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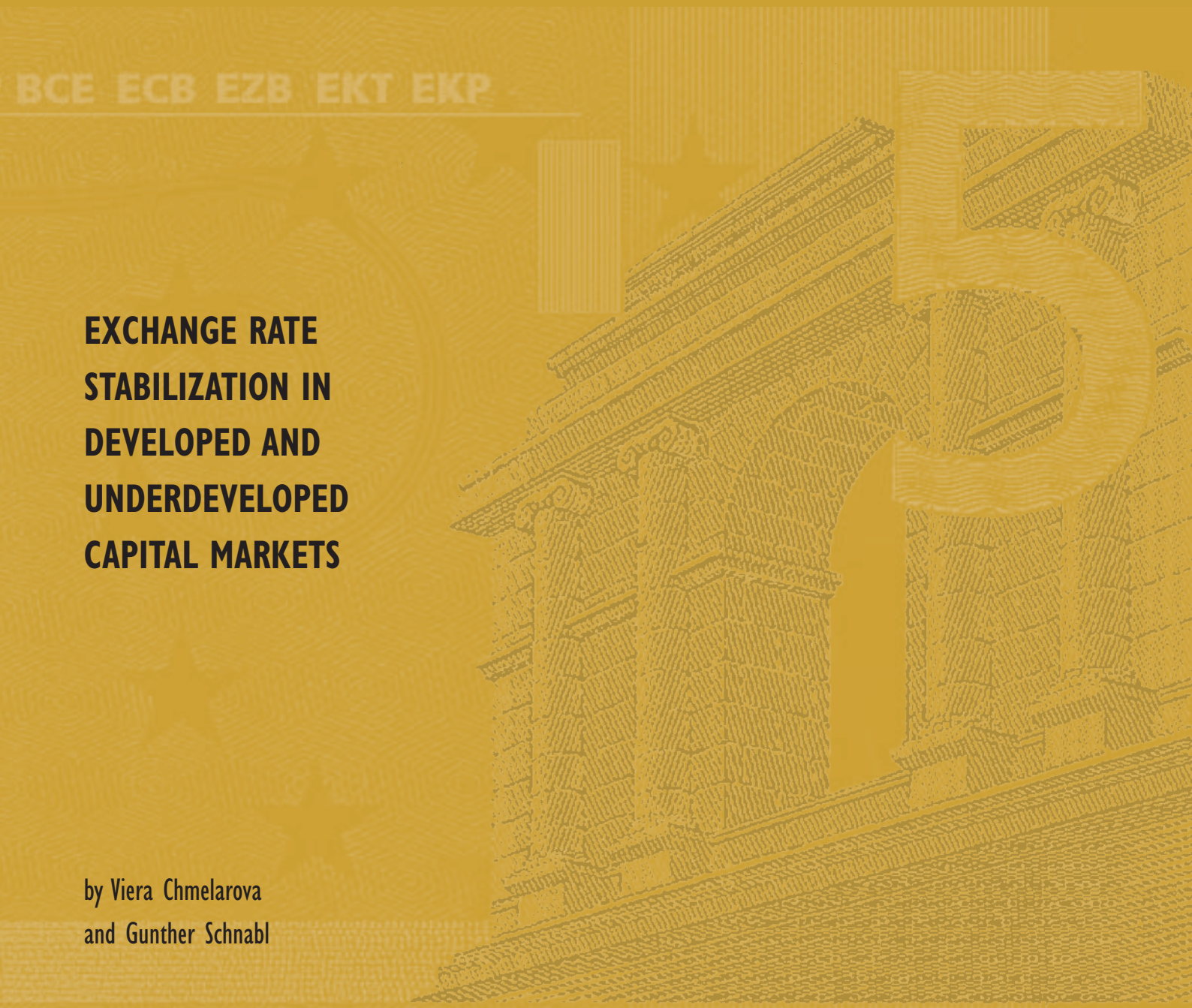

EXCHANGE RATE STABILIZATION IN DEVELOPED AND UNDERDEVELOPED CAPITAL MARKETS

by Viera Chmelarova
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In 2006 all ECB publications will feature a motif taken from the €5 banknote.

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Abstract:
The target zone model by Krugman (1991) assumes that foreign exchange intervention targets exchange rate levels. We argue that the fit of this model depends on the stage of development of capital markets. Foreign exchange intervention of countries with highly developed capital markets is in line with Krugman's (1991) model as the exchange rate level is targeted (mostly to sustain the competitiveness of exports) and the volatility of day-to-day exchange rate changes are left to market forces. In contrast, countries with underdeveloped capital markets control both volatility of day-to-day exchange rate changes as well as long-term fluctuations of the exchange rate levels to sustain the competitiveness of exports as well as to reduce the risk for short-term and long-term payment flows. Estimations of foreign exchange intervention reaction functions for Japan and Croatia trace the asymmetric pattern of foreign exchange intervention in countries with developed and underdeveloped capital markets.

Keywords: *Foreign exchange intervention, target zones, underdeveloped capital markets, reactions functions.*

JEL classification: *F31*

Non-technical Summary

Since the so-called Jurgensen report a large and still growing literature has scrutinized the motivation and effects of sterilized foreign exchange intervention in Germany, Japan and the US, i.e. in large countries issuing international currencies. This research on foreign exchange intervention has been traditionally based on the institutional setting of independent monetary policy making, freely floating exchange rates, full capital mobility and the international use of the respective currencies.

Recently, as some emerging markets have released data on their intervention activities, a new branch of literature on foreign exchange intervention in emerging markets has emerged. While this literature has partially acknowledged the different institutional setting of foreign exchange intervention—i.e. fragmented capital markets, an internationally and domestically restricted role of the respective currencies and (therefore) (partly) unsterilized intervention—the different patterns of foreign exchange intervention in small countries with underdeveloped capital markets in comparison to large countries with highly developed capital markets has not been systematically explored so far.

In contrast to most former papers on foreign exchange intervention, which have mainly scrutinized the effectiveness of foreign exchange intervention and have treated reaction functions as a (subordinated) part of this research, we focus on the motivations for foreign exchange intervention. We draw a distinction between the pattern of foreign exchange intervention in large countries with highly developed capital markets and the intervention pattern in emerging markets with underdeveloped capital markets.

To trace the (different) motivations for foreign exchange intervention Japan is taken as a case study of a country with highly developed capital markets. In line with the Krugman (1991) target zone model, Japan is expected to mainly target the exchange rate level (to sustain the competitiveness of the export industry and to avoid revaluation losses of international dollar assets). Croatia represents the small countries with underdeveloped capital markets. It is expected to target both the exchange level (to sustain the competitiveness of exports in times of appreciation and to sustain financial stability in times of depreciation) and day-to-day exchange rate volatility (to reduce the risk for short-term payment flows).

Binary probit and tobit estimations of reaction functions trace the different intervention patterns for Japan and Croatia econometrically. The results for Croatia widely confirm the notion that emerging markets with underdeveloped capital markets tend to heavily manage both day-to-day exchange rate volatilities as well as exchange rate levels. The pattern of foreign exchange intervention for Croatia confirms a fear of depreciation (with respect to balance sheet effects of the banking sector) more than a fear of appreciation (with respect to export competitiveness).

The results for Japan are less robust. The asymmetric intervention pattern clearly confirms a fear of a high yen which can be attributed to concerns about the competitiveness of the export industry as well valuations losses of international dollar reserves. There is less econometric evidence that also exchange rate volatility matters. As exchange rate volatility has been consistently higher in Japan than in Croatia, the Japanese monetary authorities do not seem concerned about day-to-day volatility which is in line the highly developed capital markets which provide sufficient instruments to hedge short-term foreign exchange risk.

1. Introduction

Since the so-called Jurgensen report (Jurgensen 1983) a large and still growing literature has scrutinized the motivation and effects of sterilized foreign exchange intervention in Germany, Japan and the US, i.e. in large countries issuing international currencies (e.g. Dominguez and Frankel 1993, Bonser-Neal and Tanner 1996, Dominguez 1998, Beine, Laurent and Lecourt 2003). This research on foreign exchange intervention has been traditionally based on the institutional setting of independent monetary policy making, freely floating exchange rates, full capital mobility and the international use of the respective currencies. Sarno and Taylor (2001) and Neely (2005) give overviews.

Recently, as some emerging markets—namely Croatia, Turkey, the Czech Republic and Mexico—have (partially) released data on their intervention activities, a number of papers focusing on foreign exchange intervention in emerging markets has emerged (e.g. Domaç and Mendoza 2002, Lang 2005, Égert and Komárek 2005, Akinci et al. 2005). While this new branch of literature has partially acknowledged the different institutional setting of foreign exchange intervention—i.e. fragmented capital markets, an internationally and domestically restricted role of the respective currencies and (therefore) (partly) unsterilized intervention—the different patterns of foreign exchange intervention in emerging markets in comparison to large countries with highly developed capital markets has not been systematically explored so far.

In contrast to most former papers on foreign exchange intervention, which have mainly scrutinized the effectiveness of foreign exchange intervention and have treated reaction functions as a (subordinated) part of this research, we focus on the motivations for foreign exchange intervention. We draw a distinction between the pattern of foreign exchange intervention in large countries with highly developed capital markets and in emerging markets with underdeveloped capital markets. Econometric estimations of reaction functions trace the different intervention patterns for Japan and Croatia.

2. Patterns of Exchange Rate Stabilization

McKinnon and Schnabl (2004a, 2004b) stress the asymmetric nature of the world currency system. While the United States as the issuer of the most important international currency pursue an independent monetary policy focused on domestic inflation and growth, most countries outside of Europe tend to stabilize their exchange rates against the dollar due to a high degree of openness and underdeveloped capital markets. A similar situation applies to the euro area and its periphery. The European Central Bank is independent in monetary policy making (from exchange rate considerations), while in most European non-euro area countries the euro is widely used as a banking, vehicle, invoicing, intervention, reserve, and pegging currency (ECB 2005).

2.1. Countries with Highly Developed Capital Markets

The intervention pattern of the large countries with highly developed capital markets is mainly in line with the target zone model of foreign exchange intervention as put forward by Williamson and Miller (1987) and Krugman (1991). Within this framework, the exchange rate level is defended within a certain bandwidth around a central parity between two currencies, for instance ±10% as proposed by Williamson and Miller (1987). The participating central banks implement their monetary policies independently from the exchange rate target as long as the exchange rate fluctuates within the respective target zone.

Intervention becomes necessary once the exchange rate approaches the margins in the case of strong appreciation (which hurts the competitiveness of exports) or strong depreciation (which might be considered as a threat to domestic price stability). In a wider interpretation – without having established a specific target zone – intervention would occur, when the exchange approaches a level which is regarded as inappropriate by the monetary authorities.

In the case of such a broad band[1] or informal limits to exchange rate swings considerable exchange rate flexibility would be allowed and foreign exchange intervention would be "*only occasional rather than a continuous preoccupation*" (Krugman 1991:

[1] A very tight band would be equivalent to a tightly managed float or a hard peg, although the border lines between a hard peg and a target zone are fluent.

669). Following Krugman (1991) the target zone for the exchange rate *s* can be modeled as a function of the domestic money supply *m*, a shift term representing velocity shocks *v* and expected exchange rate changes *E(ds)/dt* with positive values representing depreciation. The coefficient γ represents the impact of expectations on the exchange rate. All variables are in natural logarithms:

$$s = m + v + \gamma \frac{E(ds)}{dt} \qquad (1)$$

In equation (1) the monetary policy is "independent" as long as the exchange rate is moving within the target zones $\bar{s}$ and $-\bar{s}$ around a central parity $\bar{s}$ *. Exogenous shocks to the exchange rate are modeled by the velocity term *v* which is assumed to follow a random walk and which may push the exchange rate towards the margins. The stance in monetary policy is only changed to maintain the limits. This version of the target zone model is shown in the left panel of Figure 1. Changes in the monetary policy stance, for instance in form of unsterilized foreign exchange intervention, will keep the nominal exchange rate within the margins $\bar{s}$ and $-\bar{s}$.

While Williamson and Miller (1987) had fully excluded the exchange rate behavior within the margin from their analysis, Krugman (1991) modeled the exchange rate behavior within the band incorporating exchange rate expectations. As market participants are anticipating that the monetary authority will intervene at the upper or lower margins, this implies an s-shaped exchange rate behavior as shown in the right panel of Figure 1. In both cases the exchange rate level is clearly the target of (unsterilized) intervention activity. To "guide" expectations also intra-marginal interventions like they have been used in the European Exchange Rate System I may take place.

The target zone model as described above fits well the intervention behavior of large countries with deep capital markets issuing international currencies. The target zones as (temporarily) established among the currencies of the US, Japan and Germany by the 1987 Louvre Accord (Funabashi 1989) was in line with the Williamson-Miller proposition, although the targets—and in specific a central parity—were not officially announced. Similarly, during the 1990s and 2000s, the European Central Bank and the

Federal Reserve intervened in foreign exchange markets (very occasionally) when the exchange rate level had reached "extreme" limits—although intervention was sterilized.

The (very active) foreign exchange intervention by the Japanese monetary authorities can be argued to have followed a similar pattern because intervention was triggered once the exchange rate had reached (varying) levels of the yen against the dollar which the monetary authorities regarded as detrimental for the competitiveness of the Japanese export industry (Hillebrand and Schnabl 2006, McKinnon and Ohno 1997). The intervention pattern is reflected in clusters of intervention activity when the yen was very strong[2] and extended periods of non-intervention when the yen was weaker (Figure 2). In contrast to the Federal Reserve and the European Central Bank, the Bank of Japan has also allowed for unsterilized intervention since 1999. While the Japanese yen was prevented from rising above a certain level against the dollar, the day-to-day exchange rate volatility against the dollar remained high similar to the euro/dollar exchange rate (Figure 3).

2.2. Countries with Underdeveloped Capital Markets

McKinnon and Schnabl (2004a) provide the rationale for exchange rate stabilization in small open economies with underdeveloped capital markets. They argue that emerging markets and developing countries cannot choose their monetary framework exogenously based on specific targets of economic policy making. Rather, the regime choice is interpreted as endogenous, determined by several inherent and interdependent factors such as macroeconomic stabilization, (invoicing of) international trade, and (the currency denomination of) international capital flows.

While international trade and macroeconomic stability constitute important determinants for exchange rate stabilization, we focus on underdeveloped capital markets as they are prevalent in emerging markets and development countries (Eichengreen and Hausmann 1999). Due to a long tradition of inflation and depreciation, which have partially resulted in a high degree of dollarization or euroization of the respective econo-

[2] In some cases the financial press believed to have identified informal target zones—for instance between 115 and 122 yen per dollar in the first seven months of 2003 (Deutsche Bank Global Investment Committee June 16 2003 and Financial Times August 7 2003).

mies[3], banks and enterprises can not use the domestic currency to borrow or to lend internationally. As international investors and debtors are unwilling to accept liabilities and assets denominated in local currencies, the aggregated foreign exchange risk of net international debt and assets remains widely unhedged.

If hedging instruments are available, they are very costly due to the low degree of liquidity of the foreign exchange markets. Thus, from a short-term perspective, day-to-day exchange rate volatilities constitute a risk for short-term payments flows. In contrast, in Japan, the euro area and the US highly developed capital markets provide a broad variety of cheap instruments to hedge the foreign exchange risk of short-term payments flows.

From a more long-term perspective, fluctuations in the exchange rate level constitute a risk for the competitiveness of export industries and balance sheets of banks and enterprises. In the case of liability dollarization, sharp depreciations inflate the liabilities in terms of domestic currency increasing the probability of default and crisis.[4] In highly euroized (dollarized) countries with a high stock of foreign currency deposits and borrowing such as Croatia, the incentive to avoid sharp exchange rate fluctuations is even stronger. In contrast, in large countries which hold international debt and assets in domestic currencies, exchange rate fluctuations leave the balance sheets of domestic banks and enterprises unaffected.

The outcome for emerging markets and developments countries is exchange rate stabilization targeting day-to-day exchange rate volatility as shown by McKinnon and Schnabl (2004a) for East Asia and by Schnabl (2004) for Central and Eastern Europe. For Croatia, Lang (2005: 9-10) argues that the Croatian National Bank is (mostly) leaning against higher exchange rate volatility defined as percent exchange rate changes. Similarly in 2005, the Central Bank of Russia has announced to stabilize daily exchange rate volatilities against the dollar and the euro (Schnabl 2006). In July 2005, China announced limits to day-to-day exchange rate fluctuations of the yuan against the dollar, the euro and other currencies.

[3] For instance, most South Eastern European countries, in specific the former Yugoslav countries, are highly euroized.

[4] In the case of international creditor countries such as China, Russia or Taiwan the appreciation of the domestic currency constitutes a threat to domestic balances sheets (McKinnon and Schnabl 2004b).

Modifying equation (1) to the respective intervention pattern of countries with underdeveloped capital markets yields:

$$\Delta s = m + v + \gamma \frac{E(ds)}{dt} \qquad (2)$$

Δs corresponds to percent exchange rate changes which are subject to the official intervention activity. The central banks conduct (unsterilized) foreign exchange intervention to keep day-to-day exchange rate volatility at certain levels. The respective exchange rate policy is modeled in Figure 4. As for the target zones of exchange rate levels the bands widths can differ, i.e. being very tight for hard pegs and allowing for more day-to-day exchange rate volatility in the case of soft pegs or managed float arrangements. As in the case of the original target zone models the band width can be officially announced as in the case of China or being undisclosed as for many other East Asian currencies. The target zones on day-to-day exchange rate fluctuations can be also announced for a basket of currencies, as recently in Russia, with specific weights attributed to the basket components (Schnabl 2006). In contrast to the target zone model based on equation (1), no central parity for the exchange rate fluctuations would be announced as exchange rate returns naturally oscillate around zero.

The outcome for the exchange rate behavior is shown for Croatia and Taiwan in Figure 3. Although the foreign exchange markets of emerging markets can be assumed to be shallower and therefore more volatile than the dollar/euro market, exchange rate volatility is significantly lower than for the freely floating dollar/euro rate. As suggested by Figure 3 smoothing daily exchange rate volatility also implies a smoothing of the exchange rate level. In both Croatia and Taiwan, (periods of) low daily exchange rate volatility is associated with lower volatility of the exchange rate level.

The upshot is that smoothing exchange rate volatility on a day-to-day basis is used as an intermediate target for smoothing the exchange rate level. If the euro/dollar rate can be characterized as a random walk, managed exchange rates as the kuna/euro rate would be equivalent to a "managed walk". As daily movements are reduced also fluctuations of the exchange rate level are less. Within this setting, various targets for the exchange rate level are possible. The monetary authorities can smooth depreciations and appreciations

of the exchange rate around a certain level as suggested by Taiwan and Croatia in Figure 3. The currency can be tightly pegged to the anchor currency as currently in the Baltics or a downward crawling peg with very small day-to-day fluctuations as in Slovenia before its ERM II entry can be allowed. In Russia since 2005, the management of day-to-day exchange rate volatilities against two currencies also implies the stabilization of the exchange rate level against euro and dollar in line with the announced targets (Schnabl 2006).[5]

3. Data and Specification of the Reaction Function

Based on the analysis of section 2 we would expect the following intervention pattern in countries with different degrees of capital market development: In line with Krugman (1991) large countries issuing international currencies with highly developed capital markets may decide to stabilize exchange rate levels, but leave day-to-day exchange rate volatility to market forces. Emerging markets with underdeveloped capital markets tend to stabilize both day-to-day exchange rate fluctuations as well as exchange rate levels.

To test for different intervention behaviour we estimate foreign exchange intervention reaction functions for Japan and Croatia. The two countries are chosen for the following reasons: Japan is attributed to the group of large countries with highly developed capital markets issuing an international currency as the (yen) capital markets are among the three largest in the world. In addition, the Japanese yen is, beside the US dollar and the euro, the third largest international currency. Among the countries with the largest capital markets, i.e. US, euro area, Japan, and UK, only Japan and the US have released data on their intervention activities. As foreign exchange interventions tend to be very rare in the US (the last intervention took place in 1998) only Japan (where intervention has been traditionally very active) provides an appropriate case study.[6]

Croatia is attributed to the group of emerging market economies with underdeveloped capital markets, as the size of Croatian capital markets is small, maturities tend to be short and domestic borrowing and lending is highly "euroized". In addition foreign debt tends to be denominated in foreign currency, mostly euros. In contrast to (the small

[5] This does not exclude that other targets such as lower inflation interfere with the exchange rate target.
[6] For a more extensive analysis of Japanese foreign exchange intervention since the early 1990s see Ito (2003) and Hillebrand and Schnabl (2006).

number of) other emerging markets which have released data on their intervention activities, the data are publicly available and provided for a long time period (more than ten years). The intervention volume and the intervention currency are specified.

3.1. Data

The descriptive statistics (Table 1) give an overview. Daily data on Japanese foreign exchange intervention are provided by the Japanese Ministry of Finance starting in April 1, 1991.[7] The amounts are in trillion yen subdivided into purchases and sales of dollar, mark (euro) and other (negligible) currencies. Since the yen/dollar exchange rate is the dominant target for Japanese foreign exchange intervention, only dollar transactions are included in our sample. The yen amounts are converted into billion dollars based on daily exchange rates. On 3652 trading days the Ministry of Finance reports 337 dollar intervention days—306 dollars purchases and 31 dollar sales—exhibiting a strong asymmetric intervention pattern in favor of dollar purchases.

Croatia has provided data on its intervention activities starting from January 1996. During this observation period the Croatian National Bank purchased foreign currency on 103 trading days and sold foreign currency on 88 trading days. The total volume of foreign exchange purchases is equivalent to 24.77 million kunas, the volume of foreign exchange sales was 20.35 million of kunas. Thus, the intervention activity is distributed more symmetrically than in Japan. As since 1996 Croatian foreign exchange intervention has been predominantly denominated in euros, only euro transactions are included in the sample.

Table 1 shows that – other than expected – the unconditional probability of foreign exchange intervention is similar in Croatia and Japan. Between January 1996 and March 2005 the Croatian National Bank, which has kept the exchange rate rather tightly pegged to the euro (formerly to the DM), intervened on about 8% of trading days. In contrast the Bank of Japan, which has left the exchange rate of the Japanese yen more to market forces (as shown by higher daily exchange rate volatility), has intervened on about 9% of trading days between January 1991 and March 2005.

[7] The exact intervention time, the number of interventions within a day, the intervention market (Tokyo, London, New York), and the exchange rate at the time of intervention remain undisclosed.

The unconditional intervention probability of Croatia is likely to be downward biased in comparison to Japan for the following reasons: Small and underdeveloped capital markets allow a broad variety of informal measures other than outright intervention to control the exchange rate. Although Croatia—in contrast to most other emerging markets—has been very transparent with respect to its intervention activities, the data on foreign exchange intervention—defined as foreign exchange transactions by the monetary policies to influence exchange rates—do not provide the full picture on interventions activity for mainly three reasons.

First, in emerging markets and development countries indirect measures to affect exchange rate changes are numerous (Neely 2001) and include "disguised intervention" through undisclosed foreign exchange accounts, foreign exchange transaction of the government with the central bank as well as all kinds of capital and foreign exchange controls which prevent (temporarily) exchange rate pressure from emerging.[8] Second, credible signalling of the central bank to keep the exchange rate at a certain level may encourage stabilizing private market speculation towards the explicit or implicit official exchange rate targets.[9] Third, central banks in emerging markets may maintain a close relationship with commercial banks to control transactions in the foreign exchange markets without outright intervention.[10] In contrast, the main tool for the Japanese central bank to steer the yen exchange rate in deep markets with a large number of participants are outright foreign exchange transactions.

[8] As stressed by Lang (2005: 3-4) for Croatia the published data on foreign exchange intervention do not cover foreign exchange transactions between the central bank and the government which considerably affect the exchange rate. The Croatian finance ministry may hold privatization receipts and revenues from issuing euro bonds on its account at the CNB. During 2000 to 2004, between 12% and 99% of foreign exchange sales and purchases were defined as foreign exchange interventions.

[9] Killeen, Lyons and Moore (2001) provide an order flow model where the private sector (instead of the central bank) absorbs the exchange rate innovations given that the central bank has established a credible parity based on unsterilized intervention.

[10] Canales-Kriljenko (2003: 24) provides a survey of formal and informal administrative measures. These include surrender requirements to the central bank, prohibitions on interbank foreign exchange trading and "moral suasion". Central banks may threaten repression to commercial banks which do not comply with informal guidance with respect to foreign exchange transactions. Such measures are facilitated by the fact that number of foreign exchange trading banks is normally small.

3.2. Model Specification

In section 2, we have identified two main motivations for foreign exchange intervention: (1) Smoothing day-to-day exchange rate volatility to reduce the exchange rate risk for short-term payment flows, (2) Softening long-term fluctuations of the exchange rate level to maintain the competitiveness of the domestic (export) industry in times of appreciation and to protect the balance sheets of domestic firms and enterprises against depreciation.

To test for the determinants of Croatian and Japanese foreign exchange intervention, we estimate binary probit and tobit reaction functions. The Croatian National Bank and Japanese monetary authorities may decide to intervene in foreign exchange markets if the kuna/euro (yen/dollar) exchange rate of the previous day (s_{t-1}) departs from an exchange rate level, which is considered as adequate for both the competitiveness of exports (in case of appreciation) and financial stability (in case of depreciation). As a proxy for this level we use one year moving averages of the kuna/euro (yen/dollar) exchange rate ($\sum_{i=1}^{k} s_{t-1-i} / k$, where k = 253). The probability of intervention is assumed to increase the more the exchange rate level departs from its "target value".[11]

Furthermore, the Croatian and Japanese monetary authorities may decide to buy or sell foreign exchange based on the relative exchange rate changes of the previous day (r_{t-1}), i.e. exchange rate volatility. The higher the exchange rate changes, the higher the probability of intervention. Assuming that the monetary authorities intend to soften exchange rate fluctuations, kuna appreciation triggers foreign currency purchases (negative sign) and kuna depreciation triggers foreign currency sales (positive sign). Squared returns ($(r_{t-1})^2$)[12] are used as alternative measure for exchange rate volatility.

[11] The probability of a foreign exchange *sale* will increase if the exchange rate level is above the targeted level (positive sign of the α_1 coefficient in equation 3). If the exchange rate level is below the targeted level, the probability of foreign exchange *purchase*s increases (negative sign of the α_1 coefficient in equation 3).

[12] Conditional volatilities compiled from GARCH yielded very contradictory results.

To control for capital inflows restrictions that might have an impact on the foreign exchange market in Croatia, we include a capital controls dummy (cc_t^D) which is zero in the case of Japan. The Croatian National Bank introduced "Chilean-type" capital controls from April 14, 1998 to October 14, 1998 to curtail surging short-term inflows. These controls did not last long as by fall 1998 (Russian crisis) foreign investors lost their interest in emerging markets. In October 1998 the Croatian capital controls could be removed. New capital controls were introduced in February 03, 2003 up to the present (here March 31, 2005) when capital inflows accelerated again (Kraft and Jankov 2005). In the case of capital (inflow) controls the probability of interventions is expected to decrease.

With I_t^D denoting the dummy for foreign exchange intervention this yields the following specification:[13]

$$I_t^D = \alpha_0 + \alpha_1 (s_{t-1} - \sum_{i=1}^{k} s_{t-1-i} / k) + \alpha_2 r_{t-1} + cc_t^D + \varepsilon_t \qquad (3)$$

4. Estimation Results

Previous studies on foreign exchange intervention reaction function in emerging markets have come to very heterogeneous results concerning the motivations of foreign exchange intervention in emerging markets (Table 2). Lang (2005) finds exchange rate volatility to be the main driving force of Croatian foreign exchange intervention while the exchange rate level turns out to be insignificant. In contrast, Akinci et al. (2005) find both exchange rate volatility and exchange rate levels to be explanatory variables of Turkish foreign exchange intervention. The estimations of Guimarães and Karacadag (2004) for Mexico find the exchange rate level to be partially significant, while volatility is negatively significant. Estimations for reaction functions for Japan such as by Ito (2003) and Hillebrand and Schnabl (2006) have mainly found the exchange rate level to be the driving force of Japanese foreign exchange intervention. We want to shed more

[13] Specifications with lagged interventions as explanatory variables led to very similar results. The results are not reported here as we could not provide rolling estimations on these models.

light on this issue by estimations for Croatia and Japan based on the framework elaborated in section 2.

4.1. Japan

Japan represents countries with highly developed capital markets. Table 3 presents the results for binary probit estimations for the whole estimation period and for a one period lag which yields the most significant results among estimations up to a lag length of four days.

The absolute value of the deviation of the exchange rate from the moving average is highly significant and has the appropriate sign for aggregate interventions (right-hand side variables in absolute terms). The more the exchange rate deviates from the one year moving average, the higher is the probability of intervention. This finding is in line with the negative impact of yen appreciation on the Japanese export industry (McKinnon and Ohno 1997) and the negative revaluation effects in the case of yen appreciation on Japans' tremendous international dollar reserves (McKinnon and Schnabl 2004b). The proxies for exchange rate volatility—yen/dollar returns and squared returns—remain widely insignificant. For dollar purchases both the exchange rate level and the exchange rate returns turn out highly significant with the appropriate negative sign (appreciation triggers dollar purchases). In contrast, all relevant coefficients for sales, which are only 31 events, are insignificant.

We also test for the joint significance based on likelihood ratios. Under the null hypothesis that the restricted model is valid ($\alpha_1 = \alpha_2 = 0$), the test statistic has a limiting chi-squared distribution with degrees of freedom equal to the number of restrictions. The LR statistics with two degrees of freedom for the joint significance of the exchange rate level and exchange rate volatility for Japanese foreign exchange intervention are highly significant for aggregate interventions and purchases but not for sales.

We perform several robustness tests. Two stage least squares estimations allow to use intervention volumes as endogenous variable with the respective sign (positive sign for foreign currency purchases and a negative sign for sales). It copes with possible endogeneity bias by using the lagged deviations from the level and lagged returns as in-

strumental variables. The results (Table 4) provide evidence that the deviation of the exchange rate from a certain level is triggering foreign exchange intervention. Exchange rate returns remain insignificant. In contrast to the binary probit estimations the deviations of the exchange rate from the moving average turn out marginally significant also for dollar sales (certain specifications).

Tobit estimation (Table 5) uses the (absolute) volumes of Japanese foreign exchange intervention as endogenous variable.[14] For aggregate interventions, the deviations from the moving average have the expected positive sign and are highly significant. Exchange rate volatility both in terms of returns and squared returns, has the expected positive sign and is significant but at lower levels than the deviation from the moving average. Purchase equation coefficients have the expected sign and are highly significant for the exchange rate levels and returns (but not squared returns). The equation for sales can not be estimated due to outliers.[15]

Rolling probit reaction functions to test for structural changes in the size and significance levels for aggregate interventions and purchases do not yield robust results and are therefore not reported here. All in all, the reaction functions for Japanese foreign exchange intervention provide strong evidence that the exchange rate level is a determinant of Japanese foreign exchange intervention. For exchange rate volatility the evidence is mixed.

4.2. Croatia

Croatia represents the group of emerging market economies with underdeveloped capital markets. Equation 3 is estimated for aggregate interventions (right-hand side variables in absolute terms), foreign currency purchases and foreign currency sales. The results of the binary probit specifications are shown in Table 6 for a one period lag which yields the most significant results among estimations up to a lag length of four days. Both exchange rate volatility and exchange rate levels seem to matter for intervention. For aggregated interventions, the α_1 coefficient representing the impact of the exchange rate level on foreign exchange intervention is highly significant. In addition,

[14] The data are censored between zero and positive infinity. This implies that all endogenous variables enter with a positive sign.
[15] The intervention on 4/10/1998 implies negative likelihood.

exchange rate volatility matters. The α_2 coefficient representing the impact of absolute exchange rate returns and squared returns is highly significant.

Separating into purchases and sales of foreign currency yields an asymmetric outcome. For euro purchases which normally take place in times of kuna appreciation pressure, only exchange rate volatility (defined as percent changes) turns out to be significant. The exchange rate level seems not to affect official foreign currency purchases. In contrast, the α_1 coefficient for foreign currency sales has the expected negative sign for the deviation from the average level (kuna appreciation triggers foreign currency purchases) and is highly significant. This may be attributed to the fact that the Croatian banking sector is highly exposed to foreign currency borrowing (Kraft and Jankov 2005). As the banking sector is vulnerable in the case of kuna depreciation more decisive intervention is triggered than in the face of appreciation. In the equation for foreign currency sales also the coefficients for exchange rate volatility turn out highly significant.

As both exchange rate levels and exchange rate volatility seem to matter for Croatia we test for the joint significance of both variables based on likelihood ratios. The LR statistics with two degrees of freedom for the joint significance of the exchange rate level and exchange rate volatility for Croatian foreign exchange intervention are highly significant for most specifications (these statistics are not reported but can be provided upon request). The capital control dummy is negative and highly significant suggesting that since 2003 capital controls have successfully reduced the need for intervention.[16]

We perform several robustness tests. In two stage least squares estimations deviations from the exchange rate level coefficients have the expected signs for aggregate interventions, purchases and sales and are all highly significant (Table 7). The Tobit estimations are widely in line with the standard probit reaction function (Table 8).

We estimate rolling probit reaction functions to test for structural changes in the size and significance levels for aggregate interventions, purchases and sales. We report a

[16] For the sake of brevity, we do not include the period from April 14, 1998 to October 14, 1998. The dummy is positive and highly significant in the probit and tobit models suggesting that the capital controls were not effective. This can be explained by the Russian crisis and by Croatia's banking sector problems accompanied by a high current account deficit and exchange rate pressure.

window size of 500 trading days (Figure 6).[17] For aggregate interventions the level of significance is rather volatile for both levels and volatility. Separating into purchases and sales, the coefficient indicating the impact of the exchange rate level of foreign currency purchases is highly volatile and mostly not significant. In contrast, exchange rate volatility defined as exchange rate returns has a significant impact on official currency purchases. For sales, exchange rate volatility clearly matters. The exchange rate level seems to have mattered around 1999, 2001 and from 2003 up to the present.

Finally, rolling likelihood ratios (Figure 7) suggest that the deviations from the moving average and exchange rate returns are mostly jointly significant. When purchases and sales are analyzed separately, both deviations from the moving average and exchange rate returns seem to have a very significant joint impact on Croatian foreign exchange intervention. As suggested by Figure 7, a decline in the significance level is related to non-intervention periods. With likelihood measures being significantly higher for euro sales than euro purchases Figure 7 also provides evidence for "more decisive" intervention in times of kuna depreciation than in times of kuna appreciation as discussed above.

Summarizing we can conclude that although the determinants of Croatian foreign exchange intervention can not be identified without ambiguity, it seems that both the exchange rate level and exchange rate volatility matter for Croatian foreign exchange intervention. What is particular for Croatia is the sensibility with respect to kuna depreciation due to the highly euroized financial sector and high foreign currency denominated debt. This finding seems to be consistent with the role of capital markets for foreign exchange intervention in emerging markets as put forward in section 2. This is even more plausible as the volatility of daily returns and the fluctuations exchange rate levels seem intertwined.

[17] Small window sizes are more sensible to structural changes, while they tend to be more instable than large window sizes. The results of large window sizes are similar and can be supplied upon request.

5. Conclusion

We have scrutinized the motivation for foreign exchange intervention in large countries with highly developed capital markets as well as in small countries with underdeveloped capital markets. Although official data on Croatian foreign exchange intervention are likely not to represent the full picture of intervention activities, the econometric results for Croatia widely confirm the notion that emerging markets with underdeveloped capital markets tend to heavily manage both day-to-day exchange rate volatilities as well as exchange rate levels. The pattern of foreign exchange intervention for Croatia confirms a fear of depreciation (with respect to balance sheet effects of the banking sector) more than a fear of appreciation (with respect to export competitiveness).

The results for Japan are less robust. The asymmetric intervention pattern clearly confirms a fear of a high yen which can be attributed to concerns about the competitiveness of the export industry as well valuations losses of international dollar reserves. There is less econometric evidence that also exchange rate volatility matters. As exchange rate volatility has been consistently higher in Japan than in Croatia, the Japanese monetary authorities do not seem concerned about day-to-day volatility which is in line the highly developed capital markets providing sufficient instruments to hedge foreign exchange risk.

References

Akinci, Özge / Culha, Olcay Yücel / Özlale, Ümit / Şahinbeyoğlu, Gülbin 2005: The Effectiveness of Foreign Exchange Interventions for the Turkish Economy: A Post-Crisis Period Analysis. *Central Bank of Turkey Research Department Working Paper* 05/06.

Bank for International Settlements BIS 2005: Foreign Exchange Market Intervention in Emerging Markets: Motives, Techniques and Implications. *BIS Papers* No. 24.

Baillie, Richard, Osterberg, William 1997: Why Do Central Banks Intervene? *Journal of International Money and Finance* 16, 6, 909-919.

Beine, Michel / Laurent, Sebastian / Lecourt, Christelle 2005: Official Central Bank Interventions and Exchange Rate Volatility: Evidence from a Regime Switching Analysis. *European Economic Review* 47, 5, 891-911.

Bonser-Neal, Catherine, Tanner, Glenn, 1996. Central Bank Intervention and the Volatility of Foreign Exchange Rates: Evidence from the Options Market. *Journal of International Money and Finance* 15, pp. 853-878.

Canales-Kriljenko, Jorge 2003: Foreign Exchange Intervention in Developing Countries and Transition Economies. Results of a Survey. *IMF Working Paper* 03/95.

Domaç, Ilker / Mendoza, Alfonso 2002: Is there Room for Forex Interventions under Inflation Targeting Framework? Evidence from Mexiko and Turkey. *Mimeo.*

Dominguez, Kathryn / Frankel, Jeffrey, 1993. Does Foreign Exchange Intervention Work? *Institute for International Economics*, Washington DC.

Dominguez, Kathryn 1998: Central Bank Intervention and Exchange Rate Volatility. *Journal of International Money and Finance* 17, 161-190.

Égert, Balázs / Komárek, Luboš 2005: Official Foreign Exchange Interevntions in the Czech Republic: Did they Matter? *William Davidson Institute Working Paper* 760.

Eichengreen, Barry / Hausmann, Ricardo 1999: Exchange Rates and Financial Fragility, *NBER Working Paper* 7418.

European Central Bank ECB 2005: Review of the International Role of Euro. Frankfurt November 2000.

Funabashi, Yoichi 1989: Managing the Dollar: From the Plaza to the Louvre, Washington D.C.

Guimarães, Roberto / Karacadag, Cem 2004: The Empirics of Foreign Exchange Intervention in Emerging Market Countries: The Cases of Mexico and Turkey, *IMF Working Paper* 04/123.

Hillebrand, Eric / Schnabl, Gunther 2006: A Structural Break in the Effects of Japanese Foreign Exchange Intervention on the Yen/Dollar Exchange Rate Volatility. *Forthcoming as ECB Working Paper.*

Ito, Takatoshi 2003: Is Foreign Exchange Intervention Effective? The Japanese Experience in the 1990s. In: Mizen, Paul (ed.): Monetary History, Exchange Rates and Financial Markets, Essays in Honour of Charles Goodhart, Vol. 2, 126-153.

Jurgensen, Phillipe 1983: Report of the Working Group on Exchange Market Intervention.

Killeen, William / Lyons, Richard / Moore, Michael 2001: Fixed versus Flexible: Lessons from EMS Order Flows. *NBER Working Paper* 8941.

King, Robert / Levine, Ross 1993: Finance and Growth: Schumpeter Might Be Right. Quarterly *Journal of Economics* 108, 717-738.

Kraft, Evan / Jankov, Ljubinko 2005: Does Speed Kill? Lending Booms and their Consequences in Croatia. *Journal of Banking and Finance* 29, 1, 105-122.

Krugman, Paul 1991: Target Zones and Exchange Rate Dynamics. *Quarterly Journal of Economics*, 106, 669-682.

Lang, Maroje 2005: The Effectiveness of Foreign Exchange Intervention in Croatia. Paper presented at the Bank of Albania 5th International Conference on Central Banking in the Time of Integration.

McKinnon, Ronald / Ohno, Kenichi 1997: Dollar and Yen: Resolving Economic Conflict between the United States and Japan. MIT Press, Cambridge Massachusetts.

McKinnon, Ronald / Schnabl, Gunther 2003: Synchronized Business Cycles in East Asia and Fluctuations in the Yen/Dollar Exchange Rate. *The World Economy* 26, 8, 1067-1088.

McKinnon, Ronald / Schnabl, Gunther 2004a: The East Asian Dollar Standard, Fear of Floating, and Original Sin. *Review of Development Economics* 8 (2004a), 3, 331-360.

McKinnon, Ronald / Schnabl, Gunther 2004b: A Return to Exchange Rate Stability in East Asia? Mitigating Conflicted Virtue. *International Finance* 7 (2004a), 2, 169-201.

Neely, Christopher 2001: The Practice of Central Bank Intervention: Looking under the Hood. *Federal Reserve Bank of St. Louis Review* May/June 2001, 1-10.

Neely, Christopher 2005: An Analysis of Recent Studies of the Effect of Foreign Exchange Intervention. *Mimeo.*

Sarno, Lucio / Taylor, Mark 2001: Official Intervention in the Foreign Exchange Market: Is it Effective and, if so, How Does it Work? *Journal of Economic Literature* 39, 839-868.

Schnabl, Gunther 2004: De jure versus de facto Exchange Rate Stabilization in Central and Eastern Europe. *Aussenwirtschaft* 59, 2, 171-190.

Schnabl, Gunther 2006: The Russian Currency Basket: Recent Developments in Russia's Exchange Rate Policies and the Role of the Euro. Forthcoming in *Intereconomics May/June 2006.*

Williamson, John / Miller, Marcus 1987: Targets and Indicators: a Blueprint for the International Policy Coordination of Economic Policy. *Policy Analysis in International Economics 22*, Institute for International Economics, Washington D.C.

Table 1: Summary Statistics for Bank of Japan (1991:04-2005:03) and for Croatian National Bank Interventions (1996:01-2005:03)

	Japan	Croatia
Total intervention days	337	191
Total transaction volume (billion dollars and millions of kunas)	615.69	45.12
Percentage of interventions in the yen/dollar and kuna/euro market (volume)	98.41%	98.95%
Unconditional intervention probability	9.23%	8.15%
Number of days with dollar purchases (yen sales) and euro purchases	306	103
Total amount of dollar purchases (billions) and euro purchases (millions of kunas)	578.19	24.77
Mean absolute value of dollar purchases (billions) and euro purchases (millions of kunas)	1.89	0.24
Number of days with dollar sales (yen purchases) and euro sales	31	88
Total amount of dollar sales (billions) and euro sales (millions of kunas)	37.50	20.35
Mean absolute value of dollar sales (billions) and euro sales (millions of kunas)	1.21	0.23

Source: Japan: Ministry of Finance and Croatian National Bank.

Table 2: Studies on Foreign Exchange Intervention Reaction Function in Emerging Markets

Country	Author/Time Period	Model	Reaction Function	
			Exchange rate level	Volatility
Croatia	**Lang (2005)** 01/1996 - 12/2002	Logit (purchases and sales separately)	**insignificant** (exchange rate level)	**significant** (exchange rate returns)
		Tobit (only purchases)	**insignificant** (exchange rate level)	**significant** (exchange rate returns)
		OLS system		**significant** (exchange rate returns)
Czech Republic	**Égert/Komárek (2005)** 01/1997 - 08/2002	Granger causality		**partially significant** (GARCH estimated conditional variance); it causes sales, not purchases
Turkey	**Guimarães/Karacadag (2004)** 03/2001 - 10/2003 (foreign exchange auctions)	Probit (purchases and sales together)	**insignificant** (deviation of the exchange rate from moving average)	**insignificant** (deviations of GARCH estimated conditional variance from trend)
	Akinci et al. (2005) 05/2001 - 12/2003 (foreign exchange interventions)	Probit (purchases and sales separately)	**significant** (deviations of the exchange rate from moving average) (leaning against the wind)	**significant** (GARCH estimated conditional variance)
		Granger causality	**partially significant** (deviations of the exchange rate from trend); they cause sales, not purchases	**partially significant** (GARCH estimated conditional variance); it causes sales, not purchases
Mexico	**Guimarães/Karacadag (2004)** 08/1996 - 06/2003	Probit (purchases and sales together)	**partially significant** (deviations of the exchange rate from moving average); "depreciations increase the probability of interventions", appreciations *decrease*	**negatively significant** (deviations of GARCH estimated conditional variance from its trend); they *decrease* the probability of intervention

Note: Volatility is significant if higher volatility or an increase in deviations from its trend raise the probability of interventions.

Table 3: Binary Probit Reaction Function for Japanese Foreign Exchange Intervention (04/1991-03/2005)

	Aggregate Interventions		Purchases		Sales	
Constant	-1.653***	-1.629***	-1.676***	-1.676***	-2.491***	-2.494***
	(0.063)	(0.060)	(0.046)	(0.046)	(0.078)	(0.078)
Deviation from moving average	0.046***	0.046***	-0.079***	-0.080***	0.011	0.010
$(s_{t-1} - \sum_{i=1}^{k} s_{t-1-i}/k)$ §	(0.007)	(0.007)	(0.006)	(0.006)	(0.010)	(0.010)
Yen/dollar return	0.075		-0.157***		-0.151	
r_{t-1} §	(0.054)		(0.042)		(0.093)	
Yen/dollar squared return		0.025*		0.012		0.027
$(r_{t-1})^2$		(0.014)		(0.015)		(0.023)
LR statistic (2 df)	44.69***	45.67***	281.08***	268.16***	3.38	1.87

§*Note*: For the aggregate interventions regression, we use expressions in absolute values.

Table 4: Two Stage Least Squares Reaction Function for Japanese Foreign Exchange Intervention, 04/1991-03/2005

	Aggregate Interventions		Purchases		Sales	
Constant	0.116	0.235***	0.111	0.242***	-0.005	0.007
	(0.094)	(0.086)	(0.168)	(0.080)	(0.080)	(0.030)
Deviation from moving average	-0.017***	-0.017**	-0.015	-0.015***	0.002	0.002**
$(s_{t-1} - \sum_{i=1}^{k} s_{t-1-i} / k)$	(0.006)	(0.003)	(0.011)	(0.002)	(0.005)	(0.001)
Yen/dollar return	-3.234		-6.082		-2.848	
r_{t-1}	(12.950)		(23.086)		(10.907)	
Yen/dollar squared return		-0.196		-0.182		0.013
$(r_{t-1})^2$		(0.167)		(0.156)		(0.058)

Table 5: Tobit Reaction Function for Japanese Foreign Exchange Intervention, 04/1991-03/2005

	Aggregate Interventions		Purchases	
Constant	-7.718***	-7.575***	-7.341***	-7.429***
	(0.476)	(0.463)	(0.420)	(0.426)
Deviation from moving average	0.185***	0.186***	-0.309***	-0.319**
$(s_{t-1} - \sum_{i=1}^{k} s_{t-1-i} / k)$ §	(0.035)	(0.035)	(-0.028)	(0.028)
Yen/dollar return	0.445*		-0.761***	
r_{t-1} §	(0.244)		(0.183)	
Yen/dollar squared return		0.129**		0.076
$(r_{t-1})^2$		(0.063)		(0.062)

§*Note*: For the aggregate interventions regression, we use expressions in absolute values.
Tobit estimation for sales is infeasible.

Table 6: Binary Probit Reaction Function for Croatian Foreign Exchange Intervention (01/1996-03/2005)

	Aggregate Interventions		Purchases		Sales	
Constant	-1.69***	-1.62***	-1.74***	-1.72***	-2.09***	-2.09***
	(0.08)	(0.07)	(0.06)	(0.06)	(0.09)	(0.09)
Deviation from moving average	1.81***	1.82***	-0.21	-0.45	3.28***	3.42***
$(s_{t-1} - \sum_{i=1}^{k} s_{t-1-i}/k)$ §	(0.42)	(0.42)	(0.35)	(0.38)	(0.43)	(0.43)
Kuna/euro return	1.04***		-1.73***		1.64***	
r_{t-1} §	(0.40)		(0.36)		(0.43)	
Kuna/euro squared return		1.77**		0.98		2.45***
$(r_{t-1})^2$		(0.72)		(0.86)		(0.87)
Capital controls	-0.430***	-0.41***	-0.32**	-0.28**	-0.48***	-0.51***
(cc_t^D) *(03/02/03 – 31/03/05)*	(0.11)	(0.11)	(0.13)	(0.13)	(0.17)	(0.17)
LR statistic (3 df)	39.60***	38.79***	27.79***	6.84*	95.38***	88.31***

§*Note*: For the aggregate interventions regression, we use expressions in absolute values.

Table 7: Two Stage Least Squares Reaction Function for Croatian Exchange Intervention, 01/1996-03/2005

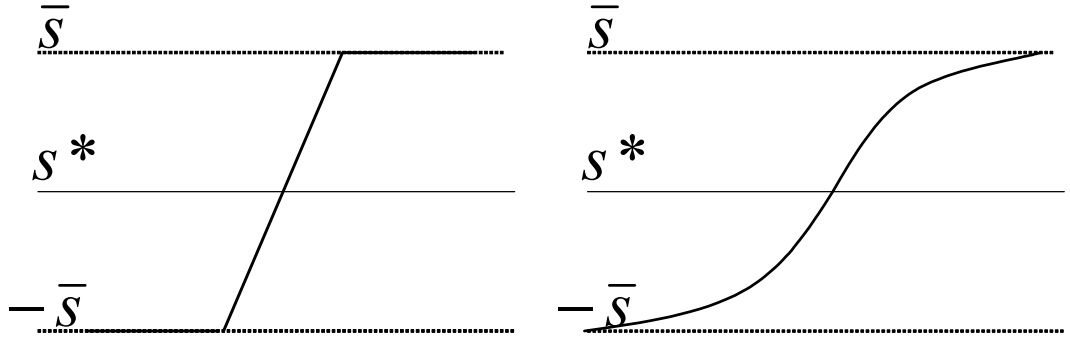
	Aggregate Interventions		Purchases		Sales	
Constant	4.07	8.63**	13.14***	11.42***	9.07***	2.78
	(2.63)	(3.75)	(1.91)	(2.71)	(1.80)	(2.54)
Deviation from moving average	-85.06***	-101.80***	-32.58***	-34.59***	52.49***	67.21***
$(s_{t-1} - \sum_{i=1}^{k} s_{t-1-i} / k)$	(16.52)	(16.96)	(11.95)	(12.24)	(11.31)	(11.49)
Kuna/euro return	-218.42***		-118.86***		99.56***	
r_{t-1}	(40.43)		(29.24)		(27.69)	
Kuna/euro squared return		-323.26**		74.32		397.58***
$(r_{t-1})^2$		(160.15)		(115.63)		(108.53)
Capital controls	0.11	8.39	-4.65	-5.35	-4.76	-13.74***
(cc_t^D) *(03/02/03 – 31/03/05)*	(5.00)	(6.00)	(3.62)	(4.34)	(3.43)	(4.07)

Table 8: Tobit Reaction Function for Croatian Foreign Exchange Intervention, 01/1996-03/2005

	Aggregate Interventions		Purchases		Sales	
Constant	-1043.34***	-982.73***	-1124.29***	-1151.22***	-1247.41***	-1290.67***
	(90.98)	(85.27)	(121.71)	(125.31)	(134.58)	(146.23)
Deviation from moving average	973.5***	977.34***	-297.02	-470.00*	1834.41***	2000.57***
$(s_{t-1} - \sum_{i=1}^{k} s_{t-1-i} / k)$ §	(259.74)	(258.55)	(250.84)	(254.00)	(271.48)	(319.21)
Kuna/euro return	848.30***		-1158.38***		1180.80***	
r_{t-1} §	(231.64)		(258.47)		(358.96)	
Kuna/euro squared return		1470.56***		738.12		1856.98***
$(r_{t-1})^2$		(383.84)		(556.26)		(463.57)
Capital controls	-252.54***	-235.16***	-200.89**	-176.23**	-242.37**	-267.67***
(cc_t^D) *(03/02/03 – 31/03/05)*	(68.96)	(67.51)	(86.79)	(86.38)	(108.26)	(101.85)

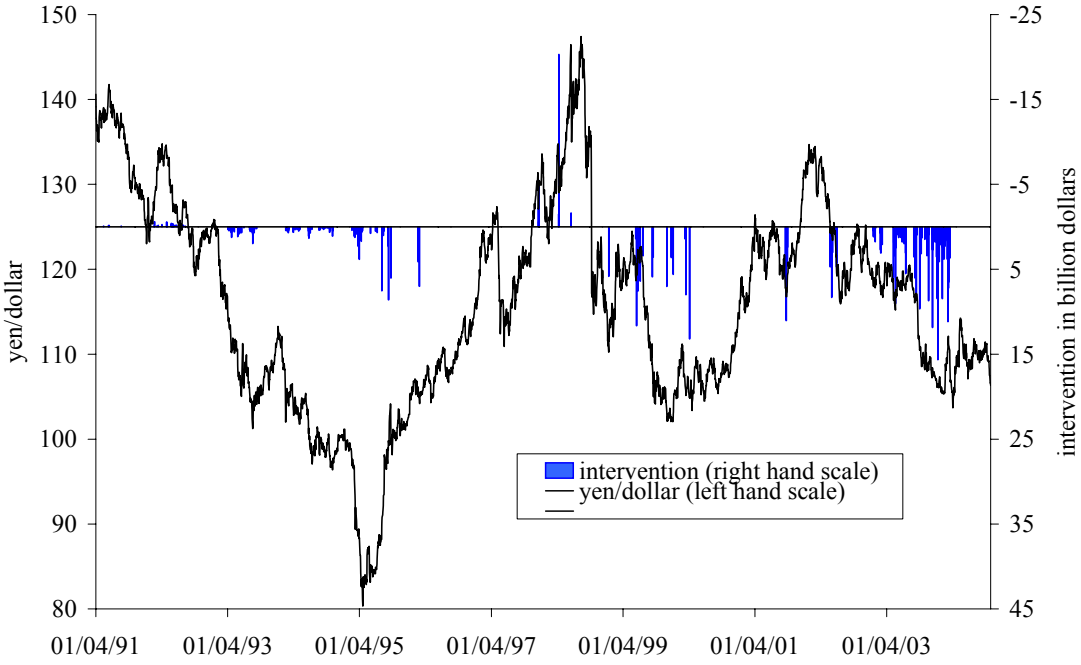
§*Note*: For the aggregate interventions regression, we use expressions in absolute values.

Figure 1: Target Zone Models by Williamson and Miller (1987) and Krugman (1991)



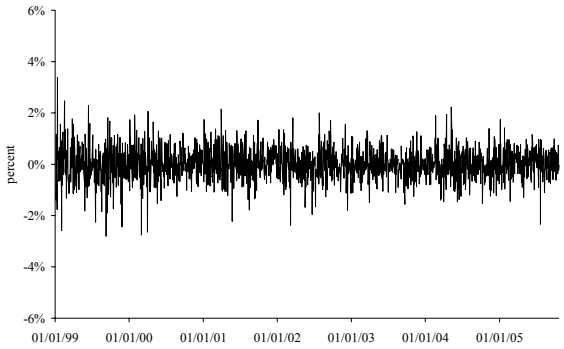
Williamson and Miller (1987) Krugman (1991)

Figure 2: Japanese Foreign Exchange Intervention

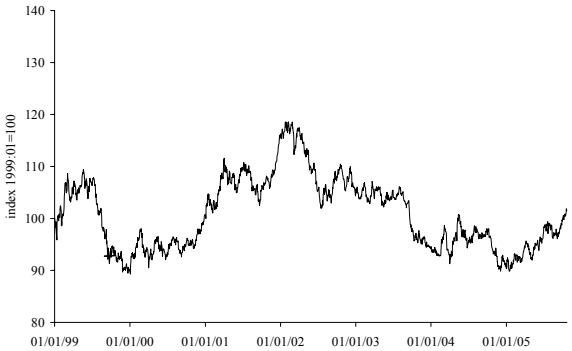


Source: Japan: Ministry of Finance.

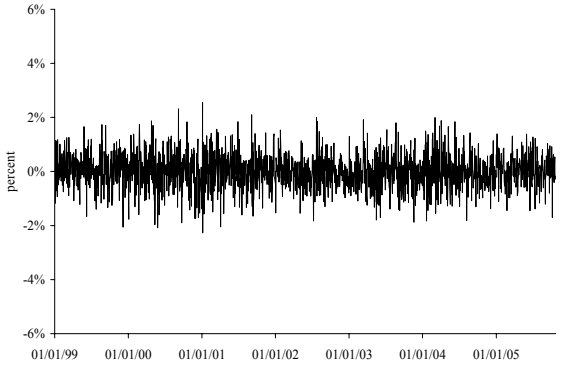
Figure 3: Exchange Rate Fluctuations in Terms of Returns and Levels



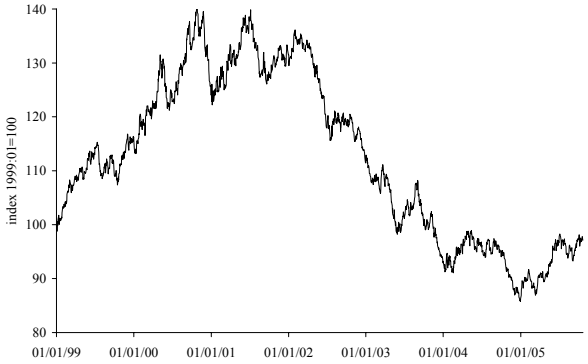
yen/dollar (percent changes)



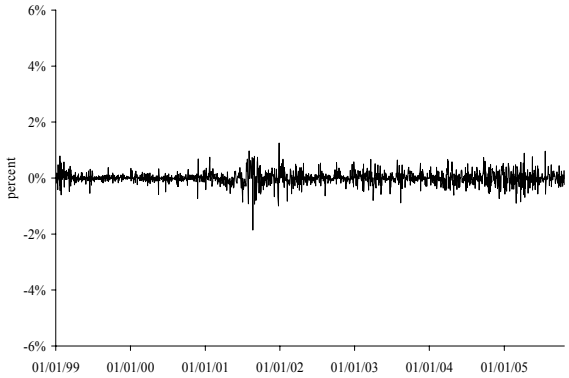
yen/dollar (01/01/99 = 100)



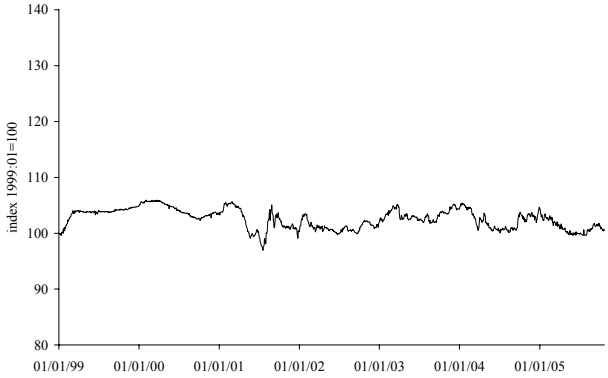
euro/dollar (percent changes)



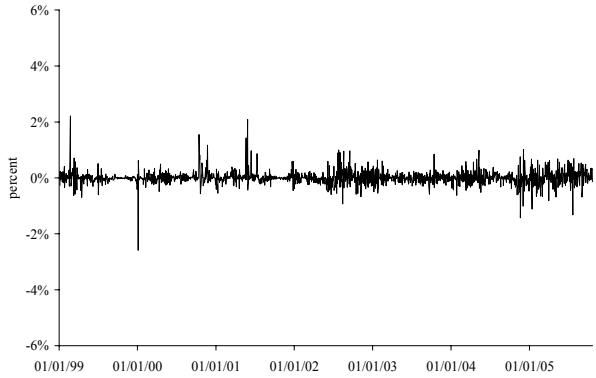
euro/dollar (01/01/99 = 100)



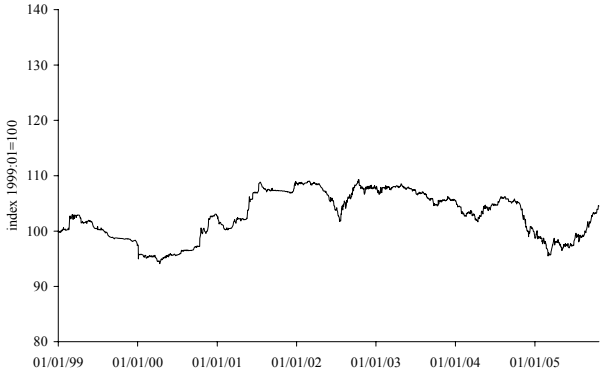
kuna/euro (percent changes)



kuna/euro (01/01/99 = 100)



new Taiwan dollar/dollar (percent changes)



new Taiwan dollar/dollar (01/01/99 = 100)

Figure 4: Target Zone Model for Emerging Markets

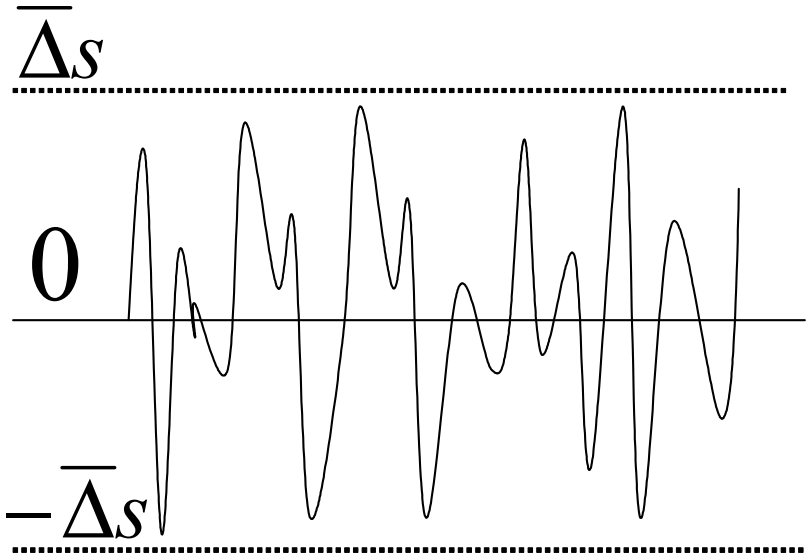
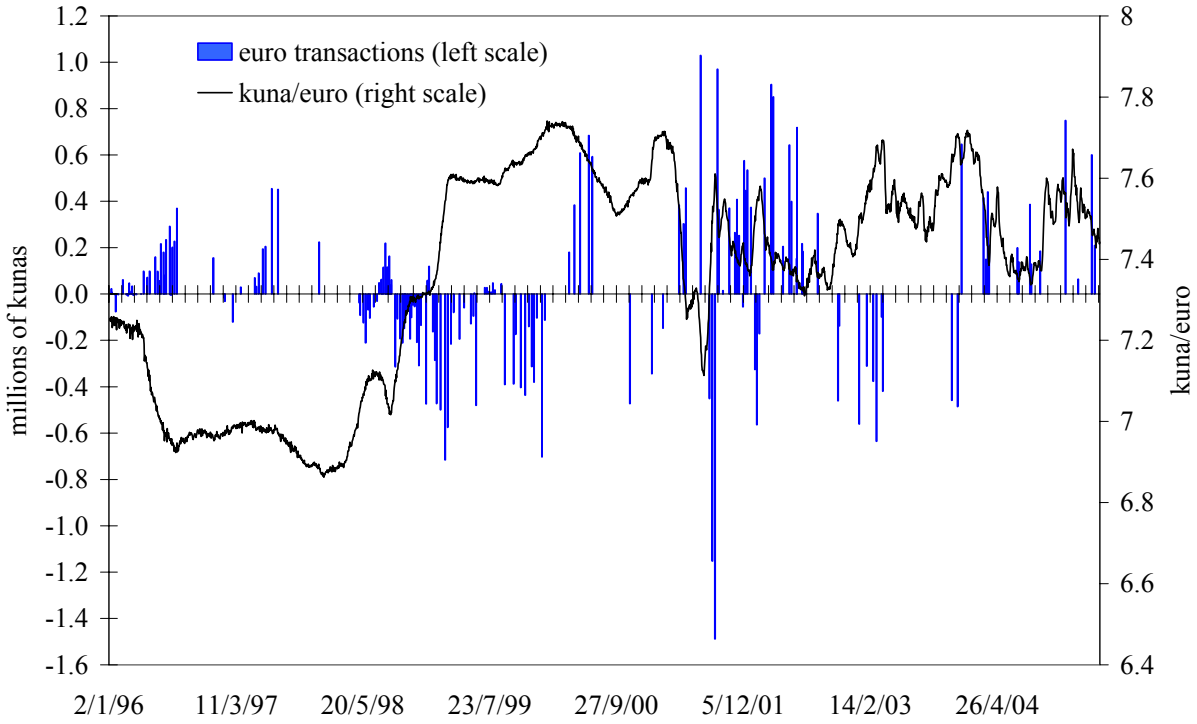
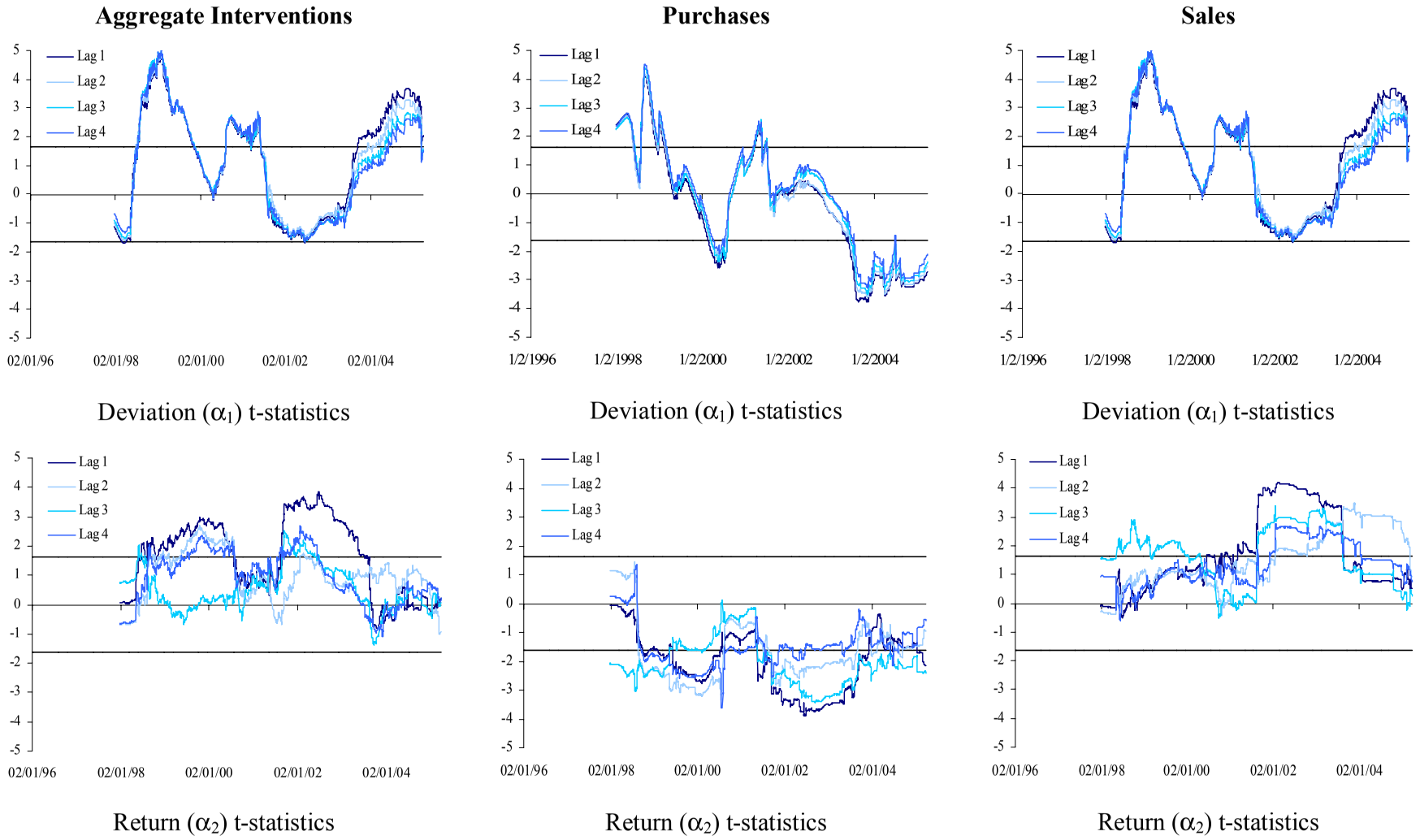


Figure 5: Croatian Foreign Exchange Intervention



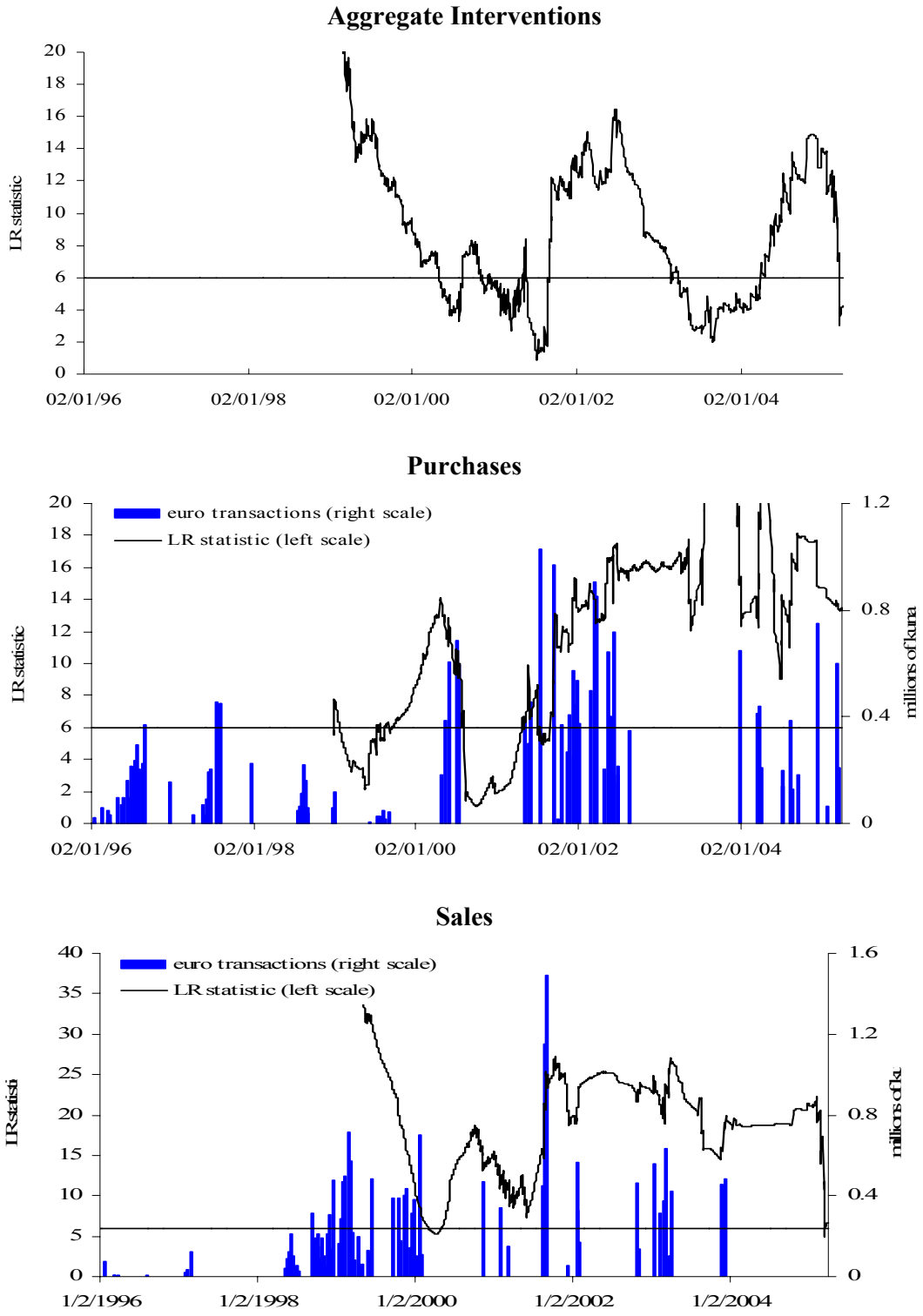
Source: Croatian National Bank.

Figure 6: Rolling Probit Reaction Function t-Statistics for Croatia (Window = 500 Observations)



Note: The critical value from a t-distribution used is 1.65.

Figure 7: Rolling Probit Estimation LR-Statistics for Joint Significance of α_1 and α_2 Coefficients and Croatian Foreign Exchange Interventions (Window = 500 Observations)



Note: The critical value from a chi-squared distribution with two degrees of freedom is 5.99.

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