WORKING PAPER SERIES 7

2005

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Printed and distributed by the Czech National Bank. Available at http://www.cnb.cz.

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Foreign Exchange Interventions and Interest Rate Policy in the Czech Republic: Hand in Glove?

Balázs Égert and Luboš Komárek *

Abstract

This paper studies the impact of daily official foreign exchange interventions on the Czech koruna's exchange rate vis-à-vis the euro (the German mark prior to 1999) from 1997 to 2002. Both the event study methodology, extended with official interest rate moves, and a variety of GARCH models reveal that central bank interventions, especially koruna purchases, seem to have been relatively ineffective from 1997 to mid-1998 compared to the size of the interventions. From mid-1998 to 2002, however, koruna sales turn out to be effective in smoothing the path of the exchange rate up to 60 days. Nevertheless, the event study approach indicates that the success of FX interventions may be intimately related to the coordination of intervention and interest rate policies.

JEL Codes: F31.
Keywords: Central bank intervention, Czech Republic, event study, foreign exchange intervention, GARCH, interest rate policy, transition economies.

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We would like to thank Marcel Fratzscher, Harald Grech, Luděk Niedermayer, Vladimir Tomsik and an anonymous referee for useful comments and suggestions and Simon Volam for excellent language advice. Many thanks also go to Jan Babetskii, Tomas Kvapil, Jan Frait, Christoph Fischer and Zoltán Walko for help in obtaining some of the data series used in the paper. The opinions expressed in the paper are those of the authors and do not necessarily represent the views of the Czech National Bank, the Oesterreichische Nationalbank or the European System of Central Banks (ESCB).

Nontechnical Summary

This paper studies the impact of daily official foreign exchange interventions on the Czech koruna's exchange rate vis-à-vis the euro (the German mark prior to 1999) from 1997 to 2002. We first apply the event study approach by also accounting for the role of official interest rate moves, and then employ a range of GARCH models to analyse the influence of official interventions on the mean and variance of the koruna's exchange rate vis-à-vis the German mark prior to 1999 and the euro after 1999.

The event study approach indicates that the foreign exchange interventions of the Czech National Bank were not particularly effective in the aftermath of the currency crisis from 1997 to mid-1998. Importantly, koruna purchases seem to have been almost always rather ineffective, whereas koruna sales resulted in exchange rate smoothing or leaning against the wind in the very short run. The GARCH estimation results broadly confirm these results, as koruna purchases were usually associated not with an appreciation but with a depreciation of the koruna. Koruna sales either had no impact or were associated with an appreciation of the exchange rate from 1997 to 1998, signalling failure.

However, from mid-1998 to 2002, the interventions – exclusively koruna sales – turn out to have been more successful in reversing the appreciation trend of the koruna in the short run and in smoothing the exchange rate at longer horizons up to 60 days. The econometric evidence indicates that koruna sales had a positive relationship to the exchange rate from mid-1998 to 2002.

Our analysis also shows that the effectiveness of FX interventions is closely linked to interest rate policy, as intervention episodes excluding changes in key policy rates seem to be ineffective from a statistical viewpoint. Interestingly, the same conclusion can be drawn for interest rate events adjusted for the effects of FX interventions. This indicates that interest rate and FX intervention policies may lead to more satisfactory outcomes when they are well coordinated, rather than when they are relied on separately or in an uncoordinated way.

Overall, our results suggest that the Czech monetary authorities were capable of altering the level of the exchange rate, particularly when trying to dampen appreciation pressures (rather than fighting against currency depreciation) in the second half of the period studied. However, this necessitated careful coordination of FX intervention and interest rate policies.

1. Introduction

Although it is widely acknowledged that unsterilised interventions may well have an influence on the exchange rate through changes in relative money supplies, for industrialised OECD economies the empirical evidence is fairly mixed regarding the effectiveness of sterilised interventions, which can work through the portfolio, signalling and microstructure (or coordination) channels. For instance, Aguilar and Nydahl (2000) found limited effectiveness of official interventions for Sweden. Morana and Beltratti (2000) report similar results for the USD/DEM exchange rate and Brandner et al. (2001) and Brandner and Grech (2002) for the ERM currencies. Brissimis and Chionis (2004) suggest that interventions by the ECB were not effective for the yen/euro exchange rate. In contrast with these findings stands Fatum (2000), who finds evidence of effectiveness for the same currency pair. Ramaswamy and Samiei (2000), Fatum and Hutchison (2003) and Brissimis and Chionis (2004) show that sterilised interventions were effective for the yen/dollar and yen/euro exchange rates. Finally, Kim et al. (2000), Edison et al. (2003) and Rogers and Siklos (2003) report mixed evidence for the case of Australia. Nonetheless, Sarno and Taylor (2001) conclude in their literature survey that official interventions may succeed in influencing the exchange rate if they are well communicated and are in line with the fundamentals.

Canales-Kriljenko (2003) has recently argued that foreign exchange interventions may be more effective in developing and transition economies than in well-established industrialised countries, because official interventions may work better in foreign exchange markets with low turnover, because the market organisation and the regulatory framework may be more conducive to interventions, and because moral suasion may also play a bigger role. Nevertheless, the lack of empirical research has long left economists wondering about the empirical relevance of the hypothesis of the effectiveness of central bank interventions in developing and emerging market economies. This lack of empirical research now seems to be evaporating quickly like a mist at sunrise, but the controversy about effectiveness has not lifted. While Domac and Mendoza (2002) and Guimaraes and Karacadag (2004) find no convincing evidence in favour of effectiveness for the cases of Turkey and Mexico, a string of papers published recently by the Research Department of the Central Bank of the Republic of Turkey provide ample support for the success of FX interventions in Turkey (Akinzi et al., 2005a,b; Herrera and Özbay, 2005). Tapia and Tokman (2004) suggest that FX interventions are transmitted to the exchange rate when announced publicly.[2] Holub (2004) analyses the case of the Czech Republic using monthly data and finds some support for the success of FX interventions on the basis of the event study methodology. At the same time, Disyatat and Galati (2005) use econometric estimates and show that FX interventions only influenced the volatility and not the level of the exchange rate in the same country.[3]

[2] BIS (2005) contains descriptive case studies for a large number of emerging economies.

[3] BIS (2005) includes two descriptive case studies for Hungary (for the attack on the stronger edge of the +/-15% band in January 2003) and Poland (for the crawling peg regime). Note that Holub (2004) is also included in the BIS band.

In this paper, we contribute to this debate by using daily intervention data for the Czech Republic from 1997 to 2002. We first apply the event study approach by also accounting for the role of official interest rate moves and then employ a range of GARCH models to analyse the influence of official interventions on the mean and variance of the koruna's exchange rate vis-à-vis the German mark prior to 1999 and the euro after 1999.

The rest of the paper is structured as follows. Section 2 briefly describes the exchange rate and monetary policies and foreign exchange interventions in the Czech Republic. Section 3 presents the results of the event study approach. Section 4 contains the estimation results of the econometric estimations. Section 5 gives some concluding remarks.

2. The Role of Foreign Exchange Interventions in the Czech Republic

2.1 The Monetary Policy Framework and FX Interventions

Similarly to other transition economies of Central and Eastern Europe, monetary policy in Czechoslovakia and, after its split-up in 1993, the Czech Republic relied, at the early stages of the transition process, on the exchange rate as an intermediate target to achieve price stability. After four rounds of devaluation against the currency basket in 1990[4], the Czech(oslovak) koruna's central parity in the pegged system remained unchanged until the introduction of a managed float following a currency crisis in 1997. As a result, average yearly inflation – running as high as 56.6% in 1991, chiefly as a consequence of price liberalisation – was brought down to 10% in 1994 and was stabilised in high one-digit territory from 1995 to 1997. After a transitional recession, real GDP growth recovered from 1993 onwards, reaching 5.9% and 4.2% in 1995 and 1996 respectively. At the same time, the current account deficit and consolidated government deficits were on the rise (see Table 1 below).

Table 1: Major Annual Macroeconomic Indicators

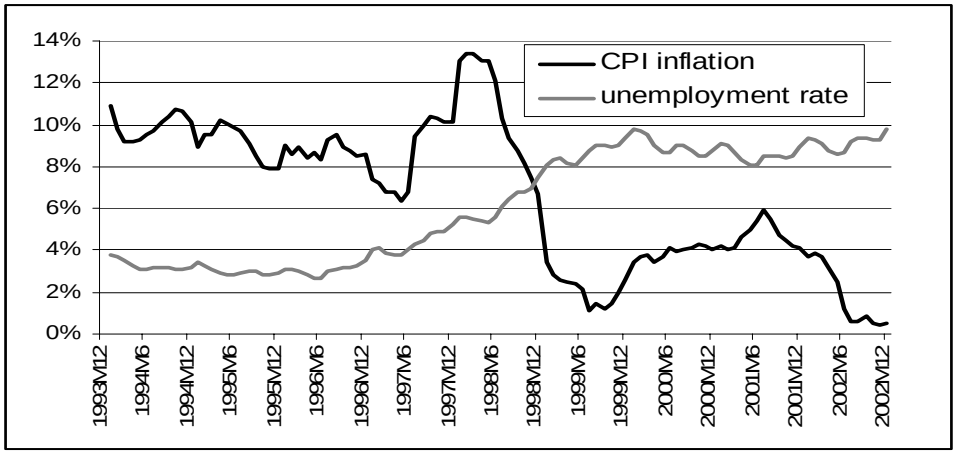
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Real GDP growth (%)	-1.2	-11.6	-0.5	0.1	2.2	5.9	4.2	-0.7	-1.1	1.2	3.9	2.6	1.5
Unemployment (%)	0.7	4.1	2.6	3.5	3.2	2.9	3.5	5.2	7.5	9.4	8.8	8.9	9.8
Inflation (%)	9.7	56.6	11.1	20.8	10.0	9.1	8.8	8.5	10.7	2.1	3.9	4.7	1.8
Current account deficit (% of GDP)	-1.0	4.5	-1.0	1.3	-1.9	-2.6	-6.7	-6.3	-2.1	-2.5	-4.9	-5.4	-5.6
Government deficit (% of GDP)						-13.4	-3.1	-2.4	-5	-3.6	-3.7	-5.9	-6.8
Stock of FDI (% of GDP)	0.2	2.2	10.4	10.2	10.7	14.3	14.1	16.8	22.6	31.6	38.6	45.2	47.1

Source: Czech National Bank and WIIW.

Notes: Unemployment is registered unemployment. Labour Force Survey-based unemployment is very similar both in levels and in dynamics. Inflation is average annual CPI. Current account deficit is in USD. Government deficit is based on ESA 95.

[4] 2 January 1990: 2.1%; 8 January 1990: 16.3%; 15 October 1990: 55.2%; 28 December 1990: 15.9%. The currency basket was composed of 32.88% USD, 40.93 % DEM, 12.32% ATS, 4.82% FRF and 9.05% CHF until 27 December 1990. On 28 December 1990, the weights in the basket were adjusted and the French franc was replaced by the British pound: 31.34% USD, 45.52% DEM, 12.35% ATS, 4.24% GBP and 6.55% CHF. On 2 January 1992, the weights were re-adjusted and the French franc regained its previous position by crowding out the British pound: 9.7% USD, 36.15% DEM, 8.07% ATS, 2.92% FRF and 3.79% CHF. Shortly after the introduction of the Czech koruna, the basket was simplified to two currencies on 3 May 1993: 35% USD and 65% DEM.

Figure 1: Monthly y-o-y CPI Inflation and Unemployment Rate, 1994–2002



Source: Czech National Bank.

The exchange rate of the koruna against the German mark came increasingly under pressure from February 1997 and depreciated by roughly 10% in the three months to May 1997. This depreciation was triggered mainly by the coincidence of three factors: a) the delayed response of policymakers in dealing with the twin deficits, b) political turbulence, and c) the start of the Asian currency crisis in Thailand (Šmídkova et al., 1998).

The speculative run against the koruna was largely facilitated by extensive capital account liberalisation[5], which also opened the door to massive capital inflows, the first consequence of which was that the extremely tight fluctuation band of ±1% or less[6] had to be widened to ±7.5% on 28 February 1996.[7]

In response to the attack, the Czech National Bank (CNB) intervened massively to support the koruna. However, the fall in foreign exchange reserves, the rise in systemic risk due to the huge fall in liquidity on the interbank market and the lack of political will to support the peg forced the Czech National Bank and the government to abandon the peg and to announce the introduction of a managed float on 26 May 1997. The new regime was oriented to the German mark and, after 1998, the euro (Šmídkova et al., 1998; CNB, 1997, p. 25).

In the new regime, the CNB strived to stabilise the exchange rate against the German mark and announced a target band of 17–19.5 CZK/DEM (33.5–38.5 CZK/EUR). From June to August 1997, the CNB intervened in both directions to keep the currency in this band and, perhaps more so, to smooth the exchange rate, as the koruna did not come close to the announced limits of the roughly 13% wide corridor until late November 1997 (Figure 2). With the stabilisation of the

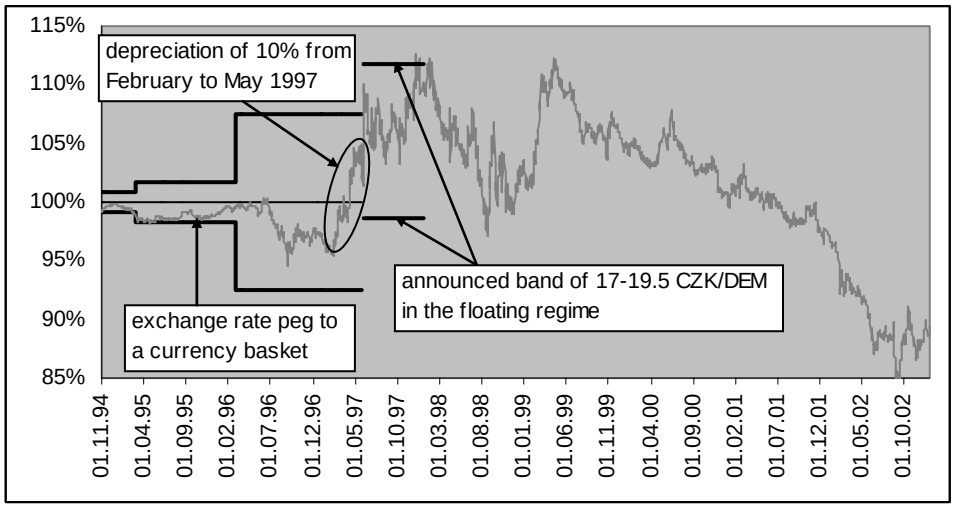
[5] The Czech Republic complied with Article VIII of the IMF from 1 October 1995 onwards and joined the OECD in December 1995.

[6] ±0% until August 1992, ±0.5% from 27 September 1992 to 24 April 1995, ±0.75% from 25 April 1995 to 27 February 1996 (this widening was due to the fact that the CNB charged an additional 25 p.p. as a fee for trades on the market) and ±7.5% from 28 February 1996 to 26 May 1997.

[7] Note also that in 1995 and 1996, the volume traded on the Czech koruna was substantially higher than on any other CEE currency except the Russian rouble.

currency achieved in July, the CNB then pumped liquidity into the interbank market to lower interest rates.

Figure 2: Exchange Rate Regime in the Czech Republic, 1993–2005



Note: Exchange rate developments are depicted relative to the official central parity prevailing in the pegged regime. The series refers to the koruna's exchange rate vis-à-vis the basket under the peg, and against the German mark and the euro in the managed float.

As the exchange rate could no longer serve as an intermediate target, and because money demand was too unstable to serve as an anchor, the Czech National Bank at the beginning of 1998 became the first central bank of a transition economy to introduce a direct inflation targeting framework.[8]

Under its inflation targeting policy, the Czech National Bank preserves the right to intervene on the foreign exchange market if there are "major deviations of the exchange rate that are not connected with domestic economic fundamentals and domestic monetary policy" (CNB, 1998, p. 46). A strong motivation for the CNB to avoid large currency misalignments is the high openness of the Czech economy in terms of exports and imports.[9]

As shown in Figure 1, the koruna was on a steady appreciating path from 1998 until the end of 2002, brought about by the massive privatisation of the corporate sector and greenfield investments, which resulted in an FDI inflow of around USD 30 billion[10] between 1998 and 2002. Table 2 shows a collection of official statements from 1998 to 2002 confirming that the CNB intervened on the foreign exchange market during this period in order to smooth the appreciation of the koruna vis-à-vis the German mark and the euro. In addition, contrary to other central banks, the CNB's FX interventions were clearly aimed at changes in the exchange rate and not its volatility.

[8] For a very comprehensive treatment of inflation targeting in the Czech Republic, see Coats (2000).

[9] The ratio ((X+M)/2)/GDP was around 50% in 1997, increased to about 60% by 2000 and stabilised at approximately 56% at the end of 2002.

[10] billion = 10^9 ; Table 1 shows that the stock of FDI grew from about 23% of GDP in 1998 to 47% of GDP in 2002.

Table 2: Overview of the CNB's Objectives on the FX Market

Source	Year	Statement
Šmídkova et al. (1998, pp. 10–11)	1997	The CNB announced that "the average koruna exchange rate should float in the range of 17–19.5 CZK/DEM"; the CNB intervened in both directions to limit exchange rate variability.
CNB (1998, p. 33)	1998	"The CNB intervened on the foreign exchange market to moderate the appreciation pressures generated by the foreign capital inflow."
CNB (1999, p. 45)	1999	"The koruna's exchange rate was affected by the CNB's interventions to prevent an excessive koruna appreciation."
CNB (2000, p. 48)	2000	"The koruna's nominal exchange rate against the euro exhibited an overall appreciation tendency in 2000. This gradual strengthening was interrupted at end-Q1 by the CNB's foreign exchange interventions to prevent excessive appreciation of the koruna…"
CNB (2002, p. 36)	2002	"The koruna continued to appreciate (…). As a result, at its extraordinary meeting on 21 January 2002 the Bank Board (…) also approved intervention in the foreign exchange market."
	2003–2005	No FX interventions

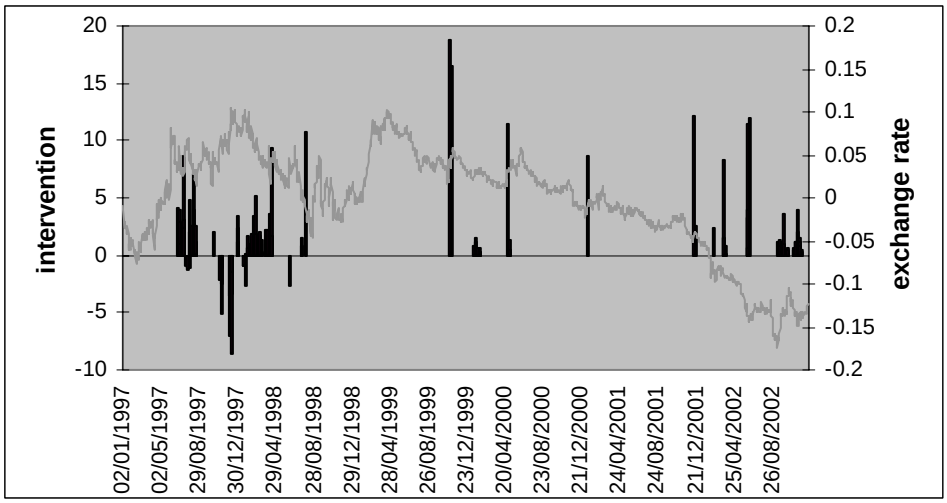
Note: The year column indicates the year to which the statement pertains.

Along these lines, off-market operations concerted between the CNB, the Ministry of Finance and the National Property Fund were also undertaken between 2000 and 2002 to neutralise the effects of privatisation revenues on the exchange rate (CNB, 2001, 2002).

2.2 Overview of Official FX Interventions from 1997 to 2002

Figure 3 and Table 3 provide an overview of the CNB's intervention activity on the foreign exchange markets, according to which the Czech central bank both sold and purchased the domestic currency in the aftermath of the currency crisis in 1997. Although it also purchased koruna in 1998 on a few occasions, from 1998 to late 2002 the Czech monetary authorities' interventions took the shape of koruna sales to smooth the appreciation or even to try to weaken the Czech currency. The CNB did not intervene on the FX market between 2003 and mid-2005.

Figure 3: Interventions in the Czech Republic



Source: Czech National Bank

Note: Interventions are in billions of Czech koruna. Negative (positive) values show koruna purchases (sales).The exchange rate is shown as the deviation from the period average koruna/euro (German mark) exchange rate.

Table 3: Summary of Intervention Activities of the Czech National Bank, 1997:06–2002:12 (CZK billions)

		Mean	Median	Min	Max	SD	Days of intervention
1997	Total	2.88	2.42	0.18	8.69	2.03	40
	Sales	2.81	2.52	0.18	8.59	1.82	27
	Purchases	3.03	2.13	0.95	8.69	2.49	13
1998	Total	1.94	1.46	0.19	10.75	2.26	37
	Sales	1.95	1.46	0.19	10.75	2.38	33
	Purchases	1.84	1.83	0.99	2.72	0.99	4
1999	Total	4.10	0.81	0.22	18.76	7.16	10
	Sales	4.10	0.81	0.22	18.76	7.16	10
	Purchases	0.00	0.00	0.00	0.00	0.00	0
2000	Total	4.45	1.27	0.36	11.49	5.24	5
	Sales	4.45	1.27	0.36	11.49	5.24	5
	Purchases	0.00	0.00	0.00	0.00	0.00	0
2001	Total	5.64	2.52	2.33	12.08	5.57	3
	Sales	5.64	2.52	2.33	12.08	5.57	3
	Purchases	0.00	0.00	0.00	0.00	0.00	0
2002	Total	1.91	0.91	0.10	12.06	2.84	37
	Sales	1.91	0.91	0.10	12.06	2.84	37
	Purchases	0.00	0.00	0.00	0.00	0.00	0
1997–2002	Total	2.56	1.43	0.10	18.76	3.24	132
	Sales	2.53	1.42	0.10	18.76	3.37	115
	Purchases	2.75	2.13	0.95	8.69	2.26	17

3. The Event Study Approach

3.1 Defining the Event and the Effectiveness of an Event

A big advantage of the event study approach over time series techniques is that it only looks at periods when interventions take place and is thus able to filter out longer periods during which no interventions happen and which may cause econometric studies to find no relation between foreign exchange interventions and exchange rate behaviour (Fatum, 2000; Fatum and Hutchinson, 2003).

When applying the event study approach, three issues have to be tackled:

a) how single interventions in one direction can form a single intervention episode or event: The question is: how many days must separate two single intervention acts going in the same direction (both purchases or both sales) for those acts to be considered as two distinct intervention events. Five alternative definitions of the intervention event are considered in this study. We consider intervention events which comprise single interventions in one direction between which up to 2, 5, 10, 20 and 30 consecutive days can pass without intervention activity. The intervention

event ends if more than 2, 5, 10, 20 or 30 days go by without intervention or if an intervention in the other direction takes place.[11]

b) how long a time horizon should be analysed before and after the intervention event (definition of pre- and post-event windows):
As to the size of the pre- and post-event windows, we look at six different lengths: 2, 5, 10, 20, 30, 40 and 60. The pre- and post-event windows are constructed in a symmetric way, implying that a 2-day (5-day etc.) pre-event window is compared to a 2-day (5-day etc.) post-event window.[12] In addition, effectiveness is analysed for the event window itself. The pre-event window is set to 2, 5, 10, 20 and 30 days if the event window size is equal to or less than 2 days (greater than 2 (5, 10, 20 and 30) but equal to or less than 5 (10, 20 and 30)).

It may happen that the pre-/post-window overlaps with one or more previous/next intervention episode, especially as the pre- and post-event window sizes increase. In such a case, the outcome of the analysis will reflect the joint effect of the overlapping intervention episodes and not the one we are interested in. Against this background, we focus on the pre- and post-event windows which do not overlap with other intervention episodes. In what follows, we refer to the non-overlapping pre- and post-event windows as "assessable" using shaded cells in Table 3 and the word ASSESSABLE in Tables 4 and 5.

c) under what circumstances an intervention episode can be viewed as effective/successful:
The following three types of intervention can be distinguished.
Leaning against the wind (breaking/reversing the trend; WIND): central bank interventions reverse the exchange rate trend, i.e. the exchange rate depreciates (appreciates) in the pre-event window, and, following purchases (sales) of the domestic currency, it appreciates (depreciates) in the post-event window.

Smoothing exchange rate movements (dampening or slowing the trend; SMOOTH): central bank interventions slow down the appreciation or depreciation of the domestic currency, i.e. buying (selling) the domestic currency causes the exchange rate to depreciate less (appreciate less) in the post-event window than in the pre-event window.[13]

Leaning with the wind (WITH): purchases (sales) of the domestic currency should cause the exchange rate to appreciate more (depreciate more) after the intervention episode than before the intervention episode. As most central banks intervene in an attempt either to dampen or to reverse the exchange rate trend, a finding that interventions are leaning with the wind may simply indicate the failure of official FX interventions. For this reason, we drop leaning with the wind for the rest of the paper and classify it as failure.

[11] Fatum (2000) and Fatum and Hutchison (2003) use up to 15 days and Edison et al. (2003) use up to 10 days with no intervention between two neighbouring interventions within an event.

[12] Fatum (2000) employs 2, 5, 10, and 15-day window sizes, while Edison et al. (2003) look at 2-day and 21-day windows. Edison and others refer to the 2-day window as the short term and the 21-day window as the long term.

[13] In contrast to Fatum (2005), Fatum and Hutchison (2003) and Fratzscher (2005), our definition of exchange rate smoothing does not encompass leaning against the wind interventions, as in our case exchange rate smoothing implies a weakening of an ongoing trend (less appreciation or less depreciation) whereas leaning against the wind refers to events when the trend on the FX markets reverses as a result of FX interventions (appreciation instead of depreciation and depreciation instead of appreciation).

In general, it should be emphasised that the analysis of the effectiveness of FX interventions on the basis of the aforementioned success categories allows an ex post judgment of the effectiveness of FX interventions, i.e. observation of the actual outcome. Nevertheless, the comparison of the ex post outcomes and the stated policy objective may give us a rough idea of how effectively the central bank's intentions prior to the realisation of FX interventions materialise on the FX market.

Finally, not only changes in the exchange rate, but also changes in the volatility of the exchange rate can be analysed. For this purpose, volatilities – measured as the standard deviation over the (symmetric) pre- and post-event windows – are compared with one another.

3.2 Statistical Measure of the Effectiveness of FX Interventions

Although it is convenient to analyse the effectiveness of FX interventions in a descriptive way, it may be also interesting to carry out formal statistical tests to verify whether the measured success of the individual intervention events can be viewed as statistically significant or just as a random phenomenon. For this purpose, we apply the non-parametric sign test. This is frequently used in event studies (MacKinley, 1997, p. 32) in general and has been extensively used in recent years in the literature on FX interventions (Humpage, 1999; Fatum, 2000, 2005; Fatum and Hutchison, 2003; and Fratzscher, 2005). The test statistic is constructed as follows: $S = (\frac{N^+}{N} - \mu)\frac{\sqrt{N}}{\mu}$, where N^+ is the number of successful events, N is the total number of non-overlapping events, μ is a probability parameter and $S \sim N(0,1)$. There is indeed a probability of 50% ($\mu = 0.5$) that the exchange rate will appreciate (depreciate) in period t+1 as compared to a depreciation (appreciation) in period t. Hence, the non-parametric sign test investigates whether the number of leaning against the wind type of successes is significantly larger than 50%. In other words, the sign test examines whether the null hypothesis of a random change in the exchange rate can be rejected against the alternative of a systematic change (due to FX interventions in our case). In a similar vein, the probability of the exchange rate depreciating (appreciating) less but not switching to an appreciation (depreciation) in the case of exchange rate smoothing is 25% ($\mu = 0.25$).[14] The sign test can also be easily applied to analyse whether FX volatility increases or decreases significantly after FX interventions.

3.3 The Role of Interest Rates

An intriguing question to be addressed in the context of FX interventions is whether changes in the exchange rate occur only as a result of FX interventions or because other factors also interfere with the impact of FX interventions. Interest rate movements have a prominent role in this respect, as FX interventions may turn out to be effective partly because they are supported by interest rate moves. In particular, if domestic currency purchases (sales) are accompanied by an increase (decrease) in the domestic reference interest rate or a decrease (increase) in the foreign interest rate, the FX intervention may be more effective. Hence, it seems meaningful to get rid of events during which domestic or foreign interest rate moves take place (Fatum and Hutchison, 2003).

[14] When exchange rate smoothing is defined as including leaning against the wind, the probability parameter takes the value of 0.75, as the 0.5 for leaning against the wind and the 0.25 for exchange rate smoothing add up.

Therefore, in a second step, only those events during which no supportive interest rate move can be observed are considered. In addition, the condition of having no overlap in the pre- and post-event windows with other intervention episodes has to be extended in such a way that the pre-and post-event windows cannot contain either other intervention episodes or any changes in domestic or foreign reference interest rates.

Table 4: Interest Rate Moves Consistent with FX Interventions

FX interventions	Domestic interest rate	Foreign interest rate
Domestic currency sale	decrease	increase
Domestic currency purchase	increase	decrease

Finally, it is also relevant for our purposes to disentangle the effect of pure interest rate moves on the exchange rate. Against this backdrop, we construct so-called interest rate events using the same event and pre- and post-window definitions as for the FX intervention events. Success is evaluated as follows:

Leaning against the wind (breaking/reversing the trend; WIND): a domestic interest rate cut (hike) or an increase (decrease) in the foreign interest rate causes exchange rate depreciation (appreciation) instead of the appreciation (depreciation) observed in the pre-event window.

Smoothing exchange rate movements (SMOOTH): a domestic interest rate cut (hike) leads to less appreciation (depreciation) in the post-event window than in the pre-event window. Similarly, increases (decreases) in the foreign interest rate bring about less appreciation (depreciation) after the event.

Table 5: Summary of Interest Rate Moves

		Czech National Bank			Bundesbank/ECB		
		Min	Max	No. of changes	Min	Max	No. of changes
1997	Total	-10.00	3.70	25	--	--	0
	Towards appreciation	0.30	3.70	2	--	--	0
	Towards depreciation	-10.00	-0.20	23	--	--	0
1998	Total	-1.00	0.25	8	--	--	0
	Towards appreciation	0.25	0.25	1	--	--	0
	Towards depreciation	-1.00	-0.50	7	--	--	0
1999	Total	-0.75	-0.25	11	-0.50	0.50	2
	Towards appreciation	--	--	0	-0.50	-0.50	1
	Towards depreciation	-0.75	-0.25	11	0.50	0.50	1
2000	Total	--	--	0	0.25	0.50	6
	Towards appreciation	--	--	0	--	--	0
	Towards depreciation	--	--	0	0.25	0.50	6
2001	Total	-0.50	0.25	3	-0.50	-0.25	4
	Towards appreciation	0.25	0.25	1	-0.50	-0.25	4
	Towards depreciation	-0.50	-0.25	2	--	--	0
2002	Total	-0.75	-0.25	5	-0.50	-0.50	1
	Towards appreciation	--	--	0	-0.50	-0.50	1
	Towards depreciation	-0.75	-0.25	5	--	--	0
1997–2002	Total	-10.00	3.70	52	-0.50	0.50	13
	Towards appreciation	0.25	3.70	4	-0.50	-0.25	6
	Towards depreciation	-10.00	-0.20	48	0.25	0.50	7

Source: Czech National Bank, Deutsche Bundesbank and Oesterreichische Nationalbank.

Note: Towards appreciation (depreciation) means an interest rate hike (cut) by the CNB and an interest rate cut (hike) by the Bundesbank/ECB.

3.4 Results

As shown in Table 6, the number of intervention episodes in the Czech Republic varies between 29 (maximum 2 days of no intervention) and 18 (maximum 30 days of no intervention). Filtering out intervention events during which changes in the domestic and foreign reference interest rates also occurred, the number of episodes drops by 7 or 8. The number of events identified is higher for interest rate events especially for the 2-day, 5-day and 10-day definitions and decreases less when overlaps with FX interventions are filtered out. In general, the number of episodes appears to be fairly robust to the use of the 10-day, 20-day and 30-day filters for FX interventions, but is less stable for interest rate events.[15]

Table 6. Number of intervention episodes identified, 1997:06 to 2002:12

Maximum days of intervention inactivity between two consecutive interventions				
FX intervention events				
2 days	**5 days**	**10 days**	**20 days**	**30 days**
29	22	21	18	18
FX intervention events adjusted for interest rate moves				
21	14	13	11	11
Interest rate events				
51	44	41	31	20
Interest rate events adjusted for FX interventions				
41	41	35	24	13

Table 7a reports results regarding the relationship between the exchange rate and exchange rate volatility on the one hand, and FX intervention events established on the basis of 30-day no-intervention on the other hand. Marked in yellow are the pre- and post-event windows without any overlap with previous or forthcoming intervention episodes. In Table 7b we report results for intervention episodes during which no interest rate moves happened. Correspondingly, yellow cells indicate the absence of any overlap between the pre- and post-event windows and any foreign or domestic interest rate moves. Finally, Table 7c shows results for interest rate events adjusted for FX interventions. Similarly, the yellow cells in Table 7c indicate that the pre- and

[15] The source of daily foreign exchange intervention data is the Czech National Bank. The sample period spans from January 1997 to the end of 2002. Note that the CNB did not intervene on the FX market between the end of 2002 and late 2005 (when the draft of this paper was completed). The interventions are expressed in terms of domestic currency because the sample period covers the switch from the German mark to the euro. Expressing interventions in the same currency units ensures full comparability. Note also that the Czech National Bank intervened in US dollar once in July 1997. As stated in CNB (1997), the managed float was, however, oriented to the German mark. In accordance with common practice in the literature, purchases (sales) of foreign currency are positive (negative) values. Thus, purchases (sales) of domestic currencies are denoted with negative (positive) figures. The exchange rate series against the German mark and the euro are provided by the Czech National Bank. Only data for trading days are considered for the study, implying the exclusion of weekends and public holidays. For interest rates, the reference rates of the CNB, the Deutsche Bundesbank and, from 1999, the ECB are used.

post-event windows do not contain any other interest rate event or FX interventions.[16] However, summary statistics for events established using intervention inactivity between two consecutive interventions of 2, 5, 10 and 30 days are given in Tables 4 and 5.

As can be seen in Table 7a, it is very difficult to assess the effectiveness of the intervention events in 1997 and early 1998, because of the overlaps between individual events. This seems to be no problem for the second half of the period. There are only four events consisting in koruna purchases, of which two (No. 5 and No. 9) are found to be completely ineffective, one (No. 7) cannot be evaluated at all because of overlaps, and the remaining one (No. 2) appears to be leaning against the wind, i.e. reversing the depreciation over a very short time period (2 days). Koruna sales during the same period are a little more effective, but only at very short time horizons. It should be mentioned, though, that there are a number of overlapping pre- and post-window sizes for which some of the intervention events qualify as either leaning against the wind or exchange rate smoothing. The difficulty in interpreting these results, however, lies not only in that they are in an overlapping window, but also in that overlaps occur between domestic currency sales and purchases.

The second part of the period under study, from mid-1998 to end-2002, only covers intervention episodes which were all koruna sales. Not only are overlapping windows less of a problem, but also these intervention events are strikingly effective in either smoothing or reverting the appreciation of the koruna. For pre- and post-event windows greater than 2 days, out of the 43 assessable windows, only a fraction are found to be unsuccessful, and for the rest success always implies either exchange rate smoothing or leaning against the wind strategies.[17]

The elimination of intervention events coinciding with changes in key rates does not really change the conclusion for the first part of the period under consideration, but it does have implications for the period from 1999 to 2002. It appears that some of the successful events (Nos. 11, 16 and 18) drop out and that during this period the remaining intervention events can be assessed only for shorter pre- and post-event windows because of overlaps with interest rate changes.

Finally, turning to the interest rate events, two striking features merit attention. First, it turns out that all interest rate events overlap with FX interventions in the first half of the period and that it is only for 1999 to 2002 that independent interest rate events can be found. The second observation emerging from Table 7c is the relative scarcity of successful events as compared to the FX intervention episodes.

[16] Detailed results for different event sizes are not reported here. These results are, however, available from the authors upon request.

[17] Our findings roughly correspond to those reported in Holub (2004), despite differences in data frequency and definitions.

Table 7a: FX Intervention Events Based on Maximum 30 Days of no Intervention

No.	YEAR	Initial intervention	Total intervention	Days of Interventions	Total days	Next episode (days away)	Type of Intervention	PRE- AND POST-EVENT WINDOW						
								2	5	10	20	30	40	60
Exchange rate returns														
1	1997	4.082	39.010	13	16	3	SALE		WIND	WIND				
2	1997	-0.954	-4.492	4	6	2	PURCHASE	WIND	WIND	WIND	WIND		WIND	WIND
3	1997	4.792	27.843	10	14	36	SALE	SMOOTH	WIND				WIND	
4	1997	2.046	2.046	1	1	16	SALE	WIND	WIND	WIND	WIND	WIND	WITH	
5	1997	-2.134	-34.871	9	26	10	PURCHASE				WIND		WIND	WIND
6	1997	1.161	7.042	3	3	8	SALE	SMOOTH	SMOOTH	WIND				
7	1998	-0.989	-4.652	3	5	1	PURCHASE	WIND	WIND	WIND	WITH	WIND	WIND	WIND
8	1998	0.196	51.453	30	56	36	SALE	WIND	WITH	WITH	WITH			
9	1998	-2.721	-2.721	1	1	24	PURCHASE							
10	1998	0.813	12.986	3	9	311	SALE	WIND	SMOOTH	SMOOTH	SMOOTH	WIND		WIND
11	1999	18.757	35.257	2	4	49	SALE		WIND	WIND	WIND	SMOOTH	SMOOTH	SMOOTH
12	1999	0.899	6.097	9	11	62	SALE		WIND	SMOOTH		SMOOTH	SMOOTH	
13	2000	11.491	13.228	3	4	164	SALE	WIND		WIND	WIND	WIND	SMOOTH	SMOOTH
14	2000	8.651	8.651	1	1	225	SALE		WIND	WIND	WIND	WIND	WIND	WIND
15	2001	12.080	14.603	2	2	38	SALE	WIND	WIND	WIND	SMOOTH	SMOOTH		
16	2001	2.332	13.064	5	25	45	SALE	WIND	WIND	SMOOTH	SMOOTH	SMOOTH	SMOOTH	SMOOTH
17	2002	11.513	31.281	5	5	61	SALE		SMOOTH	SMOOTH	WIND	WIND	WIND	SMOOTH
18	2002	1.169	28.696	28	53	50	SALE	WIND	WIND	WIND	WIND	WIND	WIND	WIND
Exchange rate volatility														
1	1997	4.082	39.010	13	16	3	SALE	LOW	LOW	LOW	LOW	LOW	LOW	LOW
2	1997	-0.954	-4.492	4	6	2	PURCHASE	LOW	LOW	HIGH	LOW	LOW	LOW	LOW
3	1997	4.792	27.843	10	14	36	SALE	LOW	LOW	LOW	LOW	LOW	LOW	LOW
4	1997	2.046	2.046	1	1	16	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
5	1997	-2.134	-34.871	9	26	10	PURCHASE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
6	1997	1.161	7.042	3	3	8	SALE	LOW	LOW	LOW	LOW	HIGH	LOW	LOW
7	1998	-0.989	-4.652	3	5	1	PURCHASE	LOW	HIGH	LOW	LOW	LOW	LOW	LOW
8	1998	0.196	51.453	30	56	36	SALE	HIGH	HIGH	HIGH	LOW	LOW	HIGH	HIGH
9	1998	-2.721	-2.721	1	1	24	PURCHASE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
10	1998	0.813	12.986	3	9	311	SALE	LOW	LOW	LOW	LOW	HIGH	HIGH	HIGH
11	1999	18.757	35.257	2	4	49	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
12	1999	0.899	6.097	9	11	62	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	LOW	LOW
13	2000	11.491	13.228	3	4	164	SALE	LOW	LOW	HIGH	HIGH	HIGH	HIGH	HIGH
14	2000	8.651	8.651	1	1	225	SALE	HIGH	LOW	HIGH	HIGH	LOW	HIGH	HIGH
15	2001	12.080	14.603	2	2	38	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
16	2001	2.332	13.064	5	25	45	SALE	LOW	LOW	LOW	LOW	LOW	LOW	LOW
17	2002	11.513	31.281	5	5	61	SALE	LOW	LOW	LOW	HIGH	HIGH	HIGH	HIGH
18	2002	1.169	28.696	28	53	50	SALE	HIGH	HIGH	LOW	LOW	LOW	LOW	LOW

Note: SMOOTH = exchange rate smoothing, WIND = leaning against the wind, WITH = leaning with the wind, HIGH (LOW) indicates that the unconditional volatility in the post-event window is higher (lower) than in the pre-event window.

Table 7b:FX Intervention Events Based on Maximum 30 Days of no Intervention, no Overlap with Interest Rate Moves

No.	YEAR	Initial intervention	Total intervention	Days of Interventions	Total days	Next episode (days away)	Type of Intervention	PRE- AND POST-EVENT WINDOW						
								2	**5**	**10**	**20**	**30**	**40**	**60**
Exchange rate returns														
2	1997	-0.954	-4.492	4	6	2	PURCHASE	WIND	WIND	WIND	WIND	WITH	WIND	WIND
4	1997	2.046	2.046	1	1	16	SALE	WIND	WIND	WIND	WIND	WIND		
7	1998	-0.989	-4.652	3	5	1	PURCHASE	WIND	WIND	WIND		WIND	WIND	WIND
8	1998	0.196	51.453	30	56	36	SALE	WIND						
9	1998	-2.721	-2.721	1	1	24	PURCHASE							
10	1998	0.813	12.986	3	9	311	SALE	WIND	SMOOTH	SMOOTH	SMOOTH	WIND		WIND
12	1999	0.899	6.097	9	11	62	SALE		WIND	SMOOTH		SMOOTH	SMOOTH	
13	2000	11.491	13.228	3	4	164	SALE	WIND		WIND	WIND	WIND	SMOOTH	SMOOTH
14	2000	8.651	8.651	1	1	225	SALE		WIND	WIND	WIND	WIND	WIND	WIND
15	2001	12.080	14.603	2	2	38	SALE	WIND	WIND	WIND	SMOOTH	SMOOTH		
17	2002	11.513	31.281	5	5	61	SALE		SMOOTH	SMOOTH	WIND	WIND	WIND	SMOOTH
Exchange rate volatility														
2	1997	-0.954	-4.492	4	6	2	PURCHASE	LOW	LOW	HIGH	LOW	LOW	LOW	LOW
4	1997	2.046	2.046	1	1	16	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
7	1998	-0.989	-4.652	3	5	1	PURCHASE	LOW	HIGH	LOW	LOW	LOW	LOW	LOW
8	1998	0.196	51.453	30	56	36	SALE	HIGH	HIGH	HIGH	LOW	LOW	HIGH	HIGH
9	1998	-2.721	-2.721	1	1	24	PURCHASE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
10	1998	0.813	12.986	3	9	311	SALE	LOW	LOW	LOW	LOW	HIGH	HIGH	HIGH
12	1999	0.899	6.097	9	11	62	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	LOW	LOW
13	2000	11.491	13.228	3	4	164	SALE	LOW	LOW	HIGH	HIGH	HIGH	HIGH	HIGH
14	2000	8.651	8.651	1	1	225	SALE	HIGH	LOW	HIGH	HIGH	LOW	HIGH	HIGH
15	2001	12.080	14.603	2	2	38	SALE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
17	2002	11.513	31.281	5	5	61	SALE	LOW	LOW	LOW	HIGH	HIGH	HIGH	HIGH

Note: SMOOTH = exchange rate smoothing, WIND = leaning against the wind, WITH = leaning with the wind, HIGH (LOW) indicates that the unconditional volatility in the post-event window is higher (lower) than in the pre-event window.

Table 7c: Interest Rate Events Based on Maximum 30 Days of no Intervention, no Overlap with FX interventions

No.	YEAR	Initial intervention	Total intervention	Days of Interventions	Total days	Next episode (days away)	Type of Intervention	PRE- AND POST-EVENT WINDOW						
								2	5	10	20	30	40	60
Exchange rate returns														
6	1999	0.5	0.5	1	1	13	APPR	WIND			WIND	WIND		
7	1999	-0.3	-0.3	1	1	37	DEPR	WIND	WIND	WIND	WIND	SMOOTH		
9	2000	-0.3	-1.3	4	89	53	DEPR	WIND	WIND					
10	2000	-0.3	-0.5	2	25	95	DEPR					SMOOTH	SMOOTH	SMOOTH
11	2001	-0.3	-0.3	1	1	51	DEPR					WIND		
12	2001	0.3	0.3	1	1	52	APPR							
13	2001	0.3	1.0	3	38	36	APPR	SMOOTH		WIND	WIND			
14	2001	0.5	0.5	1	1	14	DEPR			WIND				
15	2001	-0.5	-0.5	1	1	32	DEPR							
17	2002	-0.5	-0.5	1	1	40	DEPR				WIND	WIND	SMOOTH	SMOOTH
18	2002	-0.8	-0.8	1	1	89	DEPR				WIND	WIND	WIND	WIND
19	2002	-0.3	-0.3	1	1	24	DEPR	WIND	WIND					
20	2002	0.5	0.5	1	1	46	APPR			SMOOTH		SMOOTH	SMOOTH	SMOOTH
Exchange rate volatility														
6	1999	0.5	0.5	1	1	13	APPR	HIGH	HIGH	HIGH	LOW	LOW	LOW	LOW
7	1999	-0.3	-0.3	1	1	37	DEPR	HIGH	HIGH	HIGH	HIGH	LOW	LOW	LOW
9	2000	-0.3	-1.3	4	89	53	DEPR	LOW	LOW	HIGH	HIGH	HIGH	HIGH	HIGH
10	2000	-0.3	-0.5	2	25	95	DEPR	LOW	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
11	2001	-0.3	-0.3	1	1	51	DEPR	LOW	LOW	HIGH	LOW	LOW	LOW	LOW
12	2001	0.3	0.3	1	1	52	APPR	LOW	LOW	LOW	LOW	LOW	LOW	LOW
13	2001	0.3	1.0	3	38	36	APPR	HIGH	HIGH	HIGH	LOW	HIGH	HIGH	HIGH
14	2001	0.5	0.5	1	1	14	DEPR	HIGH	HIGH	LOW	LOW	HIGH	HIGH	HIGH
15	2001	-0.5	-0.5	1	1	32	DEPR	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
17	2002	-0.5	-0.5	1	1	40	DEPR	HIGH	HIGH	HIGH	LOW	LOW	LOW	HIGH
18	2002	-0.8	-0.8	1	1	89	DEPR	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
19	2002	-0.3	-0.3	1	1	24	DEPR	HIGH	HIGH	HIGH	LOW	LOW	LOW	LOW
20	2002	0.5	0.5	1	1	46	APPR	LOW	LOW	LOW	LOW	LOW	LOW	LOW

Note: SMOOTH = exchange rate smoothing, WIND = leaning against the wind, WITH = leaning with the wind, HIGH (LOW) indicates that the unconditional volatility in the post-event window is higher (lower) than in the pre-event window.

Table 8a shows that these results are not particularly sensitive to the definition of the intervention events (the number of days of no intervention activity between two single intervention acts). A general observation is that as the pre- and post-event window size increases, the number of assessable periods drops significantly. However, when assessable, the share of successes amount to around 80% for pre- and post-event windows of 2, 5, 10 or 20 days and even to 100% for pre- and post-event windows of 30, 40 and 60 days. The share of leaning against the wind episodes dominates exchange rate smoothing for short pre- and post-event windows, but the domination transforms into exchange rate smoothing for long pre- and post-event windows. This indicates that it is easier to reverse the exchange rate trend in the short run than at 30-day or longer horizons.

The results of the sign bias test largely confirm these findings. The null of random exchange rate changes is rejected at conventional statistical significance levels in a number of cases. In particular, it is found that FX interventions result in leaning against the wind outcomes at shorter time horizons. For the 5-day pre- and post-event windows, this holds for all the event definitions. In addition, the 2-day and 5-day event definitions also reveal leaning against the wind exchange rate movements for the 2-day, 10-day and 20-day pre- and post-event windows. Exchange rate smoothing turns out to be statistically significant at the 30 and 40-day pre- and post-event windows. It is worth noting that these results are mainly due to the observations for the period 1999 to 2002, i.e. when koruna sales took place, because koruna purchases either cannot be assessed on the grounds of overlaps with previous ones or are just not successful. Dropping the latter observation would strengthen the statistical results even further.

However, these results no longer hold once the events overlapping with interest rate changes are removed from the sample. First, it often happens that the 40- and 60-day pre- and post-event windows cannot be assessed. Second, the share of exchange rate smoothing is very low irrespective of the size of the pre- and post-event windows. Finally, although leaning against the wind dominates successful events, the sign bias test cannot reject the null of random exchange rate changes.

All this implies that FX interventions alone are not capable of systematically influencing the exchange rate. Now, the question this raises is whether or not the strong finding for FX intervention events also encompassing changes in key policy rates is due to the changes in key rates. The answer to this question is given in Table 8c, and it is a clear no, as no robust exchange rate smoothing and against the wind outcomes can be found for interest rate events for alternative event and pre- and post-event window definitions. Hence, interest rate events alone are not in a position to systematically influence the exchange rate, either.

Table 8a: FX Intervention Events

	EVENT SIZE	PRE- AND POST-EVENT WINDOW						
		2	5	10	20	30	40	60
2 DAYS	TOTAL EPISODES	29	29	29	29	29	29	29
	ASSESSABLE (% of total)	93%	55%	38%	24%	21%	17%	7%
	AGAINST (% of assessable)	72%	67%	80%	80%	50%	40%	50%
	SIGN TEST (p-value)	**0.015**	**0.097**	**0.037**	**0.083**	0.500	0.659	0.500
	SMOOTH (% of assessable)	6%	33%	40%	20%	50%	60%	50%
	SIGN TEST (p-value)	0.999	0.110	**0.037**	0.692	**0.028**	**0.018**	0.195
5 DAYS	TOTAL EPISODES	22	22	22	22	22	22	22
	ASSESSABLE (% of total)	77%	77%	68%	36%	27%	23%	9%
	AGAINST (% of assessable)	69%	71%	67%	67%	50%	40%	50%
	SIGN TEST (p-value)	**0.069**	**0.051**	*0.104*	0.185	0.500	0.662	0.500
	SMOOTH (% of assessable)	8%	29%	33%	33%	50%	60%	50%
	SIGN TEST (p-value)	0.994	0.259	0.117	0.199	**0.028**	**0.017**	0.196
10 DAYS	TOTAL EPISODES	21	21	21	21	21	21	21
	ASSESSABLE (% of total)	90%	76%	71%	38%	29%	24%	10%
	AGAINST (% of assessable)	60%	69%	67%	67%	50%	40%	50%
	SIGN TEST (p-value)	0.198	**0.074**	*0.104*	0.185	0.500	0.662	0.500
	SMOOTH (% of assessable)	13%	31%	33%	33%	50%	60%	50%
	SIGN TEST (p-value)	0.975	0.176	0.117	0.199	**0.028**	**0.017**	0.196
20/30 DAYS	TOTAL EPISODES	18	18	18	18	18	18	18
	ASSESSABLE (% of total)	89%	72%	61%	56%	44%	33%	11%
	AGAINST (% of assessable)	58%	70%	60%	63%	50%	50%	50%
	SIGN TEST (p-value)	0.266	**0.087**	0.261	0.213	0.500	0.500	0.500
	SMOOTH (% of assessable)	17%	30%	40%	38%	50%	50%	50%
	SIGN TEST (p-value)	0.891	0.242	**0.036**	**0.065**	**0.013**	**0.028**	0.196

Table 8b: FX Intervention Events Adjusted for Interest Rate Moves

	EVENT SIZE	PRE- AND POST-EVENT WINDOW						
		2	5	10	20	30	40	60
2 DAYS	TOTAL EPISODES	21	21	21	21	21	21	21
	ASSESSABLE (% of total)	81%	52%	29%	10%	5%	0%	0%
	AGAINST (% of assessable)	53%	55%	67%	50%	100%	--	--
	SIGN TEST (p-value)	0.407	0.385	0.225	0.500	--	--	--
	SMOOTH (% of assessable)	0%	27%	17%	0%	0%	--	--
	SIGN TEST (p-value)	0.999	0.385	0.775	0.804	--	--	--
5 DAYS	TOTAL EPISODES	14	14	14	14	14	14	14
	ASSESSABLE (% of total)	79%	71%	57%	29%	14%	7%	7%
	AGAINST (% of assessable)	55%	60%	63%	25%	50%	100%	100%
	SIGN TEST (p-value)	0.385	0.272	0.250	0.805	0.500	--	--
	SMOOTH (% of assessable)	0%	20%	25%	25%	50%	0%	0%
	SIGN TEST (p-value)	0.996	0.728	0.500	0.500	0.196	--	--
10 DAYS	TOTAL EPISODES	13	13	13	13	13	13	13
	ASSESSABLE (% of total)	77%	69%	62%	15%	8%	0%	0%
	AGAINST (% of assessable)	50%	56%	63%	50%	100%	--	--
	SIGN TEST (p-value)	0.500	0.375	0.250	0.500	--	--	--
	SMOOTH (% of assessable)	0%	22%	25%	0%	0%	--	--
	SIGN TEST (p-value)	0.994	0.625	0.500	0.804	--	--	--
20/30 DAYS	TOTAL EPISODES	11	11	11	11	11	11	11
	ASSESSABLE (% of total)	73%	64%	55%	18%	9%	0%	0%
	AGAINST (% of assessable)	50%	57%	50%	50%	100%	--	--
	SIGN TEST (p-value)	0.500	0.358	0.500	0.500	--	--	--
	SMOOTH (% of assessable)	0%	14%	33%	0%	0%	--	--
	SIGN TEST (p-value)	0.987	0.946	0.775	0.804	--	--	--

Table 8c: Interest Rate Events Adjusted for FX Interventions

EVENT SIZE		PRE- AND POST-EVENT WINDOW						
		2	5	10	20	30	40	60
2/5 DAYS	TOTAL EPISODES	41	41	41	41	41	41	41
	ASSESSABLE (% of total)	90%	83%	68%	37%	5%	2%	0%
	AGAINST (% of assessable)	24%	21%	29%	13%	50%	0%	--
	SIGN TEST (p-value)	0.976	0.999	0.978	0.991	0.250	--	--
	SMOOTH (% of assessable)	14%	12%	14%	27%	50%	100%	--
	SIGN TEST (p-value)	0.994	0.997	0.978	0.302	*0.102*	--	--
10 DAYS	TOTAL EPISODES	35	35	35	35	35	35	35
	ASSESSABLE (% of total)	97%	91%	89%	43%	9%	6%	0%
	AGAINST (% of assessable)	21%	19%	26%	13%	33%	0%	--
	SIGN TEST (p-value)	0.998	0.999	0.992	0.999	0.500	0.750	--
	SMOOTH (% of assessable)	12%	9%	13%	27%	33%	50%	--
	SIGN TEST (p-value)	0.997	0.999	0.992	0.302	0.147	*0.102*	--
20 DAYS	TOTAL EPISODES	24	24	24	24	24	24	24
	ASSESSABLE (% of total)	100%	92%	96%	83%	17%	17%	0%
	AGAINST (% of assessable)	25%	18%	30%	20%	75%	25%	--
	SIGN TEST (p-value)	0.984	0.995	0.949	0.989	**0.091**	0.698	--
	SMOOTH (% of assessable)	8%	5%	9%	25%	25%	50%	--
	SIGN TEST (p-value)	0.998	0.999	0.996	0.410	0.301	**0.032**	--
30 DAYS	TOTAL EPISODES	13	13	13	13	13	13	13
	ASSESSABLE (% of total)	100%	92%	92%	77%	62%	46%	0%
	AGAINST (% of assessable)	31%	25%	25%	30%	38%	17%	--
	SIGN TEST (p-value)	0.864	0.920	0.920	0.828	0.420	0.881	--
	SMOOTH (% of assessable)	8%	0%	8%	0%	13%	33%	--
	SIGN TEST (p-value)	0.980	0.996	0.970	0.993	0.852	0.119	--

It comes as no surprise that exchange rate interventions are more efficient when accompanied by changes in interest rates. A big reason for this is that the interest rate moves included in the FX intervention events are mostly in line with the underlying intervention such as outlined in Table 6. Table 9 below shows the overlaps between intervention episodes and changes in key policy rates for the 30-day event definition and indicates whether the interest rate changes are consistent with the FX intervention.[18] Note that the conclusion is very much the same for the different event definitions and even if interest rate events are matched with FX interventions (not reported here). Figure 4 also gives an idea of how FX interventions are surrounded by changes in key policy rates.

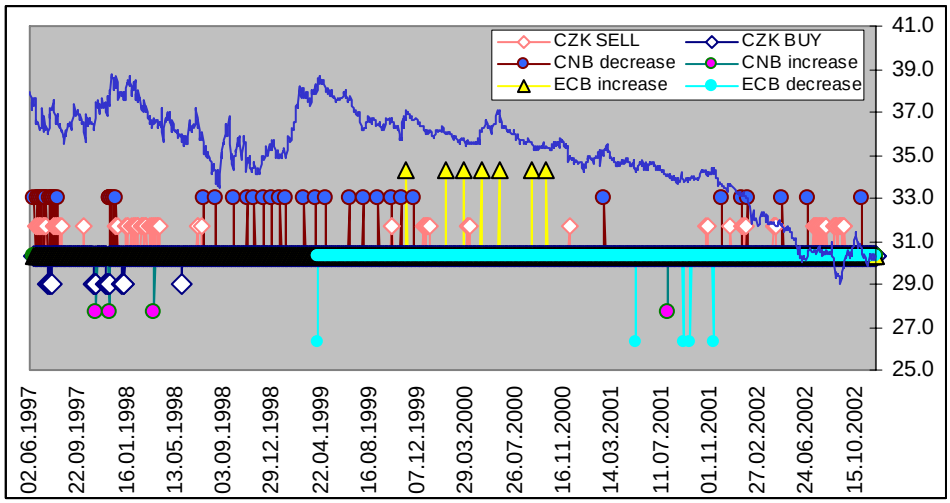
Table 9: Consistency of FX Events with Interest Rate Changes, 30-day Event Definition

No. of event	Date	FX intervention	Interest move	Consistent
1	17.6.97–8.7.97	SALE	CNB ↓	YES
2	14.7.97–21.7.97	PURCHASE	CNB ↓	NO
3	24.7.97–12.8.97	SALE	CNB ↓	YES
5	27.10.97–1.12.97	PURCHASE	CNB ↑	YES
6	16.12.97–18.12.97	SALE	CNB↓	YES
8	14.1.98–1.4.98	SALE	CNB ↑	NO
11	4.10.99–7.10.99	SALE	CNB ↓	YES
16	20.12.01–29.1.02	SALE	CNB ↓	YES
18	10.7.02–20.9.02	SALE	CNB ↓	YES

Note: The events correspond to those reported in Table 7a.

[18] Holub (2004) looks at whether interest rate moves are consistent with the (deviations from the) inflation target.

Figure 4: FX Interventions and Changes in Key Policy Rates, 1997–2002



Regarding the unconditional exchange rate volatility (measured by standard deviations), interventions are associated with both increases and decreases in volatility (Tables 7a and 7b). There are episodes for which whether or not the volatility increases or decreases hinges largely upon the size of the pre- and post-event window. For a number of episodes, especially in 1998 and 1999, interventions systematically cause exchange rate volatility to increase, while in 2001 and 2002, they tend to dampen forex volatility. Tables 10a and 10b summarise these results in a more systematic way, and suggests that for short pre- and post-event windows, the share of intervention episodes for which forex volatility increased equals that of the episodes followed by lower forex volatility. However, in the longer term (up to 60 days), foreign exchange interventions tend to be associated with a rise rather than a drop in foreign exchange volatility.

According to Table 10a, higher volatility tends to be statistically significant for the 20-day and 30-day pre- and post-event windows, while lower volatility never shows up as statistically significant (not reported here). This implies that FX interventions may lead to higher FX volatility at longer horizons. However, this relationship seems to break down once intervention events incorporating interest rate moves are dropped (Table 10b).

Table 10a: Intervention Episodes and Unconditional Exchange Rate Volatility

	EVENT SIZE	PRE- AND POST-EVENT WINDOW						
		2	5	10	20	30	40	60
2 DAYS	HIGH (% of assessable)	44%	56%	73%	100%	83%	80%	100%
	SIGN TEST (p-value)	0.730	0.319	**0.079**	**0.019**	**0.082**	0.127	0.195
5 DAYS	HIGH (% of assessable)	59%	53%	67%	88%	83%	80%	100%
	SIGN TEST (p-value)	0.235	0.403	*0.104*	**0.035**	**0.082**	0.124	0.196
10 DAYS	HIGH (% of assessable)	47%	50%	67%	88%	83%	80%	100%
	SIGN TEST (p-value)	0.601	0.500	*0.104*	**0.035**	**0.082**	0.124	0.196
20/30 DAYS	HIGH (% of assessable)	50%	54%	64%	70%	63%	67%	100%
	SIGN TEST (p-value)	0.500	0.388	0.186	0.116	0.245	0.222	0.196

Notes: The total number of episodes and the share of non-overlapping assessable episodes are reported in Table 4a.

Table 10b: Intervention Episodes and Unconditional Exchange Rate Volatility

	EVENT SIZE	PRE- AND POST-EVENT WINDOW						
		2	5	10	20	30	40	60
2 DAYS	HIGH (% of assessable)	41%	55%	67%	100%	0%	--	--
	SIGN TEST (p-value)	0.762	0.385	0.225	0.196	--	--	--
5 DAYS	HIGH (% of assessable)	55%	50%	63%	100%	50%	100%	100%
	SIGN TEST (p-value)	0.385	0.500	0.250	**0.069**	0.500	--	--
10 DAYS	HIGH (% of assessable)	50%	44%	63%	100%	0%	--	--
	SIGN TEST (p-value)	0.500	0.625	0.250	0.196	--	--	--
20/30 DAYS	HIGH (% of assessable)	63%	43%	50%	50%	100%	--	--
	SIGN TEST (p-value)	0.250	0.642	0.500	0.500	--	--	--

Notes: The total number of episodes and the share of non-overlapping assessable episodes are reported in Table 4b.

4. Econometric Investigation

4.1. Interventions, Exchange Rate and Volatility

The effectiveness of foreign exchange interventions is also investigated using a GARCH framework, which is admittedly well suited for such an investigation because it analyses simultaneously the mean and conditional variance of the exchange rate series. Dominguez (1998) used a mean equation specification in which the log-difference of the exchange rate returns (Δe_t) are regressed on the intervention series (I_t), the interest differential ($i_t - i_t^*$) between overnight money market rates in the home economy and the foreign benchmark (Germany and the euro area), and dummy variables capturing day of the week effects. The conditional variance equation includes the absolute value of interventions, the interest differential and day-of-the-week dummies. We first extend this approach by distinguishing between domestic currency sales (I_t^S) and purchases (I_t^P), which are allowed to enter the mean equation with lags as well. This ensures that we can capture the longer-term effect of interventions. We also include the Emerging Market Bond Index (EMBI) constructed by JP Morgan to capture the general sentiment towards emerging markets. The change in, rather than the level of, the EMBI and the interest differential are used ($\Delta EMBI_t$ and $\Delta(i_t - i_t^*)$).[19] Furthermore, lagged values of the exchange rate returns are introduced into the mean equation.

$$\Delta e_t = \phi_1 + \sum_{i=1}^{n} \phi_{2,i} I_{t-i}^P + \sum_{i=1}^{n} \phi_{2,i} I_{t-i}^S + \phi_3 \Delta(i_t - i_t^*) + \phi_4 \Delta EMBI_t + \sum_{i=1}^{m} \phi_{5,i} \Delta e_{t-i} + \sum_{i=1}^{4} \phi_{6,i} D_i + \varepsilon_t \qquad (1)$$

$$\varepsilon_t \left| \Omega_{t-1} \right. \sim N(0, \sigma^2) \qquad (2)$$

$$\sigma_t^2 = \psi_1 + \psi_2 I_t^P + \psi_3 I_t^S + \psi_4 \Delta(i_t - i_t^*) + \psi_4 \Delta EMBI_t + \psi_5 \Delta e_t + \sum_{i=1}^{4} \psi D_i + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \qquad (3)$$

[19] Overnight money market rates are drawn from Bloomberg for the Czech economy and from the Deutsche Bundesbank for Germany and the euro area. EMBI data are obtained from JP Morgan.

where I_t takes negative (positive) values for purchases (sales) of the domestic currency. D_1, D_2, D_3 and D_4 are dummy variables that take the value of 1 on Monday, Tuesday, Wednesday and Thursday respectively. ε_{t-1}^2 and σ_{t-1}^2 are the ARCH and GARCH terms.

Equations (1) and (3) are modified so as to differentiate between small and large interventions and one-day and longer intervention episodes. Large interventions are defined as interventions higher than the average of the interventions in the same direction over the whole period, and small interventions are those below the average of the interventions in the same direction. Ísberg and Pétursson (2003) suggest the use of a dummy variable which captures long intervention episodes. The dummy takes the value of 1 if a given intervention act is preceded by intervention activity in (t-1) and (t-2). In addition to the Ísberg and Pétursson dummy, we use a more loosely defined dummy which is 1 if any given intervention is preceded by intervention during one of the preceding five days, and is 0 otherwise.

It has to be acknowledged that our specification is only a partial model, in the sense that other aspects of interventions could be investigated, i.e. whether interventions were publicly announced, whether market participants were aware of an official intervention at the moment of and after the intervention, and, finally, whether and what kind of official statements strengthen or undermine the effect of FX interventions on the exchange rate.[20] A related issue is how official interventions interact with other factors, such as the arrival of macro news[21] and spillover effects between FX, stock, money and bond markets in the Czech Republic and from other major markets (e.g. US, UK, Germany) and regional markets (Hungary and Poland).[22] However, such extensions are beyond the scope of this paper and are left to future research.[23]

Endogeneity is an important issue at the daily frequency, as, in accordance with professional wisdom, central banks usually intervene in response to changes in the exchange rate, and the exchange rate may in turn be affected by the interventions. Neely (2005) has recently criticised all the commonly used estimation methods on these grounds.[24] However, Fratzscher (2005) argues

[20] Beine et al. (2004) analyse the influence of commenting on and confirming statements of official FX interventions for the DEM(EUR)/USD and JPY/USD currency pairs.

[21] Disyatat and Galati (2005) report results for the unexpected component of macro news (related to the CPI, retail sales and industrial production) in the daily FX equation, in which instrumented interventions are also employed on the right-hand side for the period from 2001 to 2002. FX volatility is not affected by macro news, while news on the CPI and industrial production is found to be weakly statistically significant at the 10% level and retail sales at the 5% level for exchange rate returns.

[22] Ehrmann et al. (2005) study the spillover across markets for the US and the euro area without taking into account official FX interventions for the FX market.

[23] To approach this question from a different angle, we could ask what would have happened to the exchange rate if no intervention had taken place. However, we could at best guess rather than quantify systematically such effects, so we leave them to the reader's imagination.

[24] Although very simple, the use of lagged interventions does not help circumvent simultaneity. Another method consists in estimating a reaction function of the central bank in which the probability of intervening depends on the distance of the exchange rate and its volatility from a target value. The fitted value for interventions is then plugged into an equation of the type of (1). However, the coefficient estimates (intervention => FX) will be mitigated if the reaction function has a weak explanatory power (as appears to be the case in Disyatat and Galati, 2005). The method proposed by Kearns and Rigobon (2005), which is tantamount to using structural breaks for the identification of structural parameters in a system of equations (VAR), has received criticism from Neely (2005) that such a model may be potentially unstable.

that endogeneity causes a downward bias in the coefficient estimates and therefore the contemporaneous impact of FX interventions on the exchange rate estimated in the presence of endogeneity provides a lower bound estimate for the coefficient.[25]

Bearing this in mind, we simply estimate the contemporaneous and lagged coefficients for the intervention series. The equations presented thus far rest on a GARCH (1,1) model. In order to check for robustness to the model specification and to look at possible asymmetries in the conditional variance equation, a number of alternative GARCH models are also used for the econometric investigation, namely (a) the exponential GARCH (EGARCH), (b) the threshold GARCH (TGARCH) and (c) the component GARCH (CGARCH).

For the sake of model selection, we adopt the following testing strategy. First, we allow up to 10 lags to be included for interventions and exchange rate returns by letting the Akaike information criterion pick out the optimal lag length for the mean equation. The different GARCH models estimated for the chosen mean equation are then compared in two ways. First, the Akaike and Schwarz information criteria are employed. Second, the ARCH (α) and GARCH (β) terms, the asymmetric term (λ) for the threshold and exponential GARCH models and the short-term ρ and δ terms for the component GARCH model are analysed in terms of statistical significance.

4.2 Estimation Results

The estimations are carried out for the entire period (1997:06–2002:12) and for two sub-periods. The first sub-period covers the aftermath of the currency crisis and runs from 1997:06 to 1998:05. The second sub-period – from 1998:06 to 2002:12 – is the period when only koruna sales took place, in order to slow down the nominal appreciation. The two sub-periods are further narrowed down by including only 30 observations for the exchange rate preceding (following) the first (last) observation for the interventions series.

For the whole period, the estimation results[26], reported in Table 11, indicate that while contemporaneous koruna purchases have no effect on the exchange rate, one-day lagged koruna purchases are correlated significantly with changes in the exchange rate. However, the relationship is negative, and this implies that koruna purchases are linked to currency depreciation

[25] For intraday data, say at 5-minute ticks, simultaneity is less of a problem, as interventions and changes in the exchange rate can be disentangled properly. Nonetheless, only very-short term effects can be detected in such a framework, even though the impact of FX interventions on the exchange rate is thought to take effect in a couple of days.

[26] The model selection turns out to be tricky, especially for the first sub-period. For the first specification (with separate koruna sales and purchases), both the Akaike and Schwarz information criteria choose the simple GARCH model. However, $\alpha < 0$ disqualifies this model, and the EGARCH model is chosen instead, as its structural parameters are the most acceptable among the three remaining models. For the second specification (including small and large koruna sales and purchases), although the Schwarz information criterion points to the GARCH model, the ARCH term (α) is not significant. Hence, the EGARCH model is taken instead, as also advocated by the Akaike information criterion. For the entire period, there is disagreement between the two information criteria for the first specification. We retain the GARCH model (chosen by the Schwarz info criterion) because the threshold term of the TGARCH model (chosen by Akaike) is not significant. For the second specification, both information criteria point in the direction of EGARCH. The easiest decision is for the second sub-period, as the simple GARCH model is chosen unanimously by all the criteria.

rather than to a nominal appreciation as we would have expected.[27] This finding remains unchanged when looking at the first sub-period from 1997 to 1998. The decomposition of interventions into small and large purchases[28], used in specification No. 2. suggests that both large and small koruna purchases are negatively linked to the exchange rate returns. While this suggests failure, the dummy variable capturing the length of the intervention period (D_t^{P-LONG}) is found to be statistically significant and to bear a negative sign from 1997 to 1998, which indicates that longer koruna purchases yield an appreciation of the koruna after all.

Coming now to koruna sales, they are mostly insignificant both for the whole period and for the first sub-period, with a few exceptions when koruna sales are significant with a negative sign, meaning that koruna sales go hand in hand with an appreciation of the exchange rate. This also points in the direction of failure. D_t^{S-LONG} also becomes negative for the first sub-period, and this largely confirms the previous story.

Let us now turn to the sub-period running from 1998 to 2002, which contains only koruna sales. During this period, koruna sales in specification 1 and only large koruna sales specification 2 enter significantly and with a positive sign. Hence, koruna sales seem to have the expected effect on the exchange rate by leading to a depreciation. The length of the intervention (D_t^{S-LONG}) does not seem to play a role. Finally, changes in the interest differential are systematically insignificant across all specifications and periods. The EMBI, reflecting overall emerging market riskiness, is found significant with a positive sign for the first sub-period when using aggregated intervention data. Although this finding is not very robust, it may indicate that the exchange rate changes may have been partly driven by changes in overall market sentiment: an increase in the EMBI indicates an increase in overall risk perception, which in turn leads to a domestic currency depreciation.

We now analyse the relationship between interventions and exchange rate volatility. According to the conditional variance equations reported in Table 11, it is fair to say that koruna sales and purchases tend to be associated with an increase in forex volatility. In particular, koruna purchases turn out to lead to higher volatility in the first sub-period, whereas koruna sales have the same effect from 1998 to 2002. At the same time, koruna sales during the first sub-period appear to be linked to lower FX volatility. Nevertheless, these observations should be treated with caution, given that these relationships are not very robust for either specification.

Although the econometric estimations broadly confirm the results of the event study approach, there are some apparent discrepancies. First, estimations show only a short-lived (up to two days) impact of FX interventions on the exchange rate. Second, the interest differential is not significant in the estimations. This may be – as already noted earlier - due to the large number of observations for the exchange rate without interventions. A straightforward extension for future

[27] Koruna purchases (sales) are denoted by negative (positive) figures. As the exchange rate is defined in foreign currency terms (a decrease (increase) indicates an appreciation (depreciation)), a positive relationship between koruna purchases (sales) and the exchange rate indicates that purchases (sales) cause the exchange rate to appreciate (depreciate). A negative relationship implies that purchases (sales) lead to a currency depreciation (appreciation).

[28] Large interventions are defined as interventions higher than the average of the interventions over the whole period, and small interventions are those below the average. For purchases (sales), average purchases (sales) are used. Thus, what is large is defined by comparison with the average of the interventions in the same direction.

research would be to combine the event study with econometric estimations by only looking at exchange rates preceding or following by up to, say, 40 days intervention acts.

One may ask how these results compare with those reported in Disyatat and Galati (2005). Our results for the mean equation contradict with their results, as we find that FX interventions have a statistically significant impact on the exchange rate. This may be due to the omission of macroeconomic news from our estimations. However, other factors may also explain this divergence. First, weak instruments may also cause the failure of Disyatat and Galati (2005) to find that FX interventions are not successful. Second, their estimation results obtained from 2001 to 2002 may be considerably weakened by the fact that only three observations for FX intervention are available for 2001.

Table 11: Estimation Results

SPECIFICATION 1				SPECIFICATION 2			
	1997–2002 GARCH	**1997–1998 EGARCH**	**1998–2002 GARCH**		**1997–2002 GARCH**	**1997–1998 EGARCH**	**1998–2002 GARCH**
	MEAN EQUATION				**MEAN EQUATION**		
I_t^P	0.000	0.000		$I_t^{P\_LARGE}$	0.001	-0.001**	
I_{t-1}^P	-0.001***	-0.001***		$I_{t-1}^{P\_LARGE}$	-0.001***		
				$I_t^{P\_SMALL}$	-0.001	-0.002***	
				$I_{t-1}^{P\_SMALL}$	-0.002**		
I_t^S	0.000	-0.0004**	0.0005*	$I_t^{S\_LARGE}$	0.000	0.000	0.001*
I_{t-1}^S	0.000	-0.0001		$I_{t-1}^{S\_LARGE}$	0.000		0.000
				$I_t^{S\_SMALL}$	0.001	0.001	0.002
				$I_{t-1}^{S\_SMALL}$	-0.001*		-0.002
				$D_t^{P\_LONG}$	0.002	-0.005**	
				$D_t^{S\_LONG}$	-0.001	-0.002***	-0.001
$\Delta(i_t - i_t^*)$	0.001	-0.001	0.002	$\Delta(i_t - i_t^*)$	0.000	-0.001	0.002
$\Delta EMBI_t$	0.009**	0.011*	0.008	$\Delta EMBI_t$	0.008	0.002	0.007
	VARIANCE EQUATION				**VARIANCE EQUATION**		
I_t^P	-5.23^{E}-06*	-0.090**		$I_t^{P\_LARGE}$	-0.295**	0.236***	
				$I_t^{P\_SMALL}$	-0.445	1.323***	
I_t^S	2.64^{E}-06*	0.014	8.16^{E}-06**	$I_t^{S\_LARGE}$	0.105**	0.125*	0.000
				$I_t^{S\_SMALL}$	0.272	0.439**	0.000
				$D_t^{P\_LONG}$	-1.044	2.650***	0.000
				$D_t^{S\_LONG}$	-0.265	-1.052***	
$\Delta(i_t - i_t^*)$	0.000	-0.350	0.000	$\Delta(i_t - i_t^*)$	0.058	-0.289	0.000
$\Delta EMBI_t$	0.000**	0.753	0.000	$\Delta EMBI_t$	3.310***	-1.344	0.000

Notes: I^{large} I^{small} stand for large and small interventions, $I^{purchase}$ and I^{sales} denote domestic currency purchases and sales, $I^{P-large}$ $I^{P-small}$ $I^{S-large}$ and $I^{S-small}$ refer to large and small domestic currency purchases (P) and sales (S) respectively. D^{P-long} and D^{S-long} are dummy variables capturing prolonged intervention periods of domestic currency purchases (P) and sales (S). *, ** and *** denote statistical significance at the 10%, 5% and 1% level respectively.

5. Concluding Remarks

This paper analysed the impact of foreign exchange interventions in the Czech Republic from 1997 to 2002. The event study approach showed that foreign exchange interventions of the Czech National Bank were not particularly effective in the aftermath of the currency crisis from 1997 to mid-1998. Importantly, koruna purchases seem to be almost always rather ineffective, whereas koruna sales result in exchange rate smoothing or leaning against the wind in the very short run. GARCH estimation results broadly confirm these results as koruna purchases are usually associated not with an appreciation but with a depreciation of the koruna. Koruna sales have either no impact or are associated with an appreciation of the exchange rate from 1997 to 1998, signalling failure. However, from mid-1998 to 2002, the interventions - exclusively koruna sales - turn out to be more successful in reversing the appreciation trend of the koruna in the short run and in smoothing the exchange rate at longer horizons up to 60 days. The econometric evidence indicates that koruna sales have a positive relationship with the exchange rate from mid-1998 to 2002.

However, our analysis also shows that the effectiveness of FX interventions is closely linked to interest rate policy as intervention episodes excluding changes in key policy rates seem to be ineffective from a statistical viewpoint. Interestingly, the same conclusion can be drawn for interest rate events adjusted for the effects of FX interventions. This indicates that a well coordinated interest rate and FX intervention policies may lead to more satisfactory outcomes when interest and FX intervention policies are coordinated rather than when they are relied on separately or in a uncoordinated way.

As a side effect of FX interventions, it seems that on average, interventions combined with interest rate changes tend to generate more exchange rate volatility from 30 up to 60 days after the interventions took place.

Overall, our results suggest that Czech monetary authorities were capable of altering the level of the exchange rate, particularly when trying to dampen appreciation pressures (rather than fighting against currency depreciation) in the second half of the period studied. However, this necessitated a careful coordination of FX intervention and interest rate policies.

References

AGUILAR, J., AND S. NYDAHL (2000): "Central Bank Intervention and Exchange Rates: The Case of Sweden". *Journal of International Financial Markets, Institutions and Money,* 10, 303–322.

AKINZI, Ö., O. Y. ÇULHA, Ü. ÖZLALE AND G. ŞAHINBEYOĞLU (2005a): "Causes and Effectiveness of Foreign Exchange Interventions for the Turkish Economy". Central Bank of the Republic of Turkey Research Department Working Paper No. 5.

AKINZI, Ö., O. Y. ÇULHA, Ü. ÖZLALE AND G. ŞAHINBEYOĞLU (2005b): "The Effectiveness of Foreign Exchange Interventions for the Turkish Economy: A Post-Crisis Period Analysis". Central Bank of the Republic of Turkey Research Department Working Paper No. 6.

BANK FOR INTERNATIONAL SETTLEMENTS (2005): *Foreign Exchange Market Intervention in Emerging Markets: Motives, Techniques and Implications.*

BEINE, M., G. JANSSEN AND C. LECOURT (2004): "Should Central Bankers Talk to the FX Markets?" Mimeo.

BRANDNER, P., AND H. GRECH (2002): "Why Did Central Banks Intervene in the EMS? The Post 1993 Experience". Oesterreichische Nationalbank Working Paper 77.

BRANDNER, P., H. GRECH AND H. STIX (2001): "The Effectiveness of Central Bank Intervention in the EMS: The Post 1993 Experience". Oesterreichische Nationalbank Working Paper 55.

BRISSIMIS, S. N., AND D. P. CHIONIS (2004): "Foreign Exchange Market Intervention: Implications of Publicly Announced and Secret Intervention for the Euro Exchange Rate and its Volatility". *Journal of Policy Modeling*, 26, 661–673.

CANALES-KRILJENKO, J. I. (2003): "Foreign Exchange Intervention in Developing and Transition Economies: Results of a Survey". IMF Working Paper 95.

COATS, W. (2000): *Inflation Targeting in Transition Economies: The Case of the Czech Republic*. Prague: Czech National Bank and Washington: International Monetary Fund, http://www.cnb.cz/pdf/mmf-final.pdf.

CZECH NATIONAL BANK (1997, 1998, 1999, 2000, 2001, 2002): *Annual Report*, Prague.

DISYATAT, P., AND G. GALATI (2005): "The Effectiveness of Foreign Exchange Intervention in Emerging Market Countries: Evidence from the Czech Koruna". *BIS Working Papers*, No 172.

DOMAC, I., AND A. MENDOZA (2002): "Is There Room for Forex Interventions Under Inflation Targeting Framework?" Evidence from Mexico and Turkey, Central Bank of the Republic of Turkey Discussion Paper 58.

DOMINGUEZ, K. M. (1998): "Central Bank Intervention and Exchange Rate Volatility". *Journal of International Money and Finance*, 17, 161–190.

FRATZSCHER, M. (2005): "How Successful are Exchange Rate Communication and Interventions?" Evidence from Time Series and Event-Study Approaches, ECB Working Paper (forthcoming).

EDISON, H., P. CASHIN AND H. LIANG (2003): "Foreign Exchange Intervention and the Australian Dollar: Has it Mattered?" IMF Working Paper 99.

EHRMANN, M., M. FRATZSCHER AND R. RIGOBON (2005): "Stocks, Bonds, Money Markets and Exchange Rates: Measuring International Financial Transmission". ECB Working Paper No. 452.

FATUM, R. (2000): "On the Effectiveness of Sterilised Foreign Exchange Intervention". ECB Working Paper 10.

FATUM R. (2005): "Daily Effects of Foreign Exchange Intervention: Evidence from Official Bank of Canada Data, School of Business". University of Alberta, mimeo.

FATUM, R., AND M. HUTCHISON (2003): "Effectiveness of Official Daily Foreign Exchange Market Intervention Operations in Japan". NBER Working Paper 9648.

GUIMARAES, R., AND C. KARACADAG (2004): "The Empirics of Foreign Exchange Intervention in Emerging Market Countries: The Cases of Mexico and Turkey". IMF Working Paper 123.

HERRERA, A. M., AND P. ÖZBAY (2005): "A Dynamic Model of Central Bank Intervention". Central Bank of the Republic of Turkey Research Department Working Paper No. 1.

HOLUB, T. (2004): "Foreign Exchange Interventions Under Inflation Targeting: The Czech Experience". Czech National Bank Internal Research and Policy Note 1.

HUMPAGE, O. F. (1999): "U.S. Intervention: Assessing the Probability of Success". *Journal of Money, Credit and Banking*, 31(4), 731–747.

ÍSBERG, G. AND T.G. PÉTURSSON (2003): "Central Bank Interventions in Iceland's Foreign Exchange Market and its Effect on the Exchange Rate of the Króna" Central Bank of Iceland Monetary Bulletin No. 1, 50-74.

KEARNS, J., AND R. RIGOBON (2005): "Identifying the Efficacy of Central Bank Interventions: Evidence from Australia and Japan". *Journal of International Economics*, 66(1), 31–48.

KIM, S-J., T. KORTIAN AND J. SHEEN (2000): "Central Bank Intervention and Exchange Rate Volatility – Australian Evidence". *Journal of International Financial Markets, Institutions and Money*, 10, 381–405.

MACKINLEY, A. C. (1997): "Event Studies in Economics and Finance". *Journal of Economic Literature*, 35(1), 13–39.

MORANA, C., AND A. BELTRATTI (2000): "Central Bank Interventions and Exchange Rates: An Analysis With High Frequency Data". *Journal of International Financial Markets, Institutions and Money*, 10, 349–362.

NEELY, C. J. (2005): "An Analysis of Recent Studies of the Effect of Foreign Exchange Intervention". The Federal Reserve Bank of St. Louis Working Paper No. 30B.

RAMASWAMY, R., AND H. SAMIEI (2000): "The Yen–Dollar Rate: Have Interventions Mattered?" IMF Working Paper 95.

ROGERS, J. M., AND P. L. SIKLOS (2003): "Foreign Exchange Market Intervention in Two Small Open Economies: The Canadian and Australian Experience". *Journal of International Money and Finance*, 22, 393–416.

SARNO, L., AND M. P. TAYLOR (2001): "Official Intervention in the Foreign Exchange Market: Is It Effective, and, If So, How Does It Work?" CEPR Discussion Paper 2690.

ŠMÍDKOVA, K., J. BĚHUMEK, T. HLÉDIK, J. JÍLEK, M. KOŠTEL, I. MATALIKOVÁ, D. ROTTOVÁ AND J. STAŇKOVÁ (1998): "Koruna Exchange Rate Turbulence in May 1997" Czech National Bank Working Paper No. 2.

TAPIA, M., AND A. TOKMAN (2004): "Effects of Foreign Exchange Interventions under Public Information: The Chilean Case". Central Bank of Chile Working Paper No. 255.

APPENDIX

Table A1a: Estimation Results – Model Selection, 1997 to 2002

	Specification 1				Specification 2			
	GARCH	**TGARCH**	**EGARCH**	**CGARCH**	**GARCH**	**TGARCH**	**EGARCH**	**CGARCH**
AIC	-8.182	**-8.183**	-8.169	-8.072	-8.136	-8.118	**-8.179**	-7.870
SIC	**-8.086**	-8.084	-8.070	-7.938	-7.990	-7.968	**-8.030**	-7.671
α	0.159***	0.124***	0.285***	0.638**	0.215***	0.195***	0.268***	0.500
β	0.775***	0.790***	-0.035	0.189	0.651***	0.644***	-0.023	0.040
λ		0.059	0.936***			0.062	0.943***	
ρ				0.032				0.040
δ				0.044				0.016

Table A1b: Estimation Results – Model Selection, 1997 to 1998

	Specification 1				Specification 2			
	GARCH	**TGARCH**	**EGARCH**	**CGARCH**	**GARCH**	**TGARCH**	**EGARCH**	**CGARCH**
AIC	**-7.631**	-7.466	-7.611	-7.312	-7.551	-7.532	**-7.551**	-7.239
SIC	**-7.336**	-7.158	-7.303	-6.894	**-7.193**	-7.162	-7.182	-6.710
α	-0.002	0.148*	0.179**	0.500	0.092	0.109	0.771***	0.500
β	0.757***	0.596***	-0.085	0.040	0.631***	0.613**	-0.366***	0.040
λ		0.049	0.909***			0.036	0.381***	
ρ				0.040				0.040
δ				0.016				0.016

Table A1c: Estimation Results – Model Selection, 1998 to 2002

	Specification 1				Specification 2			
	GARCH	**TGARCH**	**EGARCH**	**CGARCH**	**GARCH**	**TGARCH**	**EGARCH**	**CGARCH**
AIC	**-8.593**	-8.594	-8.592	-8.537	**-8.587**	-8.586	-8.585	-8.444
SIC	**-8.471**	-8.466	-8.464	-8.362	**-8.435**	-8.428	-8.427	-8.226
α	0.199***	0.135**	0.242***	0.638***	0.196***	0.147**	0.212***	0.000001***
β	0.595***	0.615***	-0.083	0.174	0.597***	0.613***	-0.067	0.000
λ		0.106	0.903***			0.087	0.909***	
ρ				0.070				0.016
δ				0.000				-0.000001*

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