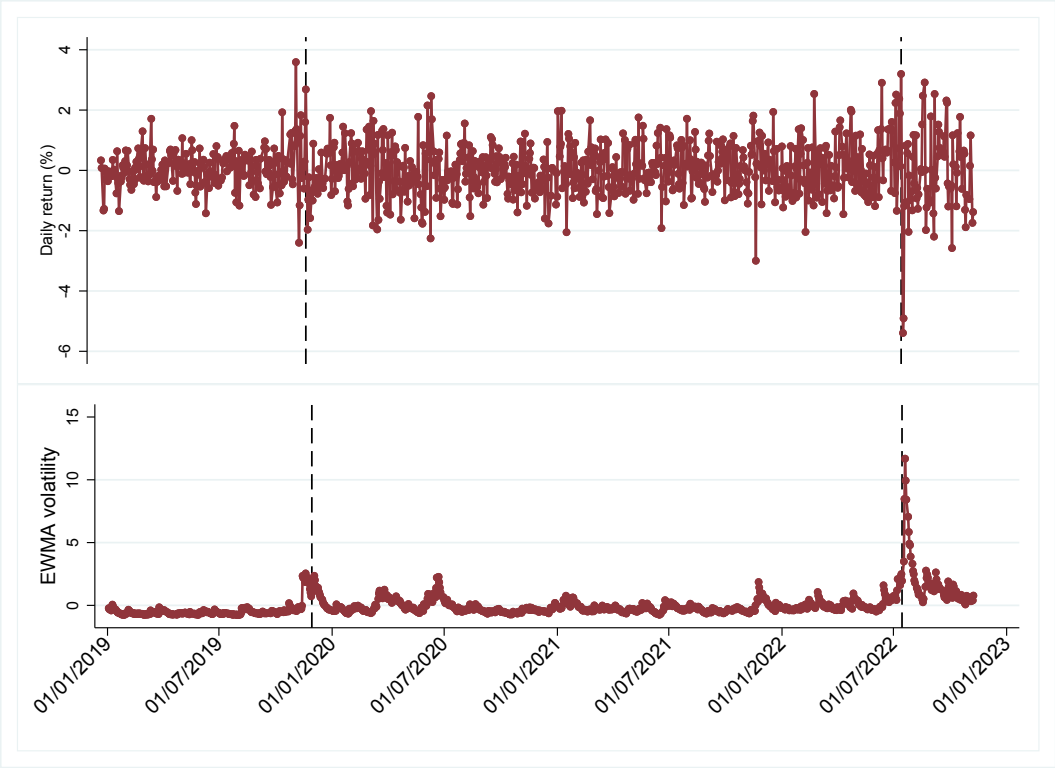

Figure 3: Daily exchange rate return and standardized variance predictions based on an *EWMA* model (parameter $\lambda = 0.94$).

methodologies to better identify the effects of interventions (Section 5.2). Additionally, controlling for fundamental exchange rate variables allows us to isolate exchange rate movements that originate from these variables, thus avoiding erroneous attribution to exchange rate interventions. Sections 5.1 and 5.3 present exercises that include these fundamental variables as controls. In particular, Section 5.3 employs the local projections approach (Jordà, 2005) to estimate dynamic responses of exchange rate volatility to intervention episodes.

In section 5.4, we use intra-daily data to evaluate the effectiveness of the 2022 FXI. To achieve this, we apply an interrupted time series methodology (Moraffah *et al.*, 2021), which enables us to estimate the effect of various communications from the BCCh on both the level and trend of the exchange rate.

5.1 Controlling for fundamentals

As a preliminary step in assessing the effectiveness of these interventions, various models are estimated below to analyse the daily levels and returns of the exchange rate, while accounting for its underlying fundamentals and variables that indicate structural breaks, in accordance with the GAM model employed by the BCCh[7]

The following equation will be estimated,

$$y_t = \alpha_0 + \alpha_1 \cdot FXI_t + \alpha_2 \cdot A_t + \alpha_3 \cdot spot_t + \alpha_4 \cdot NDF_t + \gamma' X_t + u_t, \tag{1}$$

where y_t can be, depending on the specification, the logarithm of the level of the exchange rate ($\ln(e_t)$), or its daily return ($\Delta \ln(e_t)$), observed on the day t. The variable FXI_t is a binary variable that is activated in the entire period of each intervention, A_t is a binary variable that is activated the day after the announcement of each intervention, while the variables spot_t and NDF_t indicate the daily amounts traded (in million USD) in *spot* dollars and *NDF* instruments, respectively, on day t. Lastly, the vector X_t includes the fundamental determinants of the exchange rate, variables indicative of structural breaks, and quadratic trends.

[7]For further details, refer to the Use of Macroeconomic Models in the Central Bank of Chile 2020 report (BCCh, 2020b).

Complete sample (01/01/2019 to 08/11/2022)					
	Mean	SD	Max	Min	Obs.
Exchange rate	778	74	1,043	649	962
Daily return (%)	0.029	0.861	3.590	-5.392	961

2019 FXI (02/12/2019)					
One month before	Mean	SD	Max	Min	Obs.
Exchange rate	774	29	828	726	21
Daily return (%)	0.638	1.320	3.590	-2.400	21
One month after	Mean	SD	Max	Min	Obs.
Exchange rate	770	21	812	745	20
Daily return (%)	-0.532	0.631	0.884	-1.965	20

2022 FXI (18/07/2022)					
One month before	Mean	SD	Max	Min	Obs.
Exchange rate	932	52	1,043	864	21
Daily return (%)	0.900	1.167	3.196	-1.341	21
One month after	Mean	SD	Max	Min	Obs.
Exchange rate	914	25	988	882	22
Daily return (%)	-0.761	1.672	1.174	-5.392	22

Table 2: Descriptive statistics for the level of the exchange rate and its daily return.

Fundamental variables of the exchange rate are those used by the BCCh in their *Broad* models. They include broad dollar index (*broad*), copper price (*cooper*), oil price (*oil*), local (*ipccl*) and external (*ippus*) price index, government bonds credit default swaps spread (*cds_chile_5y*) and the differential between US and Chilean one year interest rates (*dif1y*). Specification (1) includes the previous variables in logarithm, except for dif1y.

Equation (1) is estimated for different time windows with estimation of consistent standard errors of autocorrelation and heteroscedasticity (*HAC* matrix, Newey and West (1987)). When said equation is estimated for the daily exchange rate return, the fundamental variables are included in their first difference. Results are shown in Tables 3 and 4.

Results for the full sample as shown in Table 3 indicate a negative effect -that is, an appreciation- on the level of the exchange rate for both interventions. However, the effect is only significant at 99% confidence level for the 2019 intervention. Also, the effect of the return is not significant in either intervention.

On the other hand, the effect of the announcement of the intervention is positive and significant over the level of the exchange rate for both interventions. Additionally, the effect over the daily return is negative and significant in both cases.

This is due to having estimated equation (1) using the full sample. By comparing between the level of exchange rate in the days immediately following the announcement against the level of exchange rate of all other days - which obviously would include periods of stable exchange rate- a positive difference is expected.

As for the effect of the daily amounts, it is shown that *spot* dollars have a negative effect, which is only significant on the level and not on the return of the exchange rate. A contrary effect is found for the daily amounts of *NDF*, which possess a negative and significant effect only over the level of the exchange rate. Also, the coefficients of all the fundamental variables have the expected sign.

When estimating each intervention episode separately (Table 3) it can be noted that some effects switch to their expected direction. For instance, the announcement of the 2022 intervention has a negative and significant effect over both the level and return of the exchange rate. Also, restricting the sample seems to reduce the significance of the effect of the amounts of *NDF* in both episodes. Whereas the effect of *spot* dollars is significant and negative in both interventions. However, it is so over the return for the former and over the level for the latter.

Nonetheless, the null hypothesis of similar effects between both instruments for both intervention episodes can not be rejected at a 95% confidence level.

Table 4 includes the estimation of model (1) separately for both episodes and for different time frames

	Full sample		2019 FXI		2022 FXI	
	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$
FXI^{2019}	-0.0107**	-0.000521	-0.0113	0.00320		
	(0.00430)	(0.000984)	(0.00933)	(0.00342)		
A^{2019}	0.0204***	-0.0224***	0.0175***	-0.0233***		
	(0.00428)	(0.00106)	(0.00505)	(0.00209)		
FXI^{2022}	-0.00869	0.00356			-0.0292	-0.00649
	(0.00768)	(0.00277)			(0.0212)	(0.00987)
A^{2022}	0.0342***	-0.0512***			-0.0136**	-0.0569***
	(0.00763)	(0.00214)			(0.00602)	(0.00469)
Spot	-0.000000257	-0.0000458***	0.0000174	-0.0000390***	-0.000213	-0.0000608
	(0.0000367)	(0.0000145)	(0.0000328)	(0.0000104)	(0.000131)	(0.0000612)
NDF	-0.0000220**	0.000000536	-0.0000233	-0.0000147	0.000000664	0.00000846
	(0.00000993)	(0.00000355)	(0.0000249)	(0.00000970)	(0.0000170)	(0.0000106)
broad	0.542***	0.0277	1.010***	0.217	0.367	-0.329
	(0.0882)	(0.117)	(0.153)	(0.145)	(0.232)	(0.256)
cooper	-0.300***	-0.0140	-0.222***	0.0305	-0.311***	0.00262
	(0.0251)	(0.0250)	(0.0333)	(0.0395)	(0.0435)	(0.0515)
oil	-0.0183*	-0.0104	-0.0151	0.000923	-0.0507**	-0.0480**
	(0.0105)	(0.00951)	(0.0105)	(0.0121)	(0.0209)	(0.0221)
ippus	1.116***	0.594*	1.134***	0.318	3.713***	1.112***
	(0.270)	(0.321)	(0.328)	(0.713)	(0.539)	(0.427)
ipccl	-1.183***	-0.123	0.797*	0.613	-1.920***	-0.647*
	(0.286)	(0.236)	(0.428)	(0.411)	(0.345)	(0.348)
cds_chile_5y	0.0431***	0.00264	0.00472	-0.00754	0.129***	0.0619**
	(0.00814)	(0.00921)	(0.0107)	(0.0108)	(0.0216)	(0.0292)
dif1y	-0.00665***	0.00664	0.00190	0.00923	0.00277	0.00968*
	(0.00219)	(0.00417)	(0.00604)	(0.00644)	(0.00339)	(0.00581)
_cons	4.811***	0.000697	-6.941***	-0.00184*	-2.566	0.0782
	(1.446)	(0.000707)	(2.555)	(0.00095)	(2.866)	(0.358)
Quadratic trends	✓	✓	✓	✓	✓	✓
Test *spot* = *NDF*						
P-val	0.5872	0.0030	0.3151	0.0549	0.1350	0.2835
N	962	961	505	504	190	190

HAC standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3: Estimation of equation (1). The FXI 2019 sample starts on January 1st 2019 and ends on January 9th 2021. The FXI 2022 sample starts on January 1st 2022 and ends on November 28th 2022.

2019 FXI						
Window:	**30 days**		**60 days**		**90 days**	
	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$
FXI^{2019}	-0.0693***	-0.0131	-0.0533***	-0.00354	-0.0407***	0.000429
	(0.0255)	(0.0152)	(0.0146)	(0.00666)	(0.0108)	(0.0050)
A^{2019}	-0.0179	-0.0331***	-0.00141	-0.0268***	0.0108**	-0.0230***
	(0.0164)	(0.00758)	(0.00765)	(0.00505)	(0.00518)	(0.00334)
spot	0.000229**	0.00000438	0.000183***	-0.0000288	0.000109**	-0.0000416***
	(0.000103)	(0.0000668)	(0.0000698)	(0.0000198)	(0.0000444)	(0.0000156)
NDF	-0.0000445	-0.0000162	-0.0000368	-0.00000733	-0.0000173	-0.00000484
	(0.0000324)	(0.0000248)	(0.0000245)	(0.0000129)	(0.0000248)	(0.0000125)
Control by fundamentals	✓	✓	✓	✓	✓	✓
Quadratic trends	✓	✓	✓	✓	✓	✓
Test *spot* = *NDF*						
P-val	0.0329	0.7995	0.0131	0.3242	0.0190	0.0573
N	61	61	121	121	181	181

2022 FXI						
Window:	**30 days**		**60 days**		**90 days**	
	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$
FXI^{2022}	-0.145***	0.00529	0.0216***	0.00903	0.0124	0.00805
	(0.0316)	(0.0307)	(0.00780)	(0.00738)	(0.00914)	(0.00616)
A^{2022}	-0.0487***	-0.0649***	-0.0170***	-0.0513***	-0.0120*	-0.0523***
	(0.00823)	(0.01098)	(0.00546)	(0.00585)	(0.00620)	(0.00462)
spot	0.000182	-0.000156	-0.000506***	-0.000133*	-0.000404***	-0.000112*
	(0.000146)	(0.000190)	(0.0000669)	(0.0000746)	(0.0000659)	(0.000058)
NDF	-0.0000102	0.0000138	0.00000656	0.0000105	-0.00000703	0.00000577
	(0.0000176)	(0.0000155)	(0.0000139)	(0.0000117)	(0.0000135)	(0.00000843)
Control by fundamentals	✓	✓	✓	✓	✓	✓
Quadratic trends	✓	✓	✓	✓	✓	✓
Test *spot* = *NDF*						
P-val	0.2159	0.3793	0.0000	0.0852	0.0000	0.0569
N	61	61	121	121	166	166

HAC standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 4: Estimation of equation (1) for time windows of 30, 60 and 90 days relative to each announcement of intervention.

(30, 60 and 90 days relative to each intervention announcement). The results displayed in Table 4 show that the effect of the announcements over the return of the exchange rate is one of the most robust ones. This is consistent with evidence from the literature (Tapia y Tokman, 2004; Fuentes *et al*., 2014; Larraín y Saravia, 2019).

As for the magnitude of the effects, for the 2019 intervention it ranges from a 3.3% to a 2.3% decrease in the daily return. It also follows a negative correlation with the length of the time frame. Regarding the 2022 episode, the effect varies between a 6.5% and a 5.2% decrease in the daily return.

Next, it is shown that *spot* dollars have a significant and negative effect over the return of the exchange rate. Similar to Table 3, it is difficult to reject the null hypothesis that the effect of both *spot* and *NDF* instruments over the return is the same.

In brief, the results of this initial exercise show that FXI indeed have significant effects over the level and return of the exchange rate. The results indicate that the announcement of the 2019 intervention reduced the daily return of the exchange rate between 2.3% and 3.3%. They also show that for every billion dollar *spot* sale, the return of the exchange rate appreciated between 3.1% and 4.2%.

The magnitude of the effects for the 2022 intervention is larger. The announcement reduced the return of the exchange rate between 5.1% and 6.5%, whereas the effect of 1 billion *spot* dollars over the return of the exchange rate fluctuates between a decrease of 11.2% and 13.3%.

The results also showcase the different channels through which FXI might impact the exchange rate.

The significance of the effect of the announcements of both episodes can be considered as partial evidence in favour of the signalling channel since a considerable effect is produced merely by communicating the intervention, without yet resorting to the sale of currencies. [8]

As mentioned in section 3.2, the amounts traded in the 2022 intervention were almost double those of the 2019 one. According to one of the implications of the portfolio channel, the magnitude of the effect of FXI depends positively on the traded amounts. Thus, the larger magnitude of the 2022 effects is evidence in favour of the portfolio channel's prediction.

5.2 Event Study

Event study models are commonly used for effectiveness evaluations of FXI (Contreras, Pistelli y Sáez 2013; Echavarría, Melo-Velandia y Villamizar-Villegas, 2014; Durán-Vanegas, 2016; Larraín y Saravia, 2019). These types of models exploit the high frecuency of data by comparing periods at the start of the intervention or at the announcement of it so as to obtain an appropriate counterfactual by using observations prior to the intervention.

In this section we use a event study model to quantify the effect of interest within time windows lasting between 3 and 30 days relative to each intervention.

The equation is simple,

$$\Delta \ln(e_t) = \beta_0 + \beta_1 \cdot FXI_t + u_t. \tag{2}$$

This specification is estimated for time frames $t \in [t_k - j; t_k + j]$, with t_k being the day of the announcement of the intervention $k \in \{2019, 2022\}$, and $j \in \{3, 4, ..., 30\}$ the days relative to the announcement. Standard errors are estimated with *HAC* matrix.

The results of this exercise are shown in Table 4. It can be observed that both interventions have a negative and significant effect over the daily return of the exchange rate, immediately as well as a month after the announcement.

However, the magnitude of the effect is larger for the 2022 intervention with an immediate reduction of approximately 6% of the daily return and 1.5% after a month. The aforementioned effects are 2% and 0.75%, respectively for the 2019 intervention. Said results are consistent with those shown in Section 5.1.

5.3 Local Projections

In order to study the dynamic effects of FXI over the volatility of the exchange rate we use the local projections method (Jordà, 2005).

The focus of local projections allows the estimation of impulse response functions through simple estimation techniques based on regressions. Also, another advantage of using this technique is the

[8] A more direct way to test this mechanism consist on studying the evolution of the expected monetary policy rate on the days following the announcement of each intervention. However, it is difficult to obtain daily expectation data

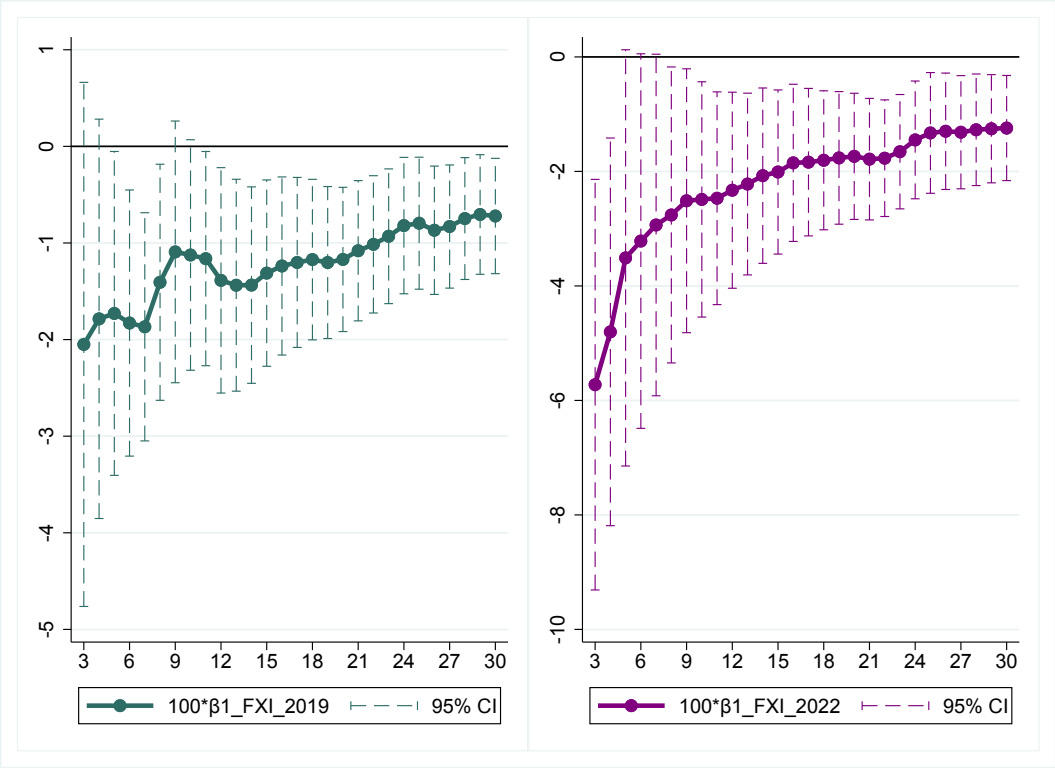

Figure 4: Estimation of β_1, and its confidence intervals, from equation (2) for different time windows.

non dependence on invertibility restrictions (unlike in an autoregressive vector approach) as well as the robustness regarding possible specification errors (Jordà, 2005; Plagborg-Møller y Wolf, 2021).

Explicitly, the following specification is estimated,

$$\sigma^2_{t+k} = \delta_{0,k} + \delta_{1,k} \cdot FXI_t + \sum_{i=1}^{6} \psi_{i,k} \cdot \sigma^2_{t-i} + \sum_{i=0}^{6} \gamma'_{i,k} X_{t-i} + u_t, \tag{3}$$

where σ^2_t is the degree of daily volatility according to the exponentially weighted moving average model *EWMA*,

$$\sigma^2_t = \lambda \sigma^2_{t-1} + (1-\lambda) \left(\Delta \ln(e_{t-1})\right)^2,$$

with a weight of $\lambda = 0.94$. Using a degree of volatility of this kind allows the inclusion of autoregressive heterocedasticity, which has been documented as in the chilean exchange rate series (Jara y Piña, 2022).

Specification (3) is estimated separately for each intervention episodes, for periods of $k \in \{0, 1, ..., 20\}$ days after each intervention. The number of lags chosen (6) in this specification follows the precedent set by Jara y Piña (2022). Results are shown in Figure 5.

It can be appreciated that the effect on the volatility for the 2019 intervention is immediate and has a magnitude of one standard deviation decrease, on average. It also lasts for up to 20 days following the start of the intervention. On the other hand, for the 2022 intervention there is initially an increase in volatility, but after a week a considerable reduction can be observed. It is also stable after 20 days of starting the intervention, reaching a maximum of four standard deviations of volatility reduction.

The increase in volatility days after the beginning of the 2022 intervention, as shown on Figure 5, may be explained by the decrease in both the level and return of the exchange rate. Such decreases were of a larger magnitude than those of the earlier intervention. It is also worth noting that the magnitude of the volatility reduction is also larger for the latter intervention that it is for the earlier one.

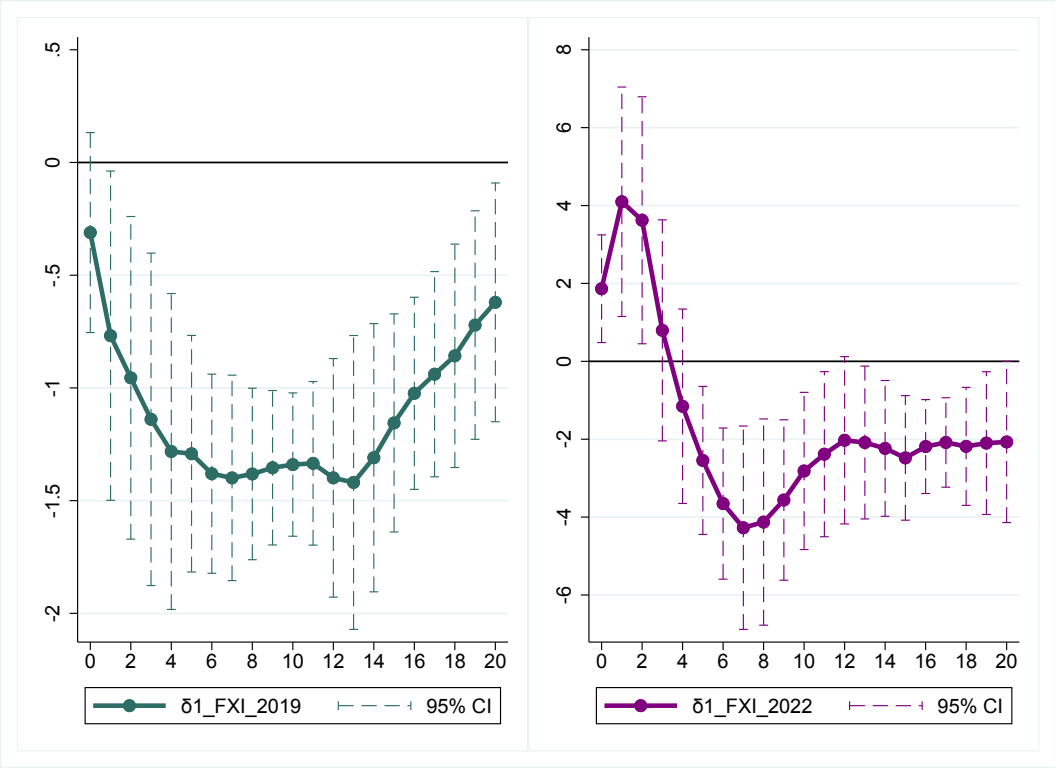

Figure 5: Estimation of δ_1, and its confidence intervals, from equation (3) with the standardized dependent variable, for different horizons.

5.4 Intra-day analysis for 2022 FXI

An effectiveness analysis is carried out for the 2022 intervention using intra daily data. A more abundant frequency of data allows for a better identification of the effect of the announcements on behalf of the BCCh regarding the start, operational details and end of the interventions. The reason for this being that it makes it possible to track the evolution of the exchange rate in real time surrounding events of interest.

Particularly, in this part the effect of the following announcement made by the BCCh in regards to the 2022 intervention is analysed using an event study:

- Announcement made on Monday 11th July 2022, uploaded to the BCCH's website at 18:00 local time. It states that intense external shocks have produced an increase in the level and volatility of the exchange rate in the last few days. The BCCh is closely monitoring markets and will take action if necessary in order to ensure their proper functioning.
- Announcement regarding the start of the intervention, uploaded to the BCCh's website on Thursday 14th July 2022 at 21:03 local time.
- Announcements regarding the operational detail of spot and NDF sales, uploaded to the BCCh's website on Friday 15th and 22nd July 2022, at 12:25 and 12:00 local time, respectively.
- Announcement regarding the end of the intervention and the renewal of NDF contracts until January 2023, uploaded to the BCCh's website on Monday 26th September 2022 at 16:30 local time.

Figure 6 shows the evolution of the exchange rate around the five events previously described. It can be seen on the graph in the upper left corner of this figure that the exchange rate opened higher on the 12th July 2022, after the BCCh had communicated the monitoring of the exchange market. However, this opening is no different to the ones observed on the days prior to this announcement. This is shown on Figure 8 in the Appendix.

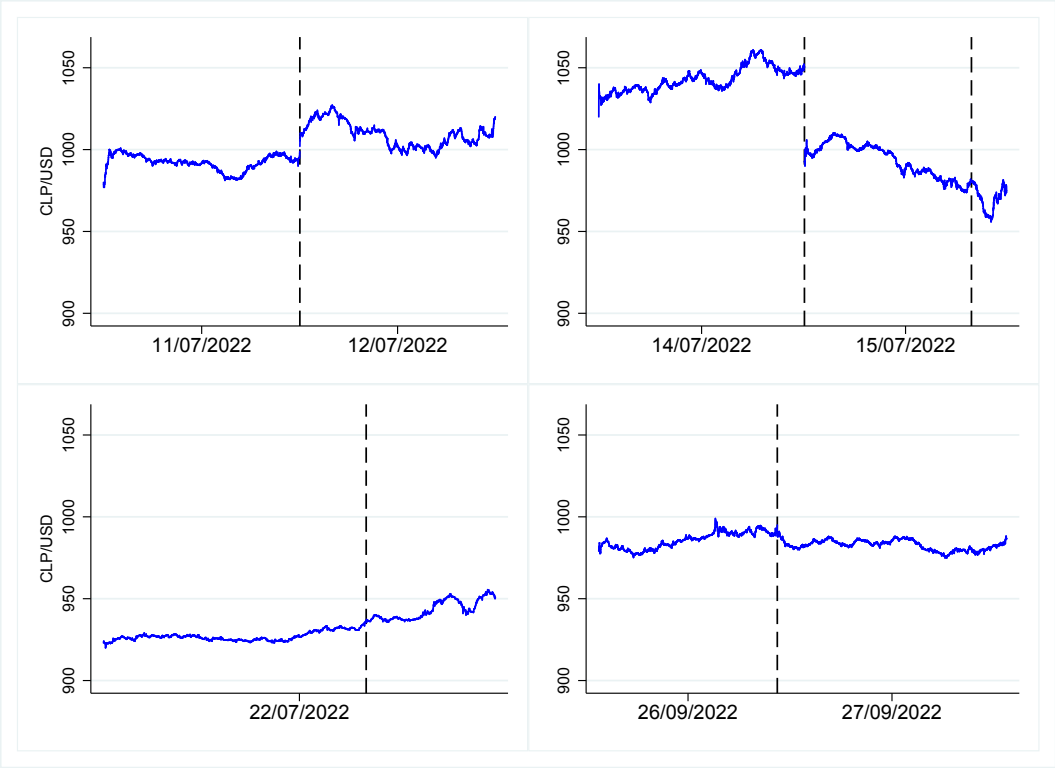

Figure 6: Exchange rate on days 11th (market monitoring statement), 12th, 14th (announcement of FXI), 15th (operational details statement) and 22nd (operational details statement) July, and 26th (renewal statement *NDF*) and 27th September 2022.

The effect of the announcement of the intervention can be seen on the upper right corner graph. This announcement, made on the 14th July 2022, seems to have had a significant effect on the level of the exchange rate. A decrease of almost 50 CLP can be seen in the opening value the day after the announcement.

Additionally, a tendency to appreciate can be observed on the 15th July 2022, which is not shown on previous days. It can also be noted on the 15th July that after the details of the operation for the following week were announced, the series appreciates once again.

As for the announcements made on the 22nd July 2022 and on the 26th September 2022, no substantial movement can be observed in the exchange rate series as shown on Figure 6, neither on the level nor on the slope.

In order to cuantify the effect of each of these announcements, an event study is effectuated. Unlike in the model presented in Section 5.2, linear tendencies are now included within each day. This model also allows for flexibility of these tendencies around the moment of the announcement. A specification of this kind is also known as an interrupted times series (Moraffah *et al.*, 2021).

Thus, the equation we shall estimate consists of

$$y_{t,h} = \eta_0 + \eta_1 \cdot Announcement_{t,h} + \eta_2 \cdot T_{t,h} + \eta_3 \cdot (Announcement_{t,h} \cdot T_{t,h}) + u_{t,h}, \tag{4}$$

where $y_{t,h}$ can be the logarithm of the exchange rate ($\ln(e_{t,h})$), or its instant return h, thus, $\Delta \ln(e_{t,h}) = \ln(e_{t,h}) - \ln(e_{t,h-1})$,[9] within day t. The variable $T_{t,h}$ are the instants h relative to the moment of each announcement. This specification is estimated for time frames of 30, 60, 90 and 120 minutes surrounding the moment of the announcement. For the case of the events of the 11th and 14th July, as well as the 26th September, which were uploaded after the closing of the market, the time frames are considered as the minutes prior/following the closing/opening of operations.

Results are shown on Table 5 of the Appendix. As for the announcement made on the 11th July, regarding the monitoring of the exchange market, results indicate the exchange rate depreciated 1% in the first 30

[9]Note that the return is only defined from the second observation of each day, so that the return between the closing value of the previous day and the opening value of the following day is not considered as such

minutes after the start of operations on the 12th July. In a two hour window, the depreciation peaked at 2.5%. Nevertheless, in the week prior to this announcement, the exchange rate had been opening at high levels (Figure 8), which renders this effect no different to the tendency displayed in the previos days.

Regarding the announcement of the intervention -14th July 2022- results show that the exchange rate appreciated 5.2% in a 30 minute window. Two hours after the announcement, it had appreciated 4.4% in comparison to the level two hours before the closing of the market the previous day. Also, results indicate a change occurred in the direction of the movement of the exchange rate. It switched from a depreciative tendency of a magnitude of 0.009% per minute one hour before the closing of the market on Thursday 14th July, to an appreciative tendency of double the magnitude, one hour after the opening of the market on Friday 15th July.

It is worth noting that the sale of currencies had not yet begun on Friday 15th July. Therefore, the effect can be attributed entirely to the announcement of the intervention.

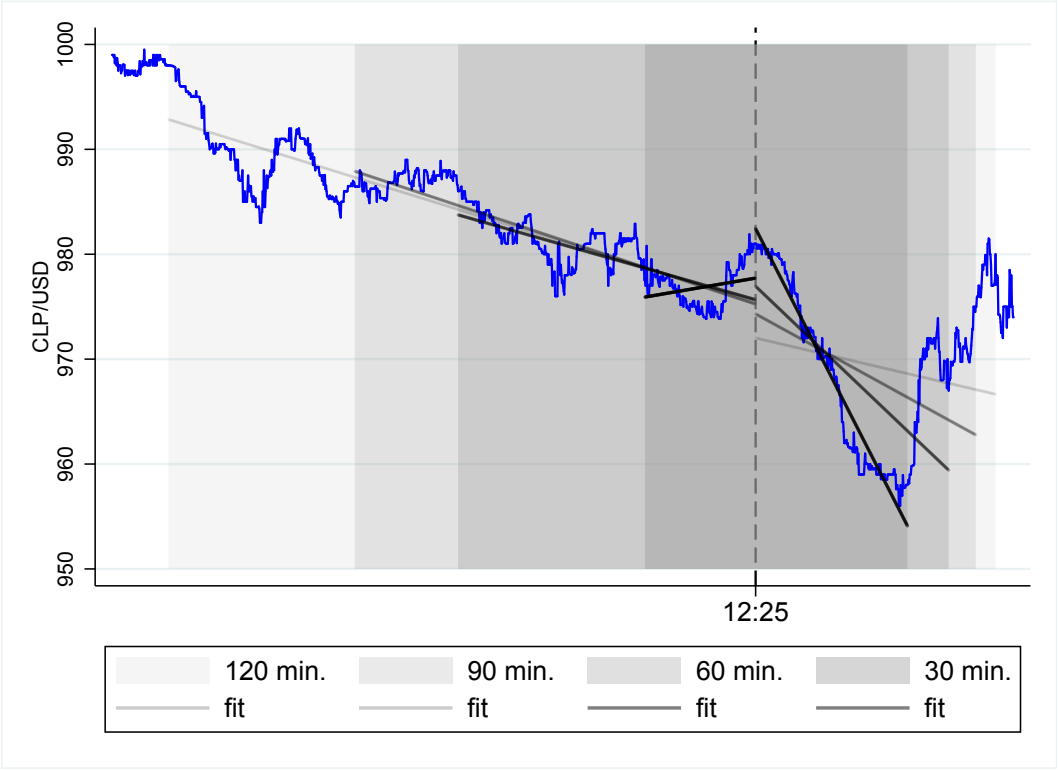

Figure 7: Evolution of the exchange rate within Friday 15th July 2022, surrounding the uploading of the announcement regarding the operational details of the intervention (12:25, dotted vertical line).

Figure 7 graphically depicts the results of the estimation of equation (4) for the event corresponding to the announcement made on Friday 15th July 2022 at 12:25 regarding the operational details of the sale of currencies scheduled for the first week of the intervention.

The different time frames used for the estimation are shaded in this figure, which range from 30 to 120 minutes. When a 30 minute window is used for the estimation, a significant change of the slope can be observed, from a depreciative tendency of 0.0009% per minute before the announcement to an appreciative tendency of 0.012% per minute after the announcement was uploaded (Table 5). As the time frame increases, the difference in slope is reduced. However, a difference in level becomes evident, albeit of small magnitude.

Regarding the announcements made on the 22nd July 2022 (operational details) and on the 26th September 2022 (NDF renewal), significant effects over the level of the exchange rate can be found, in the direction of a depreciation for the 22nd of July event and as an appreciation for the 26th September event. Again, the magnitude of the effects is negligible.

6 Final comments

In this article we empirically evaluated the effectiveness of the last two FXI carried out by the BCCh. Using data of daily and intra-daily frequency for the exchange rate and through different econometric exercises, results show a significant effect in the expected direction for both intervention episodes, both on the level and volatility of the exchange rate.

For the 2019 intervention, the average effect of the reduction of the exchange rate is 2%, whereas the effect on volatility is a reduction of one standard deviation, on average. As for the 2022 intervention, the magnitude of the average effect over the exchange rate is an appreciation of 6% and the decrease in volatility is of nearly two standard deviations, on average.

Additionally, results show that the announcement of the interventions have a greater effect compared to that of the interventions themselves. Also, the greater magnitude of the aggregate effects of the 2022 intervention are attributed to the larger amounts traded by the BCCh in comparison to those traded during the 2019 intervention.

Results discussed in this article contribute to the literature on the effectiveness of FXI by highlighting evidence from a Chilean context. Characterized by a free floating regime and an independent monetary policy in a framework of inflation targeting. Furthermore, we partially distinguish between the different channels through which these interventions seem to be achieving their objectives.

Lastly, a relevant finding presented in this article refers to the inability to reject the null hypothesis that the effect of the amounts of the intervention in spot dollars is different to that of the NDF contracts in the same intervention episode. This finding is quite interesting because there is a tendency to intervene both markets simultaneously in a singular intervention episode.

Thus, this result suggests the market could possibly be intervened only with NDF contracts or rather, in a higher proportion of these, while maintaining the effectiveness documented in this article and minimizing the cost associated to the sale of international reserves of Central Banks. Hence, studying this result in depth should be the topic of future research.

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8 Appendix

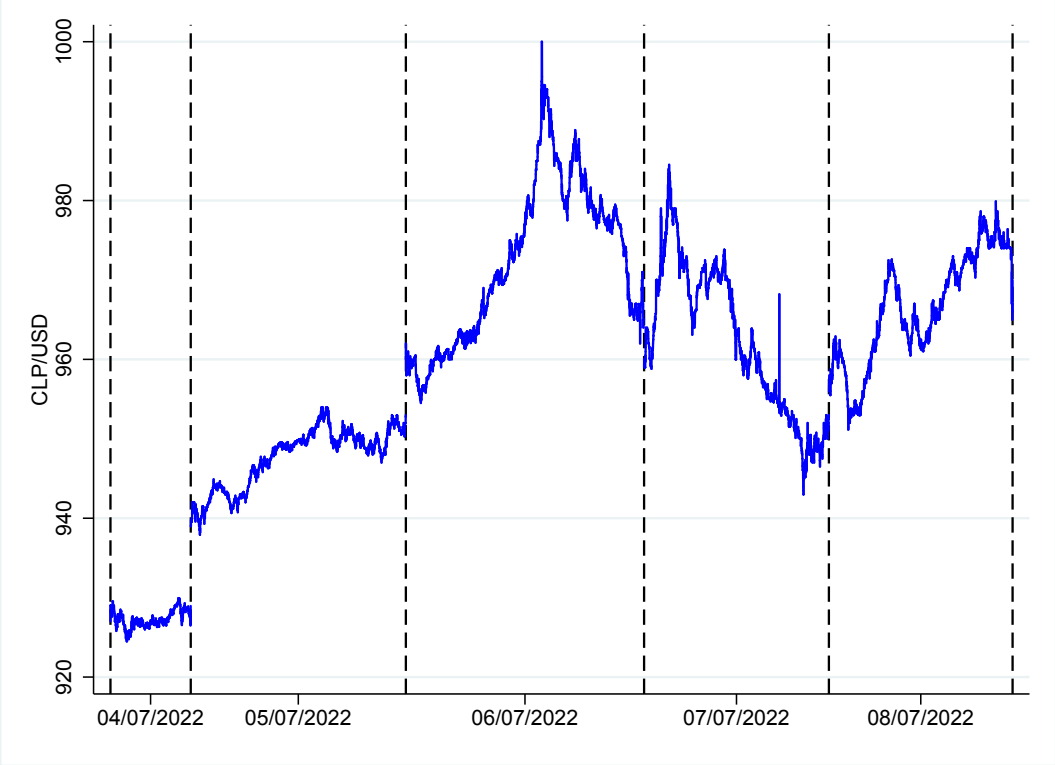

Figure 8: Intra-daily exchange rate between 4th July 2022 to 8th July 2022.

11/07/2022: market monitoring announcement

Window:	30 min.		60 min.		90 min.		120 min.	
	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$
Announcement	0.0128***	0.000241	0.0125***	-0.000110	0.0200***	0.0000321	0.0254***	0.0000611
	(0.000895)	(0.000462)	(0.000526)	(0.000237)	(0.000428)	(0.000113)	(0.000491)	(0.0000828)
T	0.0000464***	0.0000140**	0.0000255**	0.00000759	-0.0000208***	0.00000117	-0.0000136***	0.000000258
	(0.0000170)	(0.00000644)	(0.0000120)	(0.00000499)	(0.00000220)	(0.000000716)	(0.000000840)	(0.000000336)
Announcement · T	0.0000120	-0.0000359**	0.0000638***	-0.00000868*	0.0000502***	-0.00000168**	0.00000970***	-0.000000547
	(0.0000294)	(0.0000156)	(0.0000121)	(0.00000518)	(0.00000261)	(0.000000772)	(0.00000144)	(0.000000361)
_cons	6.903***	0.000441**	6.902***	0.000326*	6.900***	0.000121	6.901***	0.0000496
	(0.000531)	(0.000215)	(0.000480)	(0.000196)	(0.000269)	(0.0000893)	(0.000167)	(0.0000657)
N	87	86	226	225	628	627	989	988

14/07/2022: announcement of the start of the FXIt

Window:	30 min.		60 min.		90 min.		120 min.	
	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$
Announcement	-0.0519***	0.000104	-0.0516***	-0.00000626	-0.0524***	0.0000148	-0.0440***	0.00000904
	(0.000917)	(0.000524)	(0.000526)	(0.000305)	(0.000320)	(0.000158)	(0.000347)	(0.0000969)
T	0.0000873***	0.00000699	0.0000347***	0.00000145	0.0000120***	0.000000279	-0.00000948***	0.000000192
	(0.00000933)	(0.00000794)	(0.00000507)	(0.00000434)	(0.00000140)	(0.000000823)	(0.000000832)	(0.000000239)
Announcement · T	-0.0000863***	-0.0000133	-0.0000257***	-0.00000202	0.0000208***	-0.000000423	0.0000139***	-0.000000282
	(0.0000172)	(0.0000108)	(0.00000610)	(0.00000468)	(0.00000163)	(0.000000887)	(0.000000995)	(0.000000269)
_cons	6.958***	0.000213	6.956***	0.000101	6.955***	0.0000524	6.953***	0.0000409
	(0.000314)	(0.000264)	(0.000276)	(0.000197)	(0.000194)	(0.000118)	(0.000211)	(0.0000719)
N	136	135	277	276	690	689	1278	1277

15/07/2022: operational detail announcement

Window:	30 min.		60 min.		90 min.		120 min.	
	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$
Announcement	0.00499***	-0.000210	0.00135**	-0.000183**	-0.000971	-0.000177**	-0.00359***	-0.000179**
	(0.000372)	(0.000128)	(0.000577)	(0.0000916)	(0.000632)	(0.0000811)	(0.000734)	(0.0000761)
T	0.00000941***	0.000000788	-0.0000157***	0.000000180	-0.0000182***	5.66e-08	-0.0000170***	5.97e-08
	(0.00000266)	(0.00000118)	(0.000000681)	(0.000000162)	(0.000000423)	(0.000000103)	(0.000000297)	(6.67e-08)
Announcement · T	-0.000118***	-0.000000592	-0.0000372***	0.000000430	-0.0000122***	0.000000707*	0.00000403	0.000000700**
	(0.00000302)	(0.00000128)	(0.00000380)	(0.000000512)	(0.00000304)	(0.000000367)	(0.00000312)	(0.000000324)
_cons	6.885***	0.0000956	6.883***	0.0000366	6.883***	0.0000118	6.883***	0.0000145
	(0.000332)	(0.000107)	(0.000233)	(0.0000540)	(0.000194)	(0.0000483)	(0.000159)	(0.0000411)
N	466	466	870	870	1101	1101	1466	1466

22/07/2022: operational detail announcement

Window:	30 min.		60 min.		90 min.		120 min.	
	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$
Announcement	0.00531***	-0.00000444	-0.000873***	-0.0000226	0.00224***	-0.0000199	0.00380***	-0.0000283
	(0.000253)	(0.0000698)	(0.000292)	(0.0000478)	(0.000221)	(0.0000427)	(0.000240)	(0.0000403)
T	0.00000824***	0.000000110	0.0000216***	4.56e-08	0.0000149***	5.08e-08	0.00000857***	4.78e-08
	(0.00000118)	(0.000000363)	(0.000000347)	(0.000000108)	(0.000000236)	(5.10e-08)	(0.000000262)	(3.81e-08)
Announcement · T	-0.0000111***	-0.000000298	0.0000101***	3.49e-08	0.00000790***	-1.40e-08	0.0000157***	3.19e-08
	(0.00000145)	(0.000000448)	(0.00000103)	(0.000000182)	(0.000000785)	(0.000000135)	(0.000000706)	(0.000000117)
_cons	6.838***	0.0000383	6.840***	0.0000335	6.839***	0.0000344	6.837***	0.0000332
	(0.000190)	(0.0000510)	(0.000125)	(0.0000321)	(0.000100)	(0.0000250)	(0.000141)	(0.0000226)
N	533	533	1039	1039	1414	1414	1677	1677

26/09/2022: *NDF* contract renewal announcement

Window:	30 min.		60 min.		90 min.		120 min.	
	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$	$\ln(e_t)$	$\Delta\ln(e_t)$
Announcement	-0.00175***	-0.00115	-0.00192***	-0.000366	-0.00192***	-0.000232	-0.00625***	-0.0000955
	(0.000636)	(0.00168)	(0.000504)	(0.000332)	(0.000363)	(0.000153)	(0.000332)	(0.0000919)
T	0.000126***	0.0000181	0.0000678***	0.00000924*	-0.00000918***	0.00000181	-0.00000603***	0.000000169
	(0.0000303)	(0.0000270)	(0.00000817)	(0.00000553)	(0.00000282)	(0.00000131)	(0.00000140)	(0.000000429)
Announcement · T	-0.000935***	-0.0000181	-0.000120***	-0.0000117	-0.0000177***	-0.00000152	0.00000541***	-1.25e-08
	(0.000133)	(0.000511)	(0.0000136)	(0.00000778)	(0.00000310)	(0.00000134)	(0.00000156)	(0.000000438)
_cons	6.900***	0.000479	6.900***	0.000360	6.897***	0.000158	6.898***	0.0000433
	(0.000491)	(0.000353)	(0.000331)	(0.000261)	(0.000285)	(0.000143)	(0.000195)	(0.0000854)
N	32	31	110	109	467	466	895	894

Clustered standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 5: Estimation of equation (4) for the five events of interest, in different time windows.

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