EFFECTIVENESS OF FOREIGN EXCHANGE INTERVENTION IN CROATIA

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ABSTRACT

The purpose of this paper is to empirically explore the effectiveness of foreign exchange intervention in Croatia. Foreign exchange intervention is the main policy instrument of the Croatian National Bank (CNB), since, due to the prevailing eurisation in Croatia, monetary policy operates primarily through the exchange rate channel. This paper describes the mechanics and implementation of foreign exchange interventions and presents their statistics. For that purpose the reaction function of the CNB is estimated. The hypothesis that the foreign exchange intervention is effective is supported with the stability of the exchange rate during the last decade, as well as their profitability. In addition, two different statistical methods are employed - the time series analysis and the event study. The event-study methodology is used to analyse the elements that influence the effectiveness of individual interventions.

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Key words: monetary policy; exchange rate; foreign exchange intervention.

1 INTRODUCTION

The Croatian National Bank in achieving its main goal of price stability relies on nominal exchange rate anchor of domestic kuna currency to euro. The exchange rate is not fixed; the CNB uses the foreign exchange interventions to manage it while allowing for some oscillation in the exchange rate. The entire monetary policy framework oriented towards achieving the exchange rate stability, and the foreign exchange interventions represent the most important policy instrument. Therefore, they need to be well understood. The purpose of this paper is to explore the effectiveness of foreign exchange interventions in Croatia.

There exists an extensive literature on foreign exchange intervention. However, it is mainly oriented to industrialised countries, especially interventions in the largest currencies: US Dollar, German Mark (Euro) and Japan Yen. Notable surveys of the literature, Dominguez and Frankel (1993), Almekinders (1995) and Sarno and Taylor (2001), explain both the channels how intervention affects the exchange rate, and discuss empirical estimation of intervention's effectiveness in major currencies. However, that literature is primarily concerned with the effects of sterilised interventions in countries with developed financial markets and circumstances different from those in the emerging markets. Furthermore, it claims that unsterilized interventions are by definition effective since such interventions change the monetary policy stance. Literature on the foreign exchange interventions in emerging markets is just emerging. Surveys by Neely (2001), Canales-Kirljenko (2003) and recent BIS' survey of intervention[1] show that interventions are common in the emerging markets. Also, they significantly differ from interventions in industrialised countries in sense that they are an important part of monetary policy, are often unsterilized and relatively large compared to overall foreign exchange markets. This study contributes to this new literature on foreign currency intervention in the emerging markets by analysing interventions in Croatia.

The structure of the paper is as follows. The second chapter describes briefly monetary policy in Croatia. Third chapter explains the foreign exchange transactions of the CNB's and interventions

in particular. Fourth chapter describes exchange rate in Croatia and analyses CNB's behaviour regarding interventions – its reaction function. Fifth chapter explores the effectiveness of the CNB's foreign exchange intervention. Three different approaches are applied: profitability of interventions, time-series methodology and event study of individual intervention episodes. The latter also allows analysing factors that contribute to intervention's effectiveness. The final chapter suggests some conclusions.

2 MONETARY POLICY FRAMEWORK IN CROATIA

It is difficult to overestimate the importance of the exchange rate in the Croatian economy. In addition to the usual small open economy characteristics – large trade openness and strong capital flows – Croatia in one of the most dollarised[2] countries in the world. As the result of a few hyperinflation episodes during eighties and early nineties, Croatian citizens learned how to protect their financial asset from erosion: many prices are indexed to foreign currency, and more than 80% of all saving deposits are held in foreign currency. For that reason the exchange rate anchor was one of the main elements of the Stabilisation Programme in 1993. This policy fixed the prices of tradables, and immediately ended with depreciation (and inflation) expectations, which resulted in one of the lowest inflation rates among all transition countries during the last decade. The exchange rate stability was pursued even after successful disinflation due to large and prevailing euroisation that persists even after a decade of price stability.

The exchange rate, however, is not fixed. Croatia adopted a managed float regime that at the same time managed to provide the central bank with necessary credibility,[3] and put some flexibility in the exchange rate that discouraged speculative capital inflows (Vujčić, 2003). This flexibility also ameliorates strong seasonal exchange rate effects on the real economy, due to strong foreign currency inflows during summer tourist season, and allows for some degree of freedom in the conduct of monetary policy. In managing the exchange rate, the CNB relies primarily on the foreign exchange interventions. Their effect is not fully sterilised and one can claim

that they change the stance of monetary policy. Since Croatia is experiencing large capital inflows during the last decade, the CNB has to deal primarily with the appreciation pressures by purchasing foreign currency and creating domestic liquidity. Thus, interventions are the most important money creation instrument of the CNB. In fact, domestic credits of the CNB are almost inexistent, and overall foreign reserves of the CNB are larger than the entire money supply. In order to sterilise domestic liquidity created by purchases of foreign currency, the CNB relies on large reserve requirement – 18% on all commercial banks' liabilities except capital and central government deposits. During 1990s the CNB issued kuna denominated bills in order to sterilize excess liquidity. Such sterilisation however became too expensive, so they were replaced with an increase in the rate of required reserves in 2003.

There are additional instruments that help the CNB achieve either price stability or other intermediate objectives of exchange rate stability and overall financial stability. Most of those are different elements of capital control as well as prudential regulations intended for the commercial banks. For example, the CNB requires that commercial banks foreign currency exposure remain under 20% of their regulatory capital, which prevents commercial banks from speculative behaviour. In circumstances where banks dominate the financial system and foreign investors do not hold significant amount of assets denominated in domestic currency, this effectively restricts the scope for currency speculation.

3 THE CNB'S FOREIGN EXCHANGE TRANSACTIONS

The CNB conducts different types of transactions where domestic currency is exchanged for foreign currency. The largest ones are transactions with domestic commercial banks that are conducted with the purpose of influencing the exchange rate. Such transactions are referred to as the foreign exchange interventions and are subject of this study. However, the CNB also conducts foreign exchange transactions whose purpose is not necessarily connected with the fact of directly influencing the exchange rate. Most of such transactions are transactions with the government, which in some years were

very significant. In addition to supporting financial operations of the government, such transactions prevent exchange rate pressures that would probably emerge when government tries to exchanges large amounts of foreign currency originating from privatisation or foreign borrowing. There are also bilateral transactions with commercial banks conducted for purposes other than influencing the exchange rate[4], as well as some minor transactions in effective kuna currency with foreign banks.

Table 1 The structure of the CNB's foreign exchange transactions

	Fx Purchases					Fx Sales				
	2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
Fx Interventions	39%	62%	79%	13%	79%	65%	99%	74%	82%	12%
Other Fx Transactions	61%	38%	21%	82%	21%	35%	1%	26%	18%	88%

Foreign exchange transactions with the Croatian National Bank represent relatively large share in total foreign exchange transactions of commercial banks. As shown in Table 2, banks are more oriented to the CNB with sales of excess foreign currency than on purchases of foreign currency, although that changes in different years and circumstances. Although the share of foreign exchange transactions with the CNB declines in time, a share of such transactions is relatively large, which supports the hypothesis that the CNB can influence the exchange rate. However, the share of such transactions during the last two years decreased, which is primarily a result of the development of financial market in Croatia, but also of larger foreign exchange transactions with the government. While data in the Table 2 relate to the overall yearly market turnover, the average share of intervention on the days there were activated are larger than 20% of total foreign exchange transactions on that day, with a tendency of increase during the last few days.

Table 2 Share of foreign exchange transactions with the CNB in the total foreign transactions of commercial banks

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
Fx purchases*	6,2%	4,3%	1,3%	1,0%	8,1%	12,9%	2,0%	3,8%	2,2%	2,4%	0,1%	3,2%
Fx sales*	20,5%	8,5%	7,0%	3,8%	3,1%	0,7%	3,1%	6,2%	4,8%	0,4%	2,1%	3,9%
Gross Fx transactions	13,2%	6,4%	4,3%	2,5%	5,6%	7,1%	2,6%	5,1%	3,6%	1,4%	1,2%	3,5%

* Direction of transactions relates to the commercial banks. From the CNB's perspective, it is the opposite.

Due to its importance for the monetary policy, the estimated amounts of foreign exchange transactions (and interventions) as well their monetary effects are an important part of the overall monetary policy projection of the CNB. However, although the expected amount is set in the monetary projection based on the expected capital flows and demand for base money, actual decision when and how much to intervene is made by the CNB's management. This decision is based on daily information about economic development, especially exchange rate and domestic liquidity. There is no automatic rule that triggers intervention, and discussions preceding a certain intervention can last a few days before it is initiated.

The same morning when the CNB's management decides to intervene, the exchange rate auction is announced. All domestic commercial banks are invited to submit their bids in which they state both size and price (exchange rate). Although individual banks may submit more than one bid (bidding at different prices), there is a tendency to submit a single bid. On the basis of received bids, the CNB's management decides on the cut-off amount and/or price. Commercial banks are informed whether their bids are accepted and information about the price and size of the intervention is posted on the CNB's website. Actual transaction takes place two working days after the intervention due to international payment system regulation.

The most common auction used is the Dutch auction in which commercial banks submit both amounts and prices. During the last few years all interventions were one sided – banks are invited either to purchase or sell foreign currency to the central bank – while in nineties they were double sided (banks could bid for both purchases and sales of foreign currency). Before 1999 the CNB also conducted foreign currency swaps (total 13 of such swaps). From 2001 some auctions were executed with preannounced (fixed) price (exchange rate) and the commercial banks needed to submit only the amounts they were willing to exchange at such rate.

3.1 Statistics of the CNB's foreign exchange interventions

Total amounts of foreign exchange interventions presented in Table 3 show significant difference in size and direction of

interventions in different years. Those differences, by and large can be explained by exogenous factors influencing capital flows, and less regarding some significant changes in exchange rate policy.

In early nineties when Croatia gained independence and Croatian National Bank was founded, foreign reserves were at zero. In circumstances of initial reserve accumulation, in first half of nineties almost all interventions were purchases of foreign currency. Initial accumulation of reserves allowed that, as one of the most important elements of the Stabilisation Programme of 1993, the government decides to defend the upper depreciation level of 4,444 kuna per German Mark, which implied sales of foreign currency at that rate if needed. However, immediately after the Stabilisation Programme was initiated, exchange rate appreciated, and this exchange rate bound was never tested. Due to strong capital inflows emerging from the repatriation of domestic savings, privatisation revenues and extensive foreign borrowing, the majority of exchange rate pressures were on the appreciation side, so the CNB had primarily to defend the exchange rate by purchasing foreign currency. Sales of foreign currency by the Central Bank until 1998 were only symbolic and partially reflect double-sided interventions as well as reverse foreign currency swaps also included in these statistics.

Depreciation pressures appeared in 1998 during the recession triggered by a banking crisis. During 1998 and 1999, the CNB was intensively selling foreign currency in order to decrease depreciation pressures. With consolidation of the banking sector and economic recovery, appreciation pressures again re-emerged and started to dominate, so since 2000 most of the interventions are purchases of the foreign currency.

However, amounts of interventions are larger and more balanced (the CNB intervenes on both sides) than in nineties. The apparent imbalance of interventions in 2003 and 2004 is the result of very large foreign exchange transactions with the government. In 2003 the government net sold 3.665 million kuna worth of foreign currency stemming from privatisation and foreign financing, and in 2004 the government net bought foreign currency worth of 741 million kuna.

Table 3 The CNB's foreign exchange interventions, in millions of kuna, current exchange rate

YEAR	PURCHASES	SALES	NET	GROSS
1993	794	0	794	794
1994	2.670	6	2.664	2.676
1995	1.883	213	1.670	2.096
1996	2.645	429	2.216	3.074
1997	1.793	398	1.395	2.191
1998	1.545	3.829	-2.284	5.374
1999	365	7.060	-6.695	7.425
2000	2.178	1.287	891	3.465
2001	6.756	3.636	3.120	10.392
2002	5.495	1.658	3.837	7.153
2003	646	3.346	-2.700	3.992
2004	4.069	254	3.815	4.323
TOTAL	30.839	22.116	8.723	52.955

Because of initial accumulation of foreign reserves, only interventions from 1996 to 2002 were analysed. During that period, the CNB intervened often. Using the monthly frequency, the CNB intervened in 64 out of 84 months, which is more than ¾ of all months (76,2%). The CNB more often purchased foreign currency 50/84 months (59,5%). It sold foreign currency almost every other month (45,2%).

Monthly frequency is used only for illustration; this analysis is based on daily data since short-term effects of interventions are usually the most interesting.[5] Statistics of individual interventions are given in Table 4. During seven years included in this study, there were 174 interventions, which is approximately one intervention every other week.[6] Median gross intervention was worth of 136 million kuna (a bit under 20 million euro). In cases of depreciation pressures, the CNB had to intervene in larger amounts (109 million kuna) than during appreciation pressures (99 million kuna).

Among the interventions, all the transactions with commercial banks are included, including foreign currency swaps (both ways). If reverse swap transactions are excluded (they are fully anticipated), there were 165 interventions during that period. Most interventions were "regular" interventions (139). There were 13 foreign currency swaps (took place in the second half of 1990s), and in 2001 and 2002 a total of 13 interventions were executed at preannounced

(fixed) exchange rate. The fixed rate interventions were on average much larger than other types of interventions, which partially can be explained by larger intervention amounts during the last few years, but also by circumstances in which the CNB wanted to send stronger signal to the market about its willingness to defend the exchange rate.

Table 4 Statistics of the CNB's interventions from 1996 to 2002, by types of interventions, in millions of kuna, current exchange rate

	ALL Interventions				ALL – reverse swaps				"Regular" interventions			
	net*	gross*	purch	sale	net*	gross*	purch	sale	net*	gross*	purch	sale
Number	174	174	105	98	165	165	101	91	139	139	85	80
Average amount	15	218	197	187	18	224	201	190	33	202	196	151
Median	3	136	99	109	4	137	98	103	4	120	82	98
Minimum	-1.488	0	2	1	-1.488	0	2	1	-716	0	2	1
Maximum	1.029	1.488	1.029	1.488	1.029	1.488	1.029	1.488	1.029	1.029	1.029	716
Standard dev.	329	246	234	243	336	251	238	251	299	223	245	178
	Fixed exchange rate				Swap				Reverse swap			
	net*	gross*	purch	sale	net*	gross*	purch	sale	net*	gross*	purch	sale
Number	13	13	6	7	13	13	10	4	9	9	4	7
Average amount	-115	528	447	597	-12	147	89	263	-68	120	101	145
Median	-54	461	473	461	30	68	58	262	-30	112	109	156
Minimum	-1.488	54	252	54	-475	2	2	38	-227	17	72	30
Maximum	576	1.488	576	1.488	227	475	227	489	112	227	112	227
Standard dev.	664	392	119	533	221	159	87	243	134	83	19	78

* Gross amounts represent total amount of intervention (if double sides) and net difference between pu chase and sale of foreign currency. Purchase of foreign currency has a positive sign while sale a negative one.

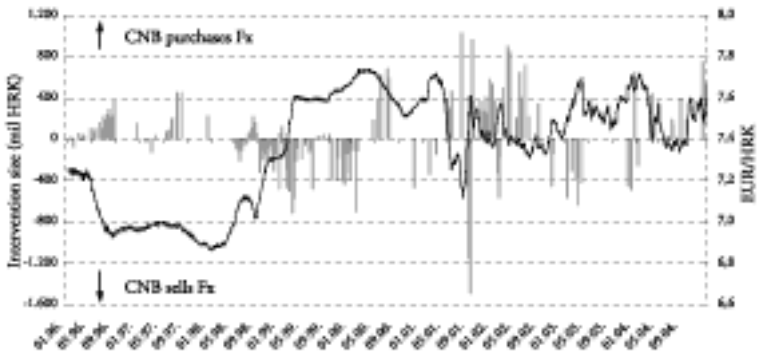
4 FOREIGN EXCHANGE INTERVENTIONS AND THE EXCHANGE RATE

Croatian National Bank follows the intervention policy of leaning against the wind – it purchases foreign currency when domestic currency appreciates and sells foreign currency when it depreciates. Exchange rate and CNB's foreign exchange interventions are shown in Figure 1. Policy of resisting exchange rate changes is the most common motive for central banks to intervene. By following such a policy, the CNB creates additional demand for foreign currency in time of capital inflows and supplies foreign currency in time of shortages. Stability of domestic currency against euro during the period under study (exchange rate fluctuated within the range of 6,8 and 7,8 kuna per euro[7]) suggests that the CNB's interventions were effective.

The period under study can be divided in three sub-periods. The first sub-period relates to period 1996-97 when economy grew strongly, capital inflows were positive and currency appreciated. The second sub-period relates to the recession in 1998-99 that was triggered by a banking crisis. During that period the CNB with its interventions resisted depreciation pressures. With the end of recession, capital inflows re-emerged in 2000 and appreciation pressures dominate since, while exchange rate has been very stable with only small seasonal oscillations.

Figure 1 shows that the size of individual interventions as well as their frequency significantly increased in the second half of 2001. In August 2001 largest individual interventions were recorded, with sales of foreign currency amounting to more than 3 billion kuna. In that month commercial banks launched speculative attack against domestic currency, which was partially motivated by partial liberalisation of capital account, which allowed unrestricted foreign exchange transactions for commercial enterprises. The CNB reacted with strong sales of foreign currency, but also additional monetary tightening.[8] On the other hand, euro notes introduction led to significant increase in households foreign currency deposits at the end 2001, and thus to supply of foreign currency, which motivated additional purchases of foreign currency by the CNB in order to prevent exchange rate appreciation. From the beginning of 2003 the

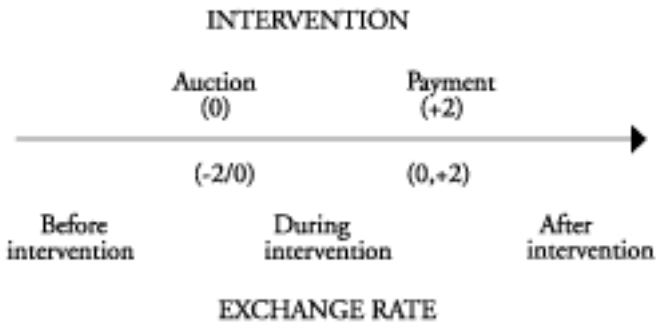
Figure 1 Exchange rate and the CNB's net foreign exchange intervention (daily data)



CNB intervenes less often, which can be explained by somewhat lower pressures on the exchange rate and which is partially a result of larger transactions with the government that prevented such pressures from emerging.

For analysing the interaction between exchange rate and interventions, it is very important to well understand the time frame of intervention and exchange rate used in this study. Individual intervention is conducted in the following way. The CNB's management makes decision when to intervene without following an automatic rule (discretion). Intervention is conducted in auction in which all commercial banks are invited to put bids. Banks usually have a few hours to submit their bids. Actual transaction, however, takes place two days after the auction, due to the international payment system, which requires two days for funds in foreign currency to be transferred from one account to another. Unlike intervention, the CNB's official middle exchange rate used in this analysis is constructed as an average of all foreign exchange transactions by commercial banks in Croatia[9]. Due to reporting schedule, the CNB's official exchange rate lags the market rate by two working days.[10] Thus, the official exchange rate corresponds to the date of intervention, but not its transaction. We can differentiate the time before, during, and after the intervention. Time scheme of intervention and exchange rate is shown in Figure 2.

Figure 2 Time scheme of intervention



Analysis of interaction between the exchange rate and foreign exchange intervention is divided in two steps. In the first step the CNB's behaviour is described, i.e. the reaction function. The second step includes the analyses whether CNB's interventions are effective in influencing the exchange rate.

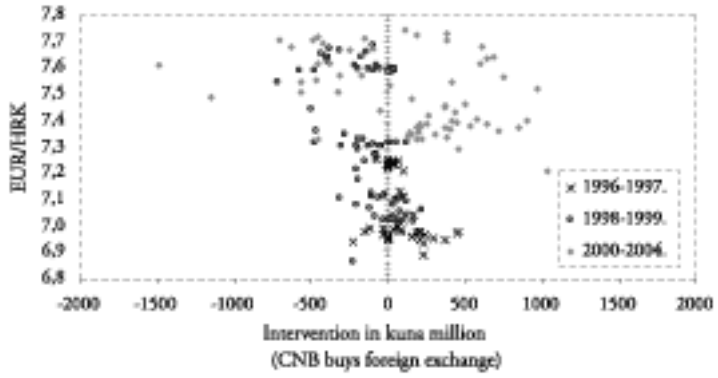
4.1 The reaction function of the Croatian National Bank

The central bank's behaviour regarding its intervention decision can be analysed ex post, which is in literature called central bank's reaction function. Central banks usually intervene on foreign exchange markets in order to keep exchange rate on a certain level (or within a certain range) or in order to decrease short-term oscillations in the exchange rate.

Graphical analysis broadly describes why the CNB intervenes. Figure 3 shows the relationship between individual interventions' size and exchange rate when they were conducted. Points are forming a cloud, which suggests that the CNB does not defend the exchange rate at some certain level. However, the figure suggests that during a certain time the CNB defended a certain path. Correlation coefficient between intervention amount and exchange rate for the entire period under study is -0.19. However, it increases during some periods. For period 1996-1997 it is –0.54, 1998-1999 –0.42 and 2000-2004 -0.39. Stronger correlation in earlier periods partly can be explained by the fact that the bulk of interventions during those periods were of the same directions – purchases during 1996-1997 and sales during the banking crisis of 1998-1999. Interventions since 2000 are much more symmetric. A declining trend in correlation coefficient suggests that the CNB is now less concerned with the exchange rate level than before.

From Figure 3 it is hard to conclude that CNB intervenes more when domestic currency is weak than when it is strong. The reason is that interventions of lower intensity that correspond to stronger domestic currency were conducted before 2000, when intervention amounts were lower. Development and deepening of the domestic financial markets also led to the increase in intervention size. After 1999 the exchange rate of kuna to euro rarely declined under 7,2 kuna per euro.

Figure 3 CNB's interventions and the exchange rate level (1996-2004)

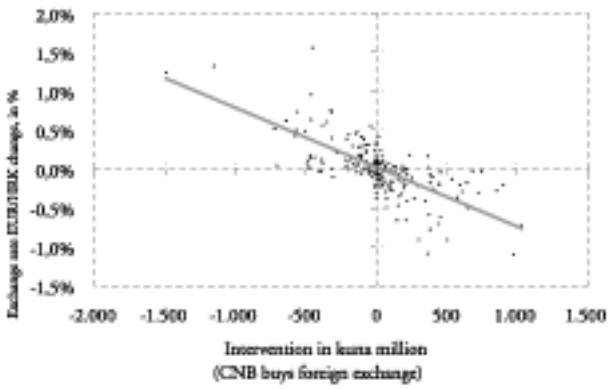


Although it seems that the CNB does not defend a certain exchange rate level, it is more concerned with resisting exchange rate changes.

Figure 4 shows the correlation between intervention amounts and exchange rate change four working days prior to intervention. Such a long period before the intervention is chosen since the decision to intervene is not automatic, but often it takes a few days for decision to be made. Correlation coefficient is the strongest for a four-day period, although shortening or lengthening of the period yields similar results. Correlation coefficient between intervention and exchange rate change is –0.71, which means that in the past the CNB bought foreign currency when exchange rate appreciated and sold when it depreciated. This is exactly the policy of leaning against the wind. Correlation coefficient increased with time, which suggests that the CNB's decisions to intervene are now more directly made in order to prevent changes in the exchange rate.

For the sub-period 1996-96, correlation is -0.20, 1998-99 -0.58 and from 2000 it increases further and is -0.78. Those results support the hypothesis that the CNB is now more concerned in resisting the change in exchange rate and less about the actual exchange rate level than it was in the past.

Figure 4 The CNB's interventions and the exchange rate change (four days prior to the intervention), 1996-2004



It is important to emphasise that this analysis is static and does not conclude that the CNB necessarily reacts after exchange rate changes. Therefore, it should be concluded that when the CNB intervenes in the foreign exchange market, it is usually because exchange rate changed. A change in the exchange rate, however, does not necessarily lead to the intervention.

For making a stronger conclusion, further analysis is needed. The central bank reaction function and motives to intervene can be modelled as:

$$INT = a\,(s - s^T) + b\,\Delta s \quad + c\,X \qquad (1)$$

where INT represents foreign exchange intervention, s exchange rate, s^T targeted exchange rate, Δs change in exchange rate, and X other describing variables. Coefficients (a, b, and c) describe the central banks behaviour in the previous period.

Equation 1 cannot be estimated using the OLS since interventions are not a continuous variable. The CNB intervened only occasionally, so the methods for discontinuous and censored variables need to be applied: LOGIT (PROBIT) or TOBIT.

The key term in such definition of reaction function is a willingness of the central bank to intervene (INT*). As already discussed, the CNB does not react automatically following a certain rule connected to the exchange rate; rather than that the decision to intervene is discrete in its nature. In such circumstances, intervention occurs only when the CNB wants to intervene (INT*>0), while in other circumstances there is no intervention.

$$INT_t = INT^*_t \quad \text{if} \quad INT^*_t > 0 \qquad (2)$$
$$INT_t = 0 \quad \text{if} \quad INT^*_t \leq 0$$

Unfortunately, the willingness to intervene is unobserved, and it has to be estimated using observed interventions.

In order to get more robust results, two different methods were used – LOGIT and TOBIT. The first method, LOGIT, explores the positive results of a binomial variable, while estimated coefficients can be interpreted as percentage contributions to the probability of the positive result. In the context of estimating the reaction function, LOGIT analysis answers to a question "what motivates the central bank to intervene". TOBIT analysis, on the other hand, is based on the censored variable, as shown in equation (2). Results of TOBIT analysis can be interpreted as "if the decision to intervene is made, how large is the intervention".

Binary model (LOGIT) is better for answering the question whether the CNB intervenes in order to defend a certain level or to resist sudden changes in the exchange rate, as shown in equation (1). Intervention is treated as a binary variable: 1 if there is intervention and 0 if there is no intervention. Independent variables are (log) level and change of the exchange rate. Purchases are distinguished from sales in order to adjust for a possibility that intervention is not symmetrical in its nature.

Both estimated equations - purchases and sales of foreign currency (in Appendix A), suggest that the exchange rate level does not explain intervention decision. Change in exchange rate, however, in both cases is significant and has the proper sign. Despite significant coefficients, it is hard to claim that the equation describes the reaction of the

CNB well. Since the number of days without intervention (INT=0) is prevailing, this model is in very few instances good for predicting the actual intervention. It affects modified R^2, which reacts strongly with small number of positive values of dependent variable in binary model. In extension of this analysis further missing variables that can explain the CNB's intervention should be included, such as money market interest rate or the level of excess reserves in the system. More lags can also be added in order to catch time needed to actually decide when to intervene. Problems in modelling the behaviour of the CNB complicate the overall estimation of its effectiveness.

TOBIT analysis gives similar results about significance of change in exchange rate in explaining intervention behaviour of the CNB and insignificance of the exchange rate level. The question that TOBIT answers is "if intervenes how much to intervene". Low R^2 can also be described by a relatively low share of days with intervention, but also suggests low explaining power of the estimated reaction function. Results are given in the Appendix B.

5 EFFECTIVENESS OF FOREIGN EXCHANGE INTERVENTIONS OF THE CNB

The main issue in the foreign exchange intervention literature is whether interventions are effective, i.e. does a central bank by purchasing or selling foreign currency can influence nominal exchange rate. The reason why this question dominates the literature is because it was developed and initially applied to major countries and currencies (US dollar, euro area/Germany, and Japan), which fully sterilized monetary effects of foreign exchange interventions. The main issue is thus whether sterilized interventions are effective. Analyses of foreign exchange interventions in minor currencies, where such interventions are often unsterilized, were not much analysed until recently. Also, the literature generally assumes that unsterilized interventions are effective by their nature.

Foreign exchange interventions represent the main monetary policy instrument in Croatia, and they are only partially (and indirectly) sterilized. Capital account is only partially liberalized, with

a tendency of increasing liberalization, and there is also regulation (rules) concerning commercial banks' position in foreign currency. Thus, our hypothesis, based on the literature on foreign exchange interventions, is that the CNB's interventions should be effective.

Before conducting more formal analysis of the CNB's foreign exchange interventions, there are two facts that support the hypothesis that the CNB's interventions are effective. First, nominal exchange rate kuna to euro has been very stable since the end of 1993. Second, the CNB's interventions have been profitable, which according to the view initiated by Milton Friedman, suggests that they are effective.

5.1 Profitability of the CNB's foreign exchange interventions

In addition to the positive impact on the CNB's income, the profitability of foreign exchange interventions can suggest that they are effective. The reason for calculating the profitability of foreign exchange interventions consists in the idea that the central bank, which is able to stabilize exchange rate, profits from speculators' attempts to destabilize exchange rate. If a central bank in its conduct of foreign exchange interventions leans against the wind, it means that it purchases exchange rate "cheaply" (when domestic currency appreciates) and sells it "expensively" (when domestic currency depreciates). If the exchange rate remains in a certain band, such policy in case of success necessarily leads to profitability. Implicitly, that also means that foreign exchange interventions that are not profitable are not effective.

During the analysed seven-year period, the CNB purchased foreign currency from commercial banks in total value of 20.7 billion kuna, and sold foreign currency for 18.3 billion kuna, which is net increase in foreign reserves of 2.5 billion kuna, as measured in the exchange rate on the day of interventions (total monetary effect). Comparison of kuna value of net purchased foreign currency on the day of intervention and its kuna value measured on the last day of the period in the analysis (31.12.2002) shows that the CNB made profit on foreign exchange interventions. The CNB for foreign exchange purchases net paid 2.5 billion kuna, while total kuna value

of net purchased foreign currency on the last day of the period under analysis was 2.9 billion kuna. Total CNB's profit during this period was 474 million kuna. On purchases of foreign exchange, the CNB paid 656 million kuna less than the value at the end 2002 (made profit) and on the sales of foreign currency received 182 million HRK less (made loss).

Table 5 Profitability of the CNB's foreign exchange interventions during 1996-2002

	In original currencies			Exchange rate	In kuna on intervention date		
	Purchases	Sales	Net	31.12.02	Purchases	Sales	Net
Interventions in SD	231	283	-52	7,14	1.650	2.022	-372
Interventions in UR	2.658	2.211	447	7,44	19.783	16.458	3.325
Total in HRK (exchange rate on the date of intervention)	20.777	18.298	2.479	1	20.777	18.298	2.479
Total in HRK (exchange rate at the end 2002)					21.434	18.480	2.953
CNB's profit					656	-182	474

Nevertheless, it is important to mention problems with the analysis intervention profitability. As Dominguez and Franker (1993) note, on the assessment of the profitability of foreign exchange interventions a large influence has the time period when it is calculated. This analysis, however, is very robust for Croatian data, and profitability is present for a large range for exchange rate[11].

5.2 Estimating the effectiveness of foreign exchange interventions using time series

While the profitability of the CNB's interventions suggests that they were overall effective, it does not say much about the effectiveness of individual interventions now factors that influence the effectiveness. For getting more robust results and estimating the reasons that influence effectiveness of individual interventions, an additional statistical analysis is required.

The first approach in this analysis, of the type suggested by Dominguez and Frankel (1993), was to estimate an equation in

which exchange rate (s) is a function of its lagged variables, foreign exchange interventions (INT) and other explaining variables (X).

$$s = f\,(s_{lag}, INT, X) \qquad (3)$$

A problem with this equation arises if there is simultaneity between exchange rate and interventions. The exchange rate change usually triggers foreign exchange interventions, if the central bank leans against the wing. This equation, however, suffers from simultaneity problem - foreign exchange intervention should influence future exchange rate movement; however, exchange rate movement also influences foreign exchange intervention. For such simultaneity, parameters next to the variable foreign exchange intervention are biased, i.e. wrong.

A proper approach in estimating the effectiveness of the foreign exchange interventions should deal with such simultaneity. One approach would be to set up a system of simultaneous equation in which exchange rate and interventions mutually interact. As it is earlier shown, change in the exchange rate affects the decision of central bank to intervene. On the other hand, foreign exchange intervention should influence exchange rate. Difficulty in estimating such a system is the very complicated structure of the system in which the first exchange rate equation is a GARCH, while the reaction function of the central bank should be estimated with LOGIT (interventions are occasional and include a large discretion of the central bank). Such a system should have the following form:

$$\begin{array}{llll} 1) & s_t & = f\,(s_{lag}, INT_{lag}, X1) & + \varepsilon_1 \\ 2) & INT & = g\,(s_{lag}, INT_{lag}, X2) & + \varepsilon_2 \end{array} \qquad (4)$$

where f(.) and g(.) explain exchange rate (s) dynamics and intervention behaviour (INT), and ε are error terms.

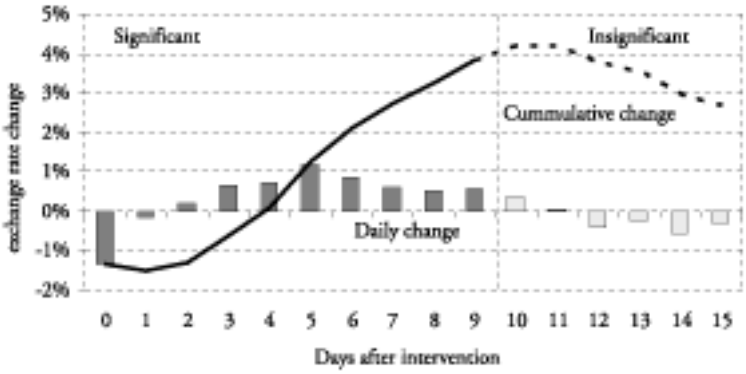
Due to a difficulty in estimating such a system, this approach is uncommon in the literature. Despite the problems, such a system is estimated by using the OLS procedure with Croatian data. Estimated intervention coefficient has a good sign although it is insignificant. This can be explained with a fact that this model does not explain

well the reaction function of the CNB (R^2 of 7%). The table with the relevant results is given in the Appendix C.

Similar results, which suggest "wrong" influence of interventions, are received in estimating exchange rate equation (7), when the decision to intervene was ignored. Naturally, in both cases wrong specification led to wrong (biased) coefficients.

In this exercise, the simultaneity problem is dealt with using a large number of explaining variables (overparametrising). It is possible due to a large sample (7 years of working days, i.e. 1799 observations). Overparametrisation should in theory improve the results by reducing the bias (and decreasing efficiency). Using information criteria, the chosen equation includes 20 lags of exchange rate change and ten lags of intervention, as well as seasonal dummies. Results of estimating this equation using OLS are given in the Appendix. Relatively high R^2 is completely a result of lagged variables and not of foreign exchange interventions. Coefficients next to the foreign exchange intervention variable, however, are significant and have right signs. Adding up coefficients shows that the effect of intervention is the largest two weeks after it was conducted. After that, its influence declines (those results estimated with a model with more than ten lags), as shown in Figure 5. It shows that, due to the construction, exchange rate depreciates two days following the intervention. Positive influence of intervention starts three days after the intervention is conducted

Figure 5 Effects of the CNB's intervention on the euro/kuna exchange rate



and gradually grows until two weeks (ten working days) after the intervention.

5.3 Event study

Instead of estimating the effectiveness of foreign exchange interventions by looking the entire time series, which requires modelling the exchange rate, it is possible to treat interventions as uncorrected events and investigate changes in the exchange rates immediately before and after the intervention was conducted, just like reaction function in the previous chapter. Although this approach neglects information on exchange rate dynamics, during the last few years, it became quite popular in the intervention literature. Moreover, as a reason for using this procedure, Fatum and Hutchinson (1999) claim that time series analysis gives imprecise information on effectiveness of foreign exchange interventions due to the imbalances of the sample, i.e. small number of days when interventions took place in the total number of days. Since interventions happen only occasionally, and exchange rate fluctuates daily, time series approach cannot fully explain the relation between interventions and exchange rate dynamics, where simultaneity does exist. For that reason, Fatum and Hutchinson have applied event study previously used in empirical finance, on analysing the effectiveness of individual intervention episodes.

The first step in using this methodology is to define individual intervention episodes. The time period in which intervention should affect exchange rate should also be defined. Finally, criteria for deciding whether individual interventions are successful or unsuccessful also need to be defined.

Defining the individual intervention episodes is necessary because central banks often intervene through a couple of days in order to move the exchange rate in the desirable direction. During the last few years, the CNB reduced the number of individual interventions and moved from smaller interventions to fewer but larger interventions. In order to have more robust results, intervention events are defined in two different ways. Division of interventions on individual episodes is described in this section, while the analysis of individual

interventions is described in the next chapter. Different definitions of events can influence different time period in which interventions influence exchange rate.

Intervention episode for the purpose of this study is defined as all interventions in the same direction between which there have been no more than 15 days. Such definition of an event is in line with other literature (i.e. Pierdziock and Stadtmann, 2003), and suits Croatian data well.[12] In the period from the beginning of 1996 and April 2003 there were 76 of such episodes, which are shown in the Appendix E. Biggest difficulties in defining episodes were at the beginning of 1996 when interventions went both ways and were very common, so within one month there are a few intervention episodes.

The second step is to define which intervention episodes were successful and which were unsuccessful. If the exchange rate dynamics is neglected, it is very easy to define rules how to differentiate between successful and unsuccessful events. The best indicator would be subjective opinion of policymakers and participants in the exchange rate market whether individual intervention achieved its goal, which in itself includes elements of exchange rate dynamics. Unfortunately, such subjective indicators are not available, so the success of individual interventions must be defined by setting up certain rules. Those are levels and change in exchange rate.

1. LEVEL. Using exchange rate level is a very strict rule. This rule considers whether exchange rate level moved in the desired direction immediately after the intervention. Intervention is successful if after central bank's purchase of foreign currency, exchange rate depreciated (and vice versa). If it does not, intervention is unsuccessful.
2. Change. Exchange rate and interventions interact. Thus depreciation often leads to sales of foreign currency by the central bank while appreciation leads to purchases. Factors that influence exchange rate dynamics are often very strong and larger than effects of the intervention on the exchange rate. Thus, a successful intervention is such when the rate of change in the exchange rate before intervention decreases compared to change after the intervention.

When using such rules, the time duration in which intervention should influence the exchange rate needs to be defined[13]. In countries with developed foreign currency markets, exchange rate change can be observed in a matter of minutes or hours after the intervention is conducted, so the literature usually uses exchange rate at the beginning and the end of the day when the intervention was conducted. Data unavailability prevents using this approach for Croatia. Undeveloped and shallow currency market can also lengthen the time needed for intervention to influence the exchange rate. If arbitrage conditions are not exploited, announcement of the intervention might not fully affect exchange rate until it is actually settled.

In order to achieve robustness, different time periods were considered. The first one includes five working days before and after the intervention episode. Second rule uses ten working days period (two weeks).

The calculated percentages of successful interventions support the results about overall effectiveness of intervention episodes. Table 6 shows percentages of intervention successes depending on the definition of success. Percentages using the level rule shows lower rate of success than using the change in the exchange rate. If exchange rate dynamics was ignored, such numbers might point to the conclusion that interventions are not effective, i.e. they even have negative effect (assuming that exchange rate is the white noise - probability of exchange rate to depreciate is 50%), since they are less than 50%. On the other hand, the rate of success using the exchange rate change, which includes some dynamics, supports the conclusion that interventions are successful, since they are larger than 75%, suggested by the white noise. Those results are confirmed with analysis of individual interventions in the next chapter.

Table 6 Successfulness of intervention episodes, in percentage, by different definitions of success

	Level		Change		
	2 days	5 days	10 days	5 days	10 days
1.19964.2003.					
Number of successes (out of 76)	27	17	24	52	66
Rate of success	36%	22%	32%	68%	87%
1.2000.-4.2003.					
Number of successes (out of 46)	18	9	14	36	43
Rate of success	38%	19%	30%	77%	91%

It is important to emphasize that intervention episodes after 2000 are more successful than those occurred during 1990s, which can be explained by the change in the way interventions are conducted, and moving from two-sided to one-sided interventions.

5.4 Determinants of the effectiveness of the CNB's interventions

Event study of foreign exchange interventions allows to analyse factors that contribute to the effectiveness of individual interventions. It is done by grouping individual interventions according to certain elements - for example purchases and sales of foreign currency, and on the basis of relative success of each group, conclude about importance of different factors.

Applied methodology is very similar to the one described in the previous chapter. The only difference is that analysing the determinants of effectiveness of interventions requires observing individual interventions rather than intervention episodes. However, overall results are in line with results generated from analysing intervention episodes presented in the previous chapter.

Moving from intervention episodes to individual interventions, however, means that there is shorter time duration between individual interventions. For that reason, time period in which interventions success is measured is shorter than when using intervention episodes. Rules L1, L2, L3, L4 and L5 show successes based on the exchange rate levels 1, 2, 3, 4, and 5 days after the intervention. C2 and C4 are based on the rate of change in exchange rate 2 and 4 days around each intervention. Rates of successes for different rules of successes are shown in Table 7.

Comparison of interventions by type of intervention shows that interventions with fixed exchange rate are more successful than the average as they have in almost all cases positive effect on the wanted change in the rate of change. Interventions marked swap represent the first step in foreign exchange swap, while reverse swap represents the counter-transaction (repayment of swap). Thus, reverse swap transactions are fully expected by market and their low

success rate is expected too. Actually, they were excluded from the time series analysis. Success rate is higher when the CNB sells foreign currency, which means that the CNB is more successful in fighting against depreciation of exchange rate than against appreciation, which confirms our experience. The difference in the success rate, however, is very small.

Table 7 Determinants of success of the CNB's intervention, by intervention type

	No.	Share of successes, by rule defining success						
		Level 1	Level 2	Level 3	Level 4	Level 5	Change 2	Change 4
Fixed rate	11	45%	27%	36%	36%	36%	91%	100%
Swap	13	23%	31%	38%	46%	46%	62%	77%
Reverse swap	9	22%	22%	33%	22%	11%	22%	44%
Excluding rev. swap*	162	41%	31%	31%	35%	32%	58%	60%
Purchases*	84	42%	30%	32%	36%	32%	55%	60%
Sales*	76	42%	34%	30%	34%	33%	63%	63%
Total	171	40%	31%	31%	34%	31%	56%	60%

* Reverse swap not included; sales and purchases of foreign currency defined on the net basis (when intervention double-sided).

Table 8 shows rates of successes based on size and time of intervention. It seems that interventions conducted after 2000 are more successful than those conducted in the nineties. The choice of defining success again complicated such a conclusion. Thus, one type of interventions shows better results using one rule, and worse results using another. By using the rate of change criterion (which is broader than the level criterion) two conclusions can be made.

Table 8 Determinants of success of the CNB's intervention, by size and time

	No.	Share of successes, by rule defining success						
		Level 1	Level 2	Level 3	Level 4	Level 5	Change 2	Change 4
Small (<100)	71	45%	42%	39%	48%	42%	49%	56%
Middle (100-500)	73	41%	25%	25%	26%	26%	64%	64%
Large (>500)	18	28%	17%	22%	17%	17%	67%	61%
1996	37	41%	30%	27%	38%	32%	54%	46%
1997	12	50%	17%	17%	25%	42%	42%	50%
1998	40	40%	40%	35%	38%	35%	53%	70%
1999	32	44%	28%	34%	38%	34%	56%	53%
2000	9	44%	22%	33%	11%	11%	78%	44%
2001.	18	33%	33%	28%	33%	28%	67%	89%
1.1.-30.6.2002.	14	43%	36%	36%	36%	29%	79%	71%
Total*	162	41%	31%	31%	35%	32%	58%	60%

* Reverse swap not included; sales and purchases of foreign currency defined on the net basis (when intervention double-sided).

First conclusion is that small interventions are less successful than the large ones. Very large interventions, however, do not give better results than middle-sized interventions. The second conclusion is that the rate of successes increased after year 2000.

Conclusions about the factors that influence effectiveness of individual interventions are by large influenced by the choice of success criteria, and should not be taken for granted. Different criteria thus yield different conclusions about the type of intervention giving better results. Also, presented percentages of successes of different intervention types are limited and exclude other factors that could influence both type and success of individual intervention episodes. For example, interventions at fixed preannounced exchange rate, large interventions, and interventions during the last few years are mutually correlated by the fact that (large) fixed rate interventions took place only during the last few years. In order to eliminate that common factor, LOGIT model, which adjusts for a larger number of explaining factors, needs to be applied. Finally, attempts to set up future interventions by using those conclusions about the past determinants of their success might not lead to more successful interventions in the future.

6 CONCLUSIONS

Monetary policy in Croatia in achieving its main goal – price stability – relies to a large extent on nominal exchange rate anchor. This makes exchange rate interventions the most important monetary policy instrument. Better understanding of the effect of the foreign exchange interventions is thus of utmost importance for policy-making.

This paper analysed the CNB's foreign exchange interventions. As shown, the CNB intervenes strongly and more actively than most central banks[14]. Interventions are not directly sterilized, they are relatively big compared to the foreign exchange market, and exchange rate against euro has been relatively stable for more than a decade. This suggests that the CNB was able to influence the exchange rate with its interventions. The CNB was successful in defending the exchange rate

during depreciation pressures in 1998 and 1999, while it also resisted appreciation pressures that occurred during the last few years.

Estimating the effectiveness of the foreign exchange interventions is a complicated statistical analysis that this study approached by using different methodologies, which increases the robustness of reported findings. Special problem occurs in time series framework due to small number of days with interventions, which makes more difficult dealing with the simultaneity between exchange rate and interventions. For that reason the event study was used.

Estimated reaction function equations do not explain well the CNB's decision when to intervene in the exchange market. Those results are definitely influenced by the discrete nature of interventions – they are not automatic and it often takes a few days to make the decision on intervention. Despite problems in estimating the reaction function, two conclusions about the CNB's past behaviour emerge – the CNB was not so much concerned with a particular level of the exchange rate; instead, interventions were triggered by the change in the exchange rate.

The problem of simultaneity between exchange rate and interventions that exists in time-series context is ameliorated by overparametrisation of exchange rate equation. Estimated coefficients suggest that interventions have positive short-term effect on the exchange rate of kuna. The effect does not appear immediately, but it usually takes the transaction to be finished for full effect to kick in. The effect lasts approximately two weeks after the intervention, when it reaches its maximum, after which it gradually dies out.

Results emerging from applying event-study approach show that interventions are successful in slowing down the rate of change in the exchange rate. However, interventions are not able to push back the exchange rate to the level before appreciation/depreciation that triggered the intervention. It seems that the effectiveness of interventions increased in last few years compared.

Event-study methodology allows estimating the factors that influence the effectiveness of individual interventions. Only a few

factors were used in this study, and there is scope for analysing additional factors. Results suggest that preannounced (fixed) rate interventions were more successful than "regular" interventions. Also, small interventions have weaker effect than larger ones. Those results, however, should not be taken for granted since relative effectiveness of fixed-rate interventions could be lost if they became the main type of intervention. The fixed-rate interventions also suffer from the fact that they send stronger signals to the market about the targeted exchange rate level. Finally, relative successfulness of the fixed-rate interventions might mean that they should be used for situations when a strong influence on the exchange rate is the most important.

There is clearly room for improvement of equation specification used in this paper and some improvement will be done when it is further developed. However, such improvement can only marginally improve the overall conclusion about the successfulness of the CNB monetary policy in achieving stable exchange rate. Instead, a different venue or research to be taken is to analyse the microstructure of the foreign exchange market.

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APPENDIX

Appendix A Estimation of the CNB's reaction function (purchases and sales) using LOGIT

Foreign currency purchases equation (LOGIT)

Dependent Variable: KUP_P
Method: ML - Binary Logit
Date: 09/02/02 Time: 16:06
Sample(adjusted): 2 1630
Included observations: 1629 after adjusting endpoints
Convergence achieved after 7 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	3.071217	5.164152	0.594718	0.5520
LOG(TEC)	-2.906849	2.601798	-1.117246	0.2639
DLOG(TEC)	-158.8968	78.66359	-2.019954	0.0434

Mean dependent var	0.063843	S.D. dependent var	0.244548
S.E. of regression	0.244259	Akaike info criterion	0.475190
Sum squared resid	97.01122	Schwarz criterion	0.485127
Log likelihood	-384.0425	Hannan-Quinn criter.	0.478877
Restr. log likelihood	-386.7456	Avg. log likelihood	-0.235754
LR statistic (2 df)	5.406218	McFadden R-squared	0.006989
Probability(LR stat)	0.066997		
Obs with Dep=0	1525	Total obs	1629
Obs with Dep=1	104		

Foreign currency sales equation (LOGIT)

Dependent Variable: PROD_P
Method: ML - Binary Logit
Date: 09/02/02 Time: 15:45
Sample(adjusted): 2 1630
Convergence achieved after 7 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.259081	5.380037	0.234028	0.8150
LOG(TEC)	-2.044553	2.709089	-0.754701	0.4504
DLOG(TEC)	204.6529	76.06711	2.690425	0.0071

Mean dependent var	0.058932	S.D. dependent var	0.235569
S.E. of regression	0.235240	Akaike info criterion	0.447179
Sum squared resid	89.97958	Schwarz criterion	0.457116
Log likelihood	-361.2273	Hannan-Quinn criter.	0.450866
Restr. log likelihood	-364.9259	Avg. log likelihood	-0.221748
LR statistic (2 df)	7.397191	McFadden R-squared	0.010135
Probability(LR stat)	0.024758		
Obs with Dep=0	1533	Total obs	1629
Obs with Dep=1	96		

Included observations: 1629 after adjusting endpoints

Appendix B Estimation of the CNB's reaction function (purchases) using TOBIT

Dependent Variable: KUP
Method: ML - Censored Normal (TOBIT)
Date: 09/05/02 Time: 10:40
Sample(adjusted): 190 1630
Included observations: 1438
Excluded observations: 3 after adjusting endpoints
Left censoring (value) at zero
Convergence achieved after 12 iterations
Covariance matrix computed using second derivatives

	Coefficient	Std. Error	z-Statistic	Prob.
C	-904.0680	1385.513	-0.652515	0.5141
LOG(TEC)	37.66020	691.9950	0.054423	0.9566
DLOG(TEC)	-54613.01	24847.20	-2.197954	0.0280
DLOG(TEC(-1))	-99992.65	25128.42	-3.979265	0.0001
DLOG(TEC(-2))	-40471.30	24378.56	-1.660118	0.0969
DLOG(TEC(-3))	-26653.51	25730.37	-1.035878	0.3003
SPL	1633.776	1374.469	1.188660	0.2346
Error Distribution				
SCALE:C(8)	482.4756	44.75686	10.77992	0.0000

R-squared	0.056090	Mean dependent var	12.40454
Adjusted R-squared	0.051469	S.D. dependent var	78.79474
S.E. of regression	76.74020	Akaike info criterion	1.174762
Sum squared resid	8421354.	Schwarz criterion	1.204086
Log likelihood	-836.6538	Hannan-Quinn criter.	1.185709
Avg. log likelihood	-0.581818		
Left censored obs	1354	Right censored obs	0
Uncensored obs	84	Total obs	1438

Appendix C Estimation of the system of exchange rate and intervention equations (OLS)

System: SYS03
Estimation Method: Least Squares
Date: 11/21/02 Time: 13:26
Sample: 190 1630
Included observations: 1438
Total system (balanced) observations 2876

	Coefficient	Std. Error	t-Statistic	Prob.
C(11)	-2.07E-05	4.61E-05	-0.448816	0.6536
C(12)	-0.207881	0.026261	-7.916054	0.0000
C(13)	0.412527	0.025851	15.95818	0.0000
C(14)	0.314262	0.026324	11.93827	0.0000
C(15)	0.106506	0.026296	4.050291	0.0001
C(16)	4.50E-07	2.62E-07	1.721149	0.0853
C(17)	0.001478	0.001575	0.938272	0.3482
C(21)	-9.320129	4.679939	-1.991507	0.0465
C(22)	-22335.14	2314.397	-9.650522	0.0000
C(23)	-10254.20	2317.368	-4.424933	0.0000
C(24)	466.5031	159.6045	2.922870	0.0035
Determinant residual covariance		0.012464		

Equation: TEC_DLOG=C(11)+C(12)*TEC_DLOG(-1)+C(13)
*TEC_DLOG(-2)+C(14)*TEC_DLOG(-3)+C(15)*TEC_DLOG(-4)
+C(16)*INT(-2)+C(17)*SPL
Observations: 1438

R-squared	0.272756	Mean dependent var	3.57E-05
Adjusted R-squared	0.269707	S.D. dependent var	0.001230
S.E. of regression	0.001051	Sum squared resid	0.001582
Durbin-Watson stat	2.016348		

Equation: INT=C(21)+C(22)*TEC_DLOG(-1)+C(23)*TEC_DLOG(-2)
+C(24)*SPL
Observations: 1438

R-squared	0.075689	Mean dependent var	0.393861
Adjusted R-squared	0.073756	S.D. dependent var	111.5185
S.E. of regression	107.3272	Sum squared resid	16518421
Durbin-Watson stat	2.145151		

Appendix D Estimation of the effectiveness of foreign exchange intervention (overparametrised)

Dependent Variable: DTEC
Method: Least Squares
Date: 02/19/03 Time: 19:56
Sample (adjusted): 22 1799
Included observations: 1778 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.902575	1.117633	-0.807577	0.4194
DTEC(-1)	-0.333424	0.024358	-13.68847	0.0000
DTEC(-2)	0.272461	0.025716	10.59483	0.0000
DTEC(-3)	0.252067	0.026609	9.472927	0.0000
DTEC(-4)	0.150715	0.027240	5.532792	0.0000
DTEC(-5)	0.151305	0.027404	5.521374	0.0000
DTEC(-6)	0.119690	0.027649	4.328940	0.0000
DTEC(-7)	0.030901	0.027750	1.113552	0.2656
DTEC(-8)	0.019331	0.027727	0.697192	0.4858
DTEC(-9)	-0.023011	0.027646	-0.832360	0.4053
DTEC(-10)	-0.034531	0.027265	-1.266513	0.2055
DTEC(-11)	0.003588	0.026697	0.134389	0.8931
DTEC(-12)	0.032673	0.026624	1.227191	0.2199
DTEC(-13)	0.004522	0.026539	0.170388	0.8647
DTEC(-14)	-0.044879	0.026502	-1.693410	0.0906
DTEC(-15)	0.030860	0.026441	1.167127	0.2433
DTEC(-16)	-0.000165	0.026294	-0.006259	0.9950
DTEC(-17)	-0.046554	0.026069	-1.785795	0.0743
DTEC(-18)	-0.023149	0.025408	-0.911117	0.3624
DTEC(-19)	0.015402	0.024552	0.627319	0.5305
DTEC(-20)	6.05E-05	0.023538	0.002568	0.9980
DUM1997	0.071706	0.971307	0.073824	0.9412
DUM1998	2.007045	0.992147	2.022931	0.0432
DUM1999	2.398994	1.006642	2.383164	0.0173
DUM2000	0.187258	0.972109	0.192630	0.8473
DUM2001	-0.267756	0.971179	-0.275702	0.7828
DUM2002	0.227043	0.981850	0.231240	0.8172
DUM01	3.359425	1.304922	2.574426	0.0101
DUM02	0.662359	1.297561	0.510465	0.6098
DUM03	0.316062	1.279192	0.247079	0.8049
DUM04	-0.933451	1.294390	-0.721151	0.4709
DUM05	-1.212700	1.305823	-0.928687	0.3532
DUM06	-0.379618	1.300790	-0.291836	0.7704
DUM07	-1.204563	1.284168	-0.938010	0.3484
DUM08	1.116422	1.302725	0.856990	0.3916
DUM09	0.799701	1.290449	0.619708	0.5355
DUM10	0.683541	1.275295	0.535986	0.5920
DUM11	0.391702	1.298034	0.301766	0.7629
INT	-0.013503	0.002691	-5.018765	0.0000
INT(-1)	-0.001531	0.002725	-0.561916	0.5742
INT(-2)	0.002152	0.002736	0.786429	0.4317
INT(-3)	0.006604	0.002741	2.409014	0.0161
INT(-4)	0.007201	0.002745	2.623053	0.0088
INT(-5)	0.011603	0.002748	4.222498	0.0000
INT(-6)	0.008571	0.002761	3.103777	0.0019
INT(-7)	0.006219	0.002770	2.245172	0.0249
INT(-8)	0.005257	0.002754	1.909086	0.0564
INT(-9)	0.005538	0.002737	2.023315	0.0432

R-squared	0.306925	Mean dependent var	0.259150
Adjusted R-squared	0.288096	S.D. dependent var	13.01391
S.E. of regression	10.98041	Akaike info criterion	7.656728
Sum squared resid	208585.1	Schwarz criterion	7.804757
Log likelihood	-6758.831	F-statistic	16.30050
Durbin-Watson stat	2.002797	Prob (F-statistic)	0.000000

Appendix E Intervention episodes

	Beginning	End	Amount	Number of interventions		Exchange rate					Success - Level			Success - Change	
				Duration		Before 5	Beginning	End	After 5		during	5 days	10 days	5 days	10 days
1	18.01.96.	11.01.96.	10,5	2	2	7,25	7,24	7,25	7,24		0	0	1	0	0
2	23.01.96.	01.02.96.	-60,0	3	8	7,23	7,24	7,23	7,24		0	1	1	1	1
3	14.02.96.	16.02.96.	15,4	1	1	7,25	7,24	7,24	7,23		1	0	0	0	0
4	29.02.96.	08.03.96.	-17,1	6	8	7,25	7,24	7,23	7,23		0	1	1	1	1
5	11.03.96.	13.03.96.	12,1	1	1	7,23	7,24	7,24	7,22		1	0	0	0	0
6	14.03.96.	14.03.96.	-0,7	1	1	7,23	7,22	7,22	7,24		0	0	0	0	1
7	18.03.96.	18.03.96.	5,6	1	1	7,24	7,22	7,22	7,22		1	0	1	1	1
8	19.03.96.	03.04.96.	-12,0	4	11	7,20	7,22	7,22	7,22		0	0	1	1	1
9	18.04.96.	18.04.96.	-0,7	1	1	7,24	7,22	7,22	7,21		0	1	1	0	1
10	26.04.96.	26.04.96.	98,5	1	1	7,22	7,21	7,21	7,16		1	0	0	0	0
11	10.05.96.	17.05.96.	160,0	2	6	7,15	7,13	7,11	7,07		0	0	0	0	1
12	07.06.96.	03.07.96.	790,6	6	22	7,06	7,04	6,98	6,96		0	0	0	1	1
13	08.07.96.	08.07.96.	-0,7	1	1	6,99	6,95	6,93	6,97		0	1	1	0	1
14	12.07.96.	23.07.96.	526,0	3	10	6,98	6,96	6,95	6,94		0	0	0	1	1
15	26.07.96.	30.07.96.	-0,8	3	5	6,97	6,96	6,94	6,95		0	1	1	0	1
16	02.08.96.	21.08.96.	797,8	3	12	6,96	6,95	6,95	6,94		0	0	0	1	1
17	28.12.96.	30.12.96.	159,7	1	1	6,98	6,98	6,98	6,97		1	1	0	1	1
18	30.01.97.	03.02.97.	-40,7	3	3	6,97	6,97	6,97	6,98		0	0	0	0	1
19	28.02.97.	28.02.97.	-120,6	1	1	6,97	6,99	6,99	6,99		0	0	0	1	1
20	27.03.97.	27.03.97.	50,1	1	1	6,99	6,99	6,99	6,99		1	0	1	1	1
21	15.05.97.	28.05.97.	150,5	9	10	6,99	7,00	6,99	6,98		0	0	0	0	0
22	13.06.97.	30.06.97.	509,0	3	7	6,98	6,98	6,98	6,98		0	0	0	1	1
23	11.07.97.	11.07.97.	404,0	1	1	6,98	6,98	6,98	6,98		1	1	1	0	1
24	01.08.97.	01.08.97.	400,6	1	1	6,98	6,97	6,97	6,96		1	0	0	1	1
25	18.12.97.	18.12.97.	505,6	1	1	6,89	6,89	6,89	6,88		1	0	0	0	0
26	09.03.98.	13.06.98.	-604,0	6	35	6,99	7,02	7,13	7,12		0	0	0	1	1
27	26.06.98.	08.07.98.	-95,6	2	9	7,10	7,12	7,11	7,10		0	1	0	1	1
28	13.07.98.	26.08.98.	1.088,8	19	30	7,11	7,10	7,02	7,09		0	0	0	1	1
29	08.09.98.	03.12.98.	-2.268,6	15	62	7,05	7,10	7,38	7,31		0	0	0	1	1
30	18.12.98.	18.12.98.	-400,5	1	1	7,32	7,31	7,31	7,32		0	0	0	0	1
31	18.12.98.	31.12.98.	0,0	9	9	7,32	7,31	7,31	7,33		1	1	1	1	1
32	14.01.99.	09.02.99.	-1.419,8	4	19	7,32	7,33	7,44	7,49		0	0	0	0	1
33	24.02.99.	24.03.99.	-1.585,0	4	21	7,49	7,54	7,61	7,68		0	0	0	1	1
34	14.04.99.	14.04.99.	-199,6	1	1	7,60	7,68	7,68	7,68		0	1	1	0	1
35	29.04.99.	29.04.99.	-98,5	1	1	7,60	7,68	7,68	7,39		0	1	1	1	1
36	21.05.99.	31.05.99.	-203,0	3	7	7,59	7,59	7,55	7,59		0	0	0	1	1
37	02.06.99.	03.06.99.	4,4	1	1	7,59	7,59	7,55	7,59		1	1	1	1	1
38	08.06.99.	08.06.99.	-400,6	1	1	7,59	7,59	7,59	7,60		0	0	0	0	1
39	08.07.99.	12.08.99.	502,4	6	28	7,60	7,59	7,59	7,58		0	0	0	1	1
40	03.09.99.	03.09.99.	-95,5	1	1	7,59	7,60	7,60	7,61		1	1	1	1	1
41	14.09.99.	14.09.99.	-600,0	1	1	7,60	7,62	7,62	7,62		0	0	0	1	1
42	13.10.99.	20.10.99.	-502,2	2	6	7,64	7,64	7,64	7,64		0	0	0	1	1
43	08.11.99.	08.11.99.	-400,0	1	1	7,64	7,64	7,64	7,63		0	0	0	0	1
44	22.11.99.	30.12.99.	-1.297,1	5	38	7,65	7,66	7,68	7,70		0	0	0	0	1
45	18.01.00.	27.01.00.	-40,6	2	7	7,70	7,71	7,72	7,74		0	0	0	0	1
46	17.04.00.	17.04.00.	100,0	1	1	7,73	7,73	7,73	7,72		1	0	0	0	1
47	08.05.00.	08.05.00.	500,5	1	1	7,73	7,70	7,70	7,70		1	0	0	1	1
48	25.05.00.	25.05.00.	600,0	1	1	7,70	7,68	7,68	7,68		1	0	0	1	1
49	27.06.00.	07.07.00.	1.277,3	2	9	7,66	7,64	7,62	7,61		0	0	0	1	1
50	13.11.00.	13.11.00.	-672,1	1	1	7,88	7,93	7,93	7,94		0	0	0	1	1
51	29.01.01.	29.01.01.	-545,2	1	1	7,59	7,64	7,64	7,65		0	0	0	1	1
52	06.03.01.	06.03.01.	-147,0	1	1	7,70	7,71	7,71	7,71		0	0	1	1	1
53	08.04.01.	08.04.01.	500,0	1	1	7,37	7,33	7,33	7,46		1	0	0	0	0
54	16.05.01.	23.05.01.	750,0	3	6	7,44	7,35	7,29	7,38		0	0	0	1	1
55	13.07.01.	13.07.01.	1.000,0	1	1	7,29	7,31	7,31	7,13		1	0	0	1	1
56	13.08.01.	31.08.01.	-0.009,2	3	16	7,20	7,33	7,61	7,54		0	0	0	1	1
57	18.09.01.	23.09.01.	1.399,2	2	6	7,44	7,52	7,48	7,49		0	0	1	1	1
58	27.09.01.	27.09.01.	14,5	1	1	7,49	7,55	7,55	7,54		1	1	1	0	0
59	18.10.01.	18.10.01.	500,0	1	1	7,50	7,45	7,45	7,41		1	0	0	1	1
60	07.11.01.	21.11.01.	975,7	8	11	7,40	7,42	7,39	7,41		0	0	1	1	1
61	04.12.01.	04.12.01.	-50,4	1	1	7,39	7,43	7,43	7,40		0	0	1	1	1
62	07.12.01.	19.12.01.	1.550,1	3	9	7,45	7,41	7,38	7,38		0	0	1	1	0
63	03.01.02.	03.01.02.	370,5	1	1	7,37	7,37	7,37	7,41		1	1	1	1	1
64	17.01.02.	31.01.02.	-1.000,4	9	11	7,40	7,37	7,37	7,36		0	0	0	1	1
65	18.02.02.	18.02.02.	499,5	1	1	7,34	7,40	7,40	7,43		1	0	0	1	1
66	12.03.02.	25.03.02.	1.755,3	2	6	7,45	7,37	7,37	7,41		1	0	0	1	1
67	22.04.02.	22.04.02.	200,1	1	1	7,20	7,37	7,37	7,29		1	1	0	1	1
68	14.05.02.	21.05.02.	1.002,3	2	6	7,40	7,37	7,37	7,37		1	0	0	1	1
69	07.06.02.	10.06.02.	870,1	3	2	7,38	7,36	7,36	7,35		1	0	0	1	0
70	26.06.02.	28.06.02.	400,7	2	2	7,35	7,33	7,33	7,32		1	0	1	0	1
71	18.08.02.	30.08.02.	347,0	1	1	7,40	7,37	7,37	7,36		1	0	0	1	1
72	24.10.02.	29.10.02.	-597,7	2	4	7,48	7,36	7,38	7,49		0	0	0	1	1
73	09.01.03.	09.01.03.	-500,0	1	1	7,44	7,51	7,51	7,51		0	0	0	1	1
74	04.02.03.	04.02.03.	-0,0,0	1	1	7,52	7,57	7,57	7,58		0	0	0	1	1
75	23.02.03.	07.03.03.	-1.011,0	2	8	7,59	7,68	7,68	7,66		0	0	0	1	1
76	23.03.03.	30.03.03.	-51,0,3	2	5	7,64	7,69	7,69	7,63		0	1	1	1	1

ENDNOTES

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Disclaimer: The views expressed in the paper do not necessarily reflect the views of the Croatian National Bank.

[1] To be published in May 2005.

[2] Actually euroised.

[3] The value of international reserves of the CNB has during the whole time exceeded the money supply, thus monetary regime resembled currency board. Therefore, this type of monetary regime is referred to as a "quasi currency board" (Vujčić) or "floating with a large lifejacket" (Calvo and Mishkin).

[4] For example, during the bank run on Rijecka banka, the CNB sold foreign currency exclusively to that bank in order to provide it with enough foreign currency to stay liquid.

[5] It is often claimed that the foreign exchange intervention can have long-term effect only if it is consistent with the fundamentals.

[6] One year has approximately 250 working days, which makes 7*250=1750 working days in the sample. That makes frequency of intervention 174/1750≈10% of working days, which is one intervention in ten working days, i.e. two weeks.

[7] Before euro was introduced in 1999, the CNB used exchange rate against German Mark. Exchange rate series used in this paper is thus constructed as kuna per DM rather as kuna per ECU before 1999.

[8] There were changes in the required reserve. Required reserve is paid on all the liabilities of the commercial banks (only capital and government deposits are excluded). RR on liabilities in domestic currency is paid in domestic currency, and RR on liabilities in foreign currency is paid in foreign currency. In August 2001 decision was made that a part of RR on liabilities in f/c to be paid in kuna. Effectively this meant increase in the rate of required reserve.

[9] Foreign exchange interventions are not included in the calculation of the official exchange rate.

[10] The official exchange rate is not used for actual foreign exchange interventions, there the price is usually either preannounced or based on the commercial banks' bids. More about exchange rate calculation see Stucka (2001).

[11] Euro/kuna exchange rate should appreciate to more than 6,15 for CNB to experience losses as calculated by this method.

[12] Alternative was to use time period between individual interventions of 21 days (3 weeks) but it does not change the number of intervention episodes.

[13] Successfulness of interventions can be defined more finely. Edison, Cashing and Liang (2003) make distinction between success, short-term success, long-term success and unsuccess.

[14] There is a limited literature on the foreign exchange intervention in emerging markets. However, available surveys made by Neely, IMF, BIS, suggest that the Croatian National Bank intervenes above average.