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CROATIAN NATIONAL BANK

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# Microstructure of Foreign Exchange Market in Croatia

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## Abstract

This paper presents the results of the first analysis of the Croatian FX market microstructure. It focuses on the investigation of correlations between trading volume, exchange rate volatility and bid-ask spreads in the market for the Croatian domestic currency – the kuna. The analysis suggests that there is a positive correlation between unexpected volume and unexpected volatility in the kuna spot market as well as a negative correlation between expected volume and unexpected volatility, both as predicted by theory. In the context of recent events in Croatia, it seems very likely that both results are an expected consequence of the flow of macroeconomic and political indicators related to the speed of Croatia's EU accession. The analysis also suggests a weak positive correlation between expected volatility and the spread in the kuna spot market and a strong negative correlation between the spread and the expected trading volume. In the case of expected trading volume, this finding supports the economies of scale explanation of spread reduction due to an increase in market liquidity, while the positive correlation between the spread and the expected volatility supports the inventory-cost explanation of bid-ask spread determination. Both results have direct consequences for the central bank policymaking since the central bank is almost the sole regulator of the Croatian foreign exchange market.

**JEL:** F31, L23, Croatia

**Key words:** exchange rate, foreign exchange market, market microstructure, Croatia

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# Contents

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## 1 Introduction

According to the microstructure approach to exchange rate analysis (see for example Sarno and Taylor, 2001), understanding of the kuna exchange rate could be significantly improved with microstructure analysis of the Croatian FX market, where that price is formed.[1] There is a detailed description (models) of currency trading within the context of the microstructure approach to FX market analysis. These models comprise all aspects of real world trading with a certain currency between all participants on all markets where that currency is traded.

However, previous surveys of kuna exchange rate analysis were mostly focused on the economics of the exchange rate in connection with the balance of payments, price inflation, central bank FX interventions, currency crises, etc. Only one relatively old review (Stučka 2001) has described the technical characteristics of the official (central bank) exchange rate calculation and the statistical characteristics of exchange rates realized in the trading between commercial banks and several institutional sectors which are the basis for this calculation. However, as far as we know, none of these papers has given a detailed description of the trading process in the Croatian FX market or has analyzed whether this trading process alone has any influence on the kuna exchange rate determination.

Therefore, the contribution of this paper to the understanding of kuna exchange rate determination lies in its detailed description of the Croatian FX market microstructure (hence, kuna FX market microstructure), and in providing preliminary econometric results on the influence that this microstructure has on every-day formation of the CNB middle FX rate. Galati (2000) gives the starting point for this analysis because it is the first paper to test the theoretical relationship between exchange rate volatility, trading volume and bid-ask spreads for emerging countries' currencies (previous papers were usually focused on major world currencies). That paper confirmed that, even for emerging countries' currencies, the unexpected component of trading volume is positively correlated with the unexpected component of exchange rate volatility, as predicted by the Mixture of Distributions Hypothesis (MDH), which states that an unpredictable inflow of

1 Although there is a theoretical possibility of kuna trading abroad, the probability that domestic kuna trading covers almost all kuna trading is very high. Thus, the FX kuna market analysis is synonymous with the Croatian FX market analysis.

new, publicly available information on the market simultaneously influences both variables (Clark 1973). That paper also confirmed a positive correlation between expected exchange rate volatility and the bid-ask spread, consistent with inventory cost models according to which the bid-ask spread is the premium that the dealer charges for his exposure to the risk of accumulating excess inventory of the instruments he trades in (O'Hara and Oldfield 1986, among others).

Following Galati, empirical analyses that are focused on the volume-volatility-spread relationships in markets for emerging countries' currencies can be found for the currencies of India (Bhanumurthy 2000), Jamaica (Walker 2002) and Tunisia (Kouki 2003). However, although the investigation of correlations between trading volume, exchange rate volatility and bid-ask spreads became the starting point for the microstructure approach to exchange rate analysis, there are some important questions within this domain that more recent empirical analyses attempt to answer. One of them is how different market participants or different trading instruments influence the mentioned three key features of the FX market microstructure. Research of the Swedish FX market (Bjønnes, Rime and Solheim 2003) has shown that trading volume between the largest banks had a crucial influence on the Swedish Crown (SKK) exchange rate volatility, which was interpreted as a sign that these FX market participants were better informed. The same research showed that the SKK trading volume between domestic banks had a greater influence on exchange rate volatility than trading volume between foreign banks, which was interpreted as an indication that the SKK exchange rate depends mostly on domestic economic conditions.

This paper presents the first analysis of the Croatian FX market microstructure (kuna FX market microstructure). It answers questions similar to the ones mentioned above, within the limits imposed by the availability of FX trading volume data for the Croatian FX market. The paper is structured as follows: after this introduction, there is a review of theoretical and empirical literature on the FX market microstructure that relates to volume-volatility-spread analysis. The third section presents a detailed description of kuna trading between different participants in the Croatian FX market. The fourth section presents an overview of the characteristics of the unique data set used. The results of the econometric analysis are presented in part five. The sixth section provides a conclusion and proposes some directions for further research.

## 2 Literature Review

As a result of shortcomings of the traditional approaches to modelling foreign exchange rates, a new approach to exchange rates, the microstructure approach, emerged during the 1990's. A core distinction between the microstructure approach to exchange rates and traditional (macro) approaches is the role of trades in price determination. In macro models, trades have no distinct role in determining price. In microstructure models, trades have a leading role – they are the prox-

imate cause of price adjustment. What distinguishes the microstructure approach is that it relaxes three of the macro approaches' most uncomfortable assumptions:

1. Information: microstructure models recognize that some information relevant to exchange rates is not publicly available.
2. Players: microstructure models recognize that market participants differ in the ways they affect prices.
3. Institutions: microstructure models recognize that trading mechanisms differ in the ways they affect prices.

Empirically, it is simply not true that all information used to determine market-clearing exchange rates is publicly available (Lyons 2001). Most prominently, FX traders at banks regularly see trades that are not publicly observable. This information forecasts subsequent exchange rates (e.g., seeing the demands of private participants or central banks before the rest of the market). Regarding differences between market participants, traders with common information regularly interpret this information differently; in addition, there are differences between market participants concerning their motives for trade: some traders are primarily hedgers, whereas others are primarily speculators (and even among the latter, speculative horizons can differ dramatically). Regarding trading mechanisms that affect prices, this mostly concerns markets where transparency is low (i.e., where individual transaction sizes and prices are not generally observable). Low transparency can slow the updating of beliefs about appropriate prices, thereby altering the path of realized prices.

Therefore, the key feature in the switch from the macro approach to exchange rate determination to micro approach is the informational role of trading process. This is most usefully analyzed by looking at signed order-flow series of registered characteristics of trading transactions (time, price, amount, initiator, etc.). The microstructure approach is based on analyzing how information relevant to FX price determination, including what is documented in the signed order-flow, is reflected in the spot exchange rate through the trading process (analytical models in this approach reflect the main characteristics of trading well). Traditional approaches, on the other hand, give little attention to how trading on the FX market is conducted. These models assume that trading details[2] do not have an influence on exchange rate behaviour. The micro approach, in contrast, does not view trading as an irrelevant market activity that can be ignored when observing exchange rate behaviour but as an integral part of the process through which exchange rates are determined.

Micro-based exchange rate models start from the premise that much of the information about the current and future state of the economy is dispersed among agents (i.e. individuals, firms and financial institutions). The agents use this information in making their everyday decisions, including decisions to trade in the

2 For example, who quotes prices and how trading takes place.

FX market at the prices quoted by dealers. Dealers quote prices (e.g. kuna per unit of foreign currency) at which they stand ready to buy or sell foreign currency; they will purchase foreign currency at their bid quote and sell foreign currency at their ask quote. Agents that choose to trade with an individual dealer (dealer's customers) send him trading orders. If the customer order is a sale order (dealer purchases FX), it has a negative sign and vice versa. The sum of the values of sale and purchase orders sent to a dealer during a particular period is a signed order-flow. Importantly, an order flow is different from trading volume because it conveys information. A positive (negative) order flow indicates to a dealer that, on balance, their customers value foreign currency more (less) than his asking (bid) price. By tracking who initiates each trade, an order flow provides a measure of the information exchanged between counterparties in a series of financial transactions. It is also important to differentiate between an order flow and FX demand and supply because an order flow involves only executed and not potential transactions. This is important because the macro approach considers even potential (not realized) FX demand and supply to be sufficient to move the exchange rate.

When a dealer gets an order from his client, he keeps the information about that order for himself. The same takes place in inter-dealer trading, where only the contract parties know the characteristics of the orders. This confidentiality is supported by the lack of obligation to announce business information on the FX market, unlike in all other segments of the financial market.

According to Cao, Evans and Lyons (2002), the private information that is carried by order flows can be separated into two groups: fundamental and non-fundamental. Fundamental information refers to undeclared information about financial instrument yield (in the case of shares, it is usually information about future dividends). Since the only information of that kind on the FX market is about interest rates on different currencies, and confidential interest rate type information is not common in practice, it follows that there is no private information on the FX market concerning fundamentals. On the other hand, non-fundamental information is related to variables that have nothing to do with future cash flow, so this information affects financial instrument price directly. In the case of exchange rates, such information concerns, for example, FX demand changes induced by reducing FX risk exposure or by speculating. This information usually determines the risk premium that is incorporated into the dealer's price. Examples of such information include the dealer's risk preference, his trading restrictions, distribution of risky assets, etc.

Unfortunately, information on signed order-flows in foreign exchange markets is very frequently unavailable to microstructure analysts. Hence, the empirical microstructure literature on foreign exchange markets has long been focused on investigating the relationship between risks and volumes rather than order-flows. For instance, the price volume relationship has a direct bearing on the empirical distribution of speculative prices. Numerous studies have found a strong, positive contemporaneous correlation between volumes and volatility. A theoretical explanation for this positive correlation is known as the Mixture of

Distribution Hypothesis (MDH). First advanced by Clark (1973), the theory states that volume and volatility are both driven by a common unobservable factor which is determined by the arrival of new information to the market, so it predicts a positive co-movement between volatility and unexpected trading volumes.

Empirical studies of the futures and equities markets that have found trading volume to be significantly positively correlated with price variability include Clark (1973), Epps and Epps (1976), Frankel and Froot (1980). Frankel and Froot (1980), using data for four currencies, found evidence of a high contemporaneous correlation between volume and volatility. There are several interpretations of this finding of a positive correlation between volume and volatility; for example, Clark argues that, since trading volume is related positively to the number of within day transactions, it is related positively to price variability.

Epps and Epps (1976) attribute a positive price variability volume relationship between the extent to which traders disagree when they revise their reservation prices and the absolute change in the market price. When applied to the foreign exchange market, this implies that the extent to which traders disagree is associated with a larger absolute change in the exchange rate and thus greater variability in the rate. The volatility volume relation arises then because trading volume is positively related to the extent to which traders disagree when they trade.

Tauchen and Pitts (1983) proposed that the correlation between volume and volatility should be positive if trading occurs because of disagreement among traders and negative when volume is determined by the number of traders. That is, volume increases because the number of traders has increased, so there is an increase in liquidity. Tauchen and Pitts noted that the model of Epps and Epps ignored the growth in size that can occur in new financial markets over time. Support for this theory is found if the variance is found to depend positively on volume and negatively on a time trend intended to reflect a steady growth in the number of traders. They provided two theoretical explanations for the co-movement of volatility and trading volume. The first is that the volatility of the market price declines as the number of traders increases. The argument here is that, as the number of participants increases, the demand shocks experienced by individual traders increasingly tend to offset each other, leaving the market price largely unaffected. The second explanation applies to more mature markets. In such markets, where the number of traders is likely to be fixed, an increase in volume is a reflection of greater disagreement among traders and hence will lead to higher volatility. The second theory is stronger when new information arrives in the market at a faster rate.

The microstructure literature highlights inventory control and information as the two channels through which trading volume generates price movements. The inventory control channel postulates that dealers use prices to control movements in their positions. The information channel focuses on the presence of traders with private information: dealers, because they are rational, will adjust their beliefs and prices in response to changes in order flow. One implication coming from both views is that trades initiated by buyers will drive prices upwards. Lyons

(1993) using intra-daily data found strong evidence in favour of both strands of the microstructure theory.

The microstructure literature has also found a positive correlation between trading volumes, volatility and spreads in foreign exchange markets. Microstructure theory suggests that inventory cost is a component of the spreads in financial markets. Models that seek to explain inventory costs establish a link between spreads, volatility and trading volumes. The cost of maintaining an open position in any currency is one determinant of inventory costs, which is positively related to price risk. According to this view, exchange rate volatility increases price risk and thereby pushes up spreads. Thus spreads widen when exchange rate volatility increases. Melvin and Bollerslev (1994), Bessembinder (1994) found a positive correlation between spreads and expected volatility measured by GARCH forecasts.

Trading activity, according to the literature (Hartmann, 1999), is another determinant of inventory costs. Volumes impact spreads differently depending on whether they are expected or unexpected. Unexpected trading volumes should have a positive impact on spreads, given that they should reflect the arrival of news to the market. By contrast, expected trading volumes should be negatively correlated with spreads to the extent that they reflect economies of scale associated with higher competition among market makers.

Furthermore, dealers collect private information in communication with their clients, other dealers and brokers. However, different sources of information have different influences on informing dealers and exchange rate behaviour. Examinations have shown that "big players" have a competitive advantage because they are better informed and hence they have more influence on exchange rate behaviour (Cheung, Chinn and Marsh, 2000). Bjønnes, Rime and Solheim (2003) use aggregated data for SKK/EUR behaviour analysis for the first time; they identified that dealers, like large, well informed banks, have a crucial influence on exchange rate behaviour. The above results confirm the heterogeneity of FX market participants, which is evident in the different amount and quality of the information they get and the different treatment they receive from those who set exchange rates – FX dealers.

Similar empirical analyses that focus on the microstructure of FX markets of emerging countries' currencies can be found for the currencies of India (Bhanumurthy 2000), Jamaica (Walker 2002) and Tunisia (Kouki 2003). In the case of India, where the focus of the analysis was a little different, one of the results was that the volatility of the Indian currency exchange rate is positively correlated with its bid-ask spread. The analyses for the Tunisian and Jamaican currencies give the same result. In the Tunisian case, however, no statistically significant correlation was found between the unexpected trading volume and the unexpected exchange rate volatility or between the expected trading volume and the bid-ask spread. In the Jamaican case, a statistically significant negative correlation was found between the unexpected trading volume and the unexpected exchange rate volatility, which is contrary to the MDH but consistent with the theo-

retical model that predicts a reduction of financial instrument price variability if the number of market participants increases. The common thread in these surveys is that most of the microstructure effects are successfully explained by the specifics of the respective currency markets.

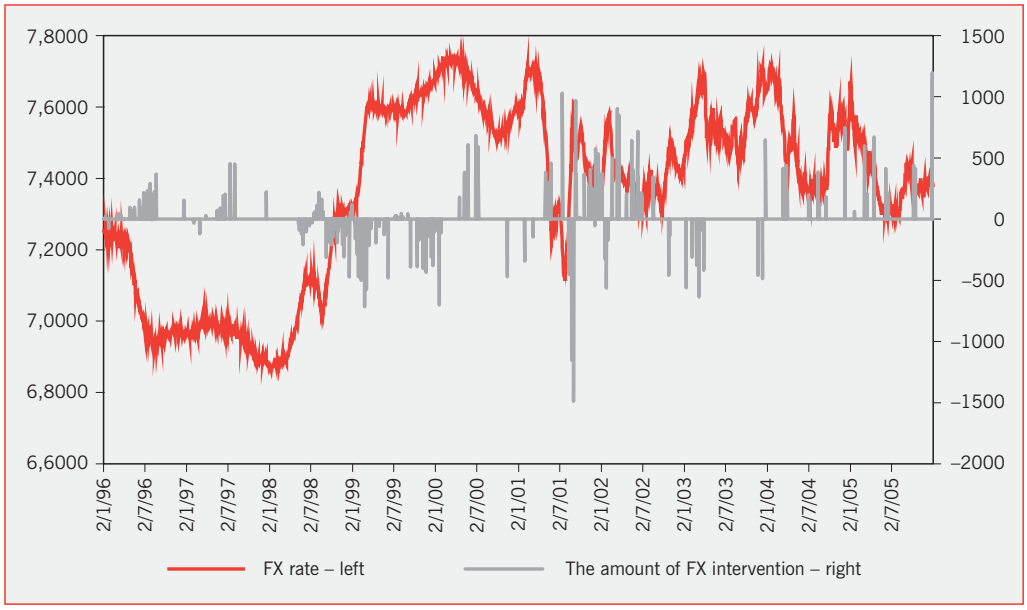
## 3 The Croatian FX Market and the FX Regime[3]

The Croatian FX market is an important segment of the Croatian financial market. It has traditionally been stimulated by significant inflows and outflows of foreign currency (based on current and capital account transactions). The inflow of foreign exchange is mainly the result of foreign income from tourism, receipts from the privatization of public companies, growing public debt, growing foreign debt of domestic banks, and the arrival of remittances from Croatian citizens working abroad. The outflow of foreign currency, on the other hand, is mainly caused by imports of goods and, more recently, by growing payments of foreign obligations by domestic companies and government. The sizable inflow and outflow of foreign currency, together with gradual liberalization of the Foreign Exchange Act (which, before 2001, had banned the domestic non-financial companies from actively trading with foreign currency) have been the main factors in the development of the Croatian FX market in the last few years. Since 1999, because of a greater inflow than outflow of foreign currency, the Croatian currency, the kuna, has mostly experienced appreciation pressures.

Croatia uses a managed float FX rate regime without announcing the planned pattern of the FX rate float. In this way, the central bank is not obliged to determine the lower or the upper intervention threshold. It intervenes when and how much it deems necessary to achieve the goals of monetary policy. Also, the CNB extremely rarely announces in public the level of the FX rate that it will defend. Although a large part of the public believes that the CNB determines the official foreign exchange rate (the CNB middle FX rate) in accordance with the needs of monetary policy, this rate is actually determined by the FX market. The CNB only determines the methodology for the calculation of the official FX rate (see Appendix 4, part 1). However, because of the longstanding operating assumption that the historical effect of volatility of the HRK/EUR rate (previously the HRK/DEM rate) on domestic prices has not disappeared, the central bank, which aims to guarantees price stability, cannot allow significant volatility of the official FX rate. Therefore, since the beginning of 1997, the CNB middle FX rate for HRK/EUR has a coefficient of variation of only 3.1% while the same coefficient for HRK/USD rate stands at 13.6% (two-thirds of Croatia's foreign reserves are denominated in euro, which emphasizes the historical connection between Croatia and strong European currencies).

3 For more details see Appendix 4.

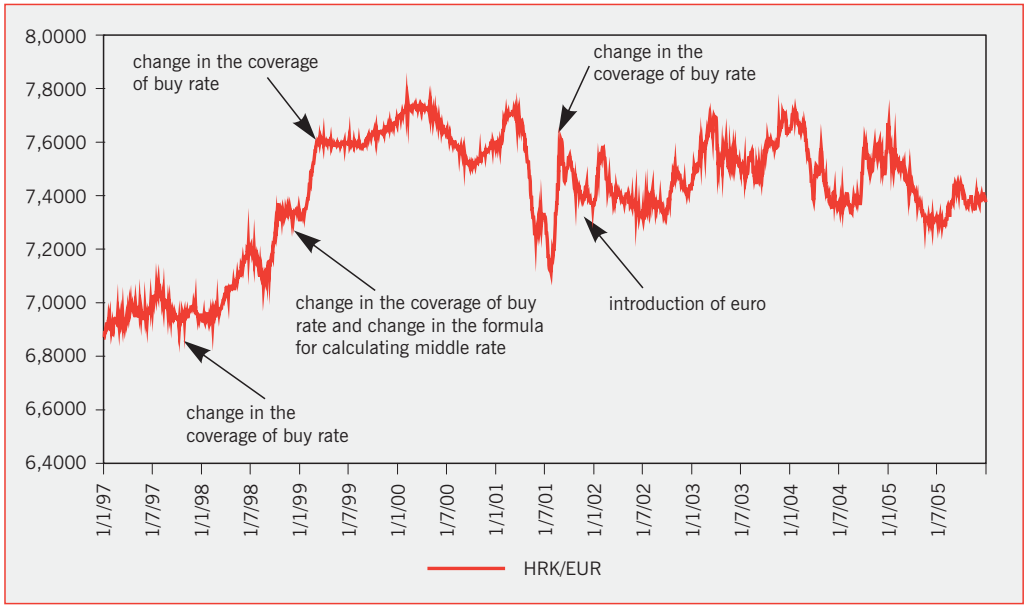
**Figure 1** Croatian National Bank Foreign Exchange Interventions and Middle FX HRK/EUR Rate




Source: CNB.

The CNB middle FX rate methodology has been changed a few times, causing some structural breaks in the time series of the CNB middle FX rate. Some changes refer to trading coverage while others refer to mathematical formulas. These changes make it impossible to display the CNB middle FX rate as a consistent time series since 1 October 1997 (see Appendix 1 for more details). Moreover, although the CNB middle FX rate is a very good approximation of the market FX rate, it is not a real market rate even when one ignores the statistical

**Figure 2** The CNB Middle FX Rate Series and Its Methodological Breaks



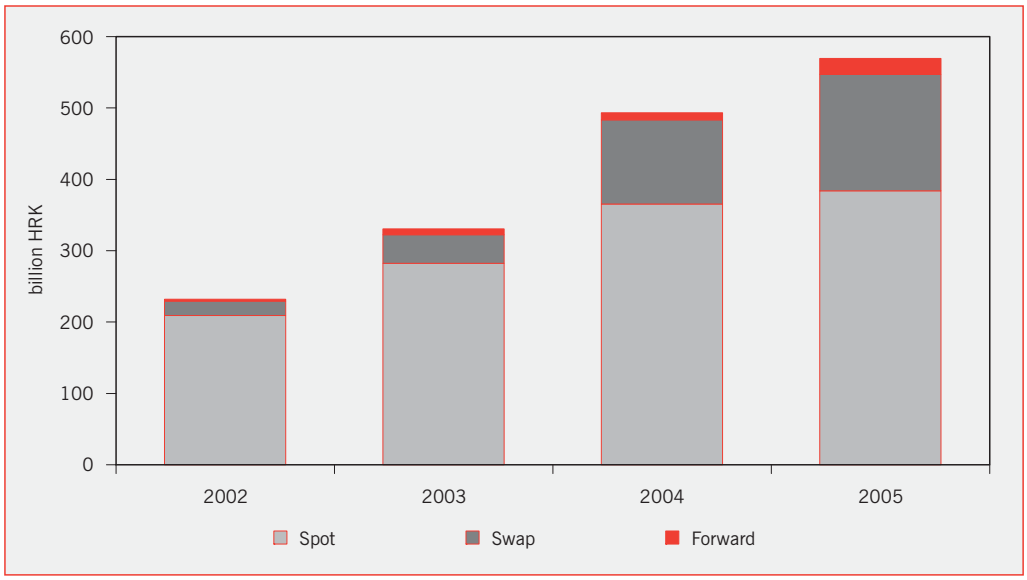

Source: CNB.

breaks; it always represents the market FX rate from two days before (or even more in the case of a non-working day, or the first day after a weekend or a holiday). In addition, the CNB gathers FX trading reports from commercial banks only, so the CNB middle FX rate may not be representative of some other unofficial FX markets for the kuna (though we judge these are negligible). Finally, the calculation of the CNB middle FX rate for the euro includes data on trading in all currencies, so the changes in the official FX rate actually reflect changes in the total supply and the total demand of kuna by FX traders and do not reflect (as one would expect) changes in the relative supplies and interest rates of the kuna and the euro in the Croatian FX market.

One of the main characteristics of the Croatian FX market is its shallowness (for more details see Appendix 4, part 2). Its structure has been very uniform (monotone) despite a continuous growth in trading volume, since almost all transactions were spot transactions until 2004. The FX swap market started to develop in 2004, and its trading volume amounted 28.6% of the total FX trading volume in 2005. The growth in trading volume of FX swaps in the last two years can most likely be explained by a rise in non-residential investments in Croatian financial markets: non-residents who are short of Croatian kuna for purchasing Croatian securities enter into FX swap deals for kuna that allow them to earn capital gains without exposing themselves to currency risk. The forward FX market doubled its trading volume in 2005 but is still by far the smallest segment of the Croatian FX market; it accounts for about 3.9% of the total FX trading volume.

One of the main players in the Croatian FX market is Croatia's central bank. The Croatian national bank runs its monetary policy primarily through the FX channel by performing occasional, unannounced, and unsterilized (or partially sterilized) FX interventions (for more details see Appendix 4, part 3). As a result, the CNB's share in the total annual FX trading volume is very small, although the

**Figure 3** Trading Volume on the Croatian FX Market by Transaction Type




Source: CNB.

FX trading volume between the CNB and banks is very large on the day (or the week or even the month) of an intervention. The CNB mostly uses spot transactions for conducting FX interventions, although is allowed to use swap transactions. The FX interventions are subject to quarterly projections of monetary policy accepted by the Council of the CNB, but it is the management of the CNB who is in charge of choosing the actual time and amount of an individual intervention. The intervention itself is conducted in the form of an auction. The CNB conducts foreign exchange interventions with both commercial banks and the government. In the latter case, the CNB buys and sells foreign currency for the account of the government with the intention of decreasing the unwanted effects of a large direct inflow or outflow of foreign currency through the banking system (see Appendix 4, part 4).

Other players are natural and legal persons. Natural persons are traditionally an FX surplus sector; the main characteristic of this sector is its large share in the total cash trading as well as the impossibility of registering each cash transaction this sector makes (see Appendix 4, part 6). Legal persons usually trade with FX instruments through the commercial banks where they have their business accounts. They are traditionally an FX deficit sector because the value of Croatian goods imports is twice the value of goods exports, and a large number of Croatian legal persons need a steady source of foreign currency to pay their foreign debt instalments. Also, after 2001, the largest Croatian companies started actively trading foreign currencies to protect themselves from the FX risk inherent in their business activities (see Appendix 4, part 7).

The only market makers on the Croatian FX market are commercial banks (for more details see Appendix 4, part 5). The Croatian FX market consists of a non-cash segment, which pertains to transactions done mainly through banks, and a cash segment, which is mostly tied to small exchange offices and private trades. Croatian banks conduct FX trading in their treasuries. The treasuries usually have a front and back office, but larger banks also have a middle office. The front office usually includes a money market desk, a fixed income desk, an FX desk, a desk for corporate clients and a cash desk. The FX desk is generally responsible for internal quotations for the client's desk, creating regular FX rates lists, FX market making and the development of new products that could be offered to clients as part of the FX trading.

The process of FX trading usually begins with identification of the bank's starting FX position. Changes in the FX position can invoke certain FX trading strategies because of the FX position rules in the current banking regulations. If a bank is too short in a certain currency, the dealers will probably be willing to buy that currency at a slightly higher price. On the other hand, if a bank is too long in a certain currency, its dealers will probably be willing to sell that currency at a slightly lower price. That way, the bank's starting FX position and its wanted FX position at the end of the day influences the choice of its beginning FX rates for that day.

After defining their starting strategy (based on the bank's FX position), the FX dealers design their profit-making strategy on the FX market, which means finding a way to buy at low prices and sell at high. In order to achieve this, they plan the wanted FX trading volume and select market segments where this plan is easiest to realize (some segments of the FX market, such as the inter-bank FX market, are suitable for larger trading volumes while other segments, such as trading with natural persons, is more suited for smaller trading volumes). The last step in the preparation stage is the quotation of the FX rates at which the dealers will make the transactions on the FX market. The FX rate on the inter-bank FX market is always quoted as the price of one currency (quoted currency) expressed in the second (base) currency. All large domestic banks have Reuters dealing system, and FX trading between banks is carried out exclusively by using this system.

Trading on the Croatian FX market is active only between 08:00 and 16:30 on working days. The trading is global, which means that Croatian banks can trade with any bank in the world up to the limits set by their risk management units. The trading amounts are usually expressed in millions of euro although it is possible to trade with smaller amounts. Small banks in the Croatian FX market do not usually trade for speculative reasons but to carry out small transactions connected with their daily activities or with satisfying FX regulations. Commercial banks are obliged to report their trading activities to the CNB on a daily basis, with trading data expressed in original currencies and in kuna value. These reports are used for calculating the CNB middle rate for the euro, which then forms the basis for the official exchange rates of kuna with respect to all other currencies.

## 4 Data

The dataset available for the econometric analysis contains total daily volumes of foreign currency transactions reported by all domestic banks between October 1997 and May 2006 and sorted by: 1) type (sale, purchase), 2) instrument (spot, swap, forward), 3) currency, and 4) sector (natural person – cash, natural person – non-cash, legal person, domestic bank, foreign bank). The data include the trading volume expressed in the transacting currency, the base currency (DEM until the end of 2001 and euro thereafter) and the domestic currency (kuna), so that the weighted average daily exchange rate can be computed separately for each reporting bank, transaction type, instrument sold, currency exchanged and the counterparty sector involved. Until the end of 2001, the dataset was based on a less extensive sectorization: all transactions by natural persons (cash and non-cash) are lumped together, and transactions with legal persons contain transactions with foreign banks. Transactions between banks and foreign currency exchange offices were reported by banks (within the natural persons – cash transactions sector) only after 2 October 2001.

Due to the euro-changeover and sectorization issues (to be elaborated further in this section), the econometric analysis in this section of the paper is based on

the portion of the dataset beginning with 1 January 2002 (and ending 31 May 2006), i.e. it is based on the sample that has the euro as its base currency for the calculation of the CNB middle FX rate and it employs the five sector classification of daily trading volumes. The dataset used is also more aggregated and covers only total daily spot transaction volumes between commercial banks and their customers, with all banks and all currencies lumped together, expressed in the base currency, the euro, and in the domestic currency, the kuna, broken down between buy and sell volume and by customer type: natural persons (broken down further as cash and non-cash transactions), legal persons (including government), domestic banks (i.e. inter-bank trading) and foreign banks. The weighted average daily kuna/euro exchange rates are then computed from these volumes and broken down in the same way as the volumes. Thus, possible effects of trading swaps and forwards on the volatility and the spread in the spot market are not analyzed in this study. Also, the possible effect of trading volumes in different currencies on the volatility and the spread are not assessed at this time.

Before testing the proposed theoretical relationships, it is informative to glance at the raw daily data on trading volumes, exchange rate returns and bid-ask spreads.

**Table 1** Main Variables – Descriptive Statistics

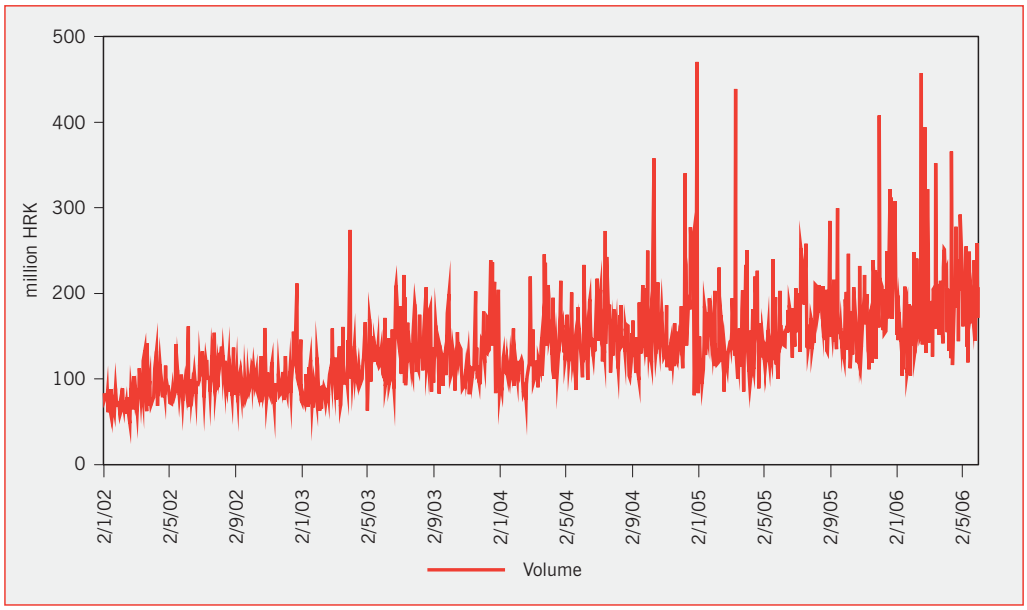
| Descriptives | ABS(DLOG(CNB_RATE)) | SQR(DLOG(CNB_RATE)) | VOLUME | SPREAD |
|---|---|---|---|---|
| Mean | 0.0012 | 0.0000 | 139 | 0.0504 |
| Median | 0.0009 | 0.0000 | 130 | 0.0492 |
| Maximum | 0.0082 | 0.0001 | 470 | 0.1076 |
| Minimum | 0.0000 | 0.0000 | 48 | 0.0131 |
| Std. dev. | 0.0011 | 0.0000 | 52 | 0.0151 |
| Skewness | 1.8 | 5.3 | 1.7 | 0.7 |
| Kurtosis | 7.8 | 45.1 | 8.4 | 3.9 |
| Jarque-Bera | 1.638 | 86.990 | 1.876 | 115 |
| Probability | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Source: CNB.

The total trading volume is measured as the sum of buy and sell orders, expressed in kuna, between commercial banks and their counterparties, not including the central bank, and counting the inter-bank volume only once. Other measures of volume were examined as well, but the results of the econometric analysis did not change significantly and so are not reported here. In the analyzed period, both the total trading volume and its volatility show a steady increase. The picture is different however, when the trading volume is disaggregated by the trading sector. While the cash trades with natural persons do not show a trend but exhibit a strong seasonal pattern, non-cash trades with this sector show an almost exponential increase in size and especially in volatility during 2005, both of unknown

origin (a rise in e-banking and open investment funds are possible but yet untested explanations of this phenomenon). On the other hand, trading with legal persons shows a much steadier increase in size and volatility, and trading with foreign banks exhibits a much larger increase in volatility than in size. Trading volumes in those trading segments do not exhibit clear seasonal patterns.

**Figure 4** Trading Volume

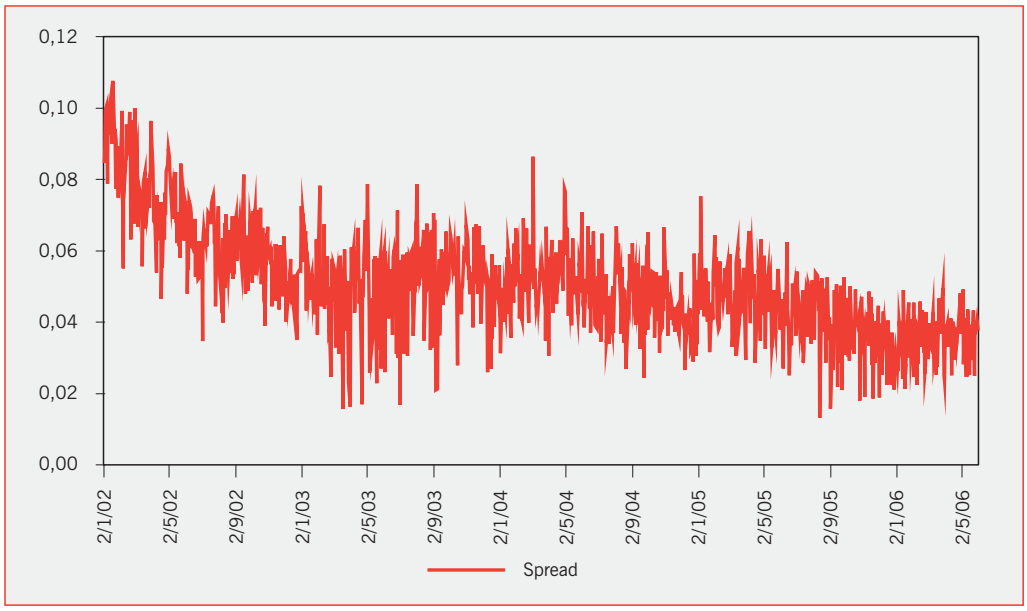



Source: CNB.

The overall bid-ask spread is measured as the volume weighted average of the spread in trading with legal persons and the spread in non-cash trading with natural persons. The omission of the foreign bank sector is intentional, because the spread for this sector cannot be computed in many instances (there are either no sales or no purchases on certain trading days). The spread in cash-trades with natural persons is also left out of the calculation of the total spread since it contains two elements that are not of interest: it carries the cost of foreign currency cash transactions and so is much higher than the spread in other trading segments, and it exhibits a seasonal pattern. The spread in the inter-bank market is not available in our dataset because it contains information on realized trades only and does not carry any information on dealers' quotes or on the initiator of the transaction (so the inter-bank volume cannot be split into "sales" and "purchases" based on the initiating side of the trade, as in the order-flow analysis strand of the microstructure approach). In the period analyzed, the overall bid-ask spread in the market for the Croatian kuna computed in the manner described above exhibits a falling trend with steady volatility.

The kuna exchange rate volatility is based on the official CNB mid-rate and measured two ways, as the average square change and as the average absolute change of the log of daily returns. Both measures are expectedly leptokurtic (both peaked and fat-tailed); however, the square measure puts more emphasis on large

**Figure 5** Bid-Ask Spread, kuna per euro

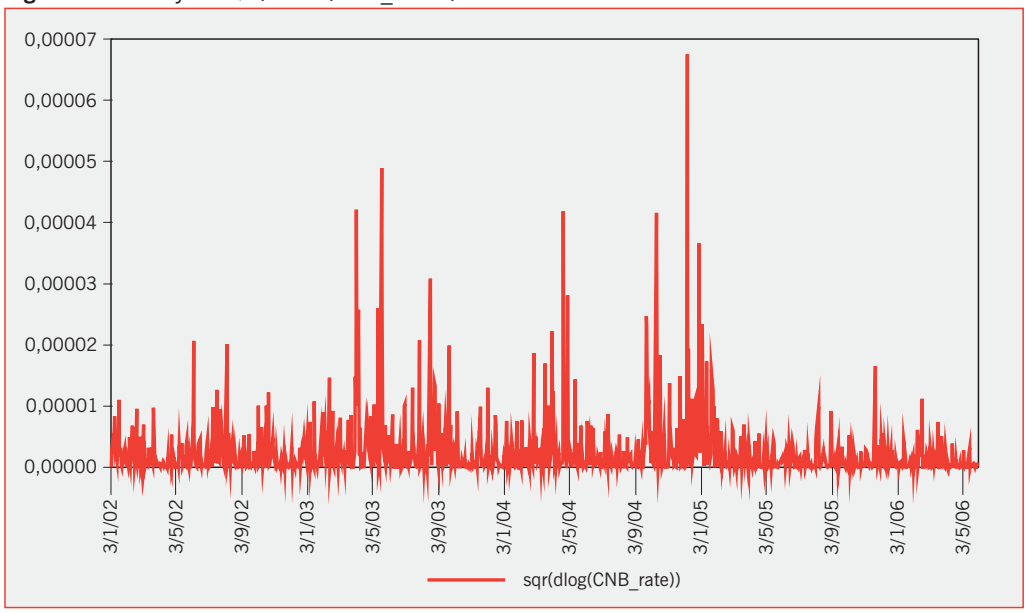



Source: CNB.

returns and is therefore more leptokurtic than the absolute measure. In the period observed, both measures of exchange rate volatility show signs of possible conditional heteroscedasticity of the daily log returns of the CNB mid-rate. It is difficult to say from graphing such a short sample whether the volatility clustering in this case can be attributed to a seasonal pattern, at least prior to 2005.

The correlations between the observed volume, volatilities and spread reveal a strong negative relationship between the volume and the spread and a much weaker positive relationship between the volume and both measures of volatility; the relationship between the volatility and the spread is indeterminate. The second

**Figure 6** Volatility – SQR(DLOG(CNB_RATE)




Source: CNB.

of these relationships gives an early indication that the Mixture of Distributions Hypothesis may hold in the market for Croatian kuna, that is, that higher volumes are associated with more heterogeneous beliefs among market participants and not with the increase in market liquidity. The first relationship, on the other hand, indicates that the spread in the Croatian kuna market is possibly much more affected by competition among trading banks than by their inventory costs, which would then probably imply that the market liquidity is affected by at least one component of the trading volume.

**Table 2** Main Variables – Correlations

| Correlations | ABS(DLOG(CNB_RATE)) | SQR(DLOG(CNB_RATE)) | VOLUME | SPREAD |
|---|---|---|---|---|
| ABS(DLOG(CNB_RATE)) | 1.0000 | 0.9038 | 0.1339 | 0.0311 |
| SQR(DLOG(CNB_RATE)) | | 1.0000 | 0.1756 | –0.0059 |
| VOLUME | | | 1.0000 | –0.6135 |
| SPREAD | | | | 1.0000 |

Source: CNB.

## 5 Econometric Analysis

To test the presumed relationships between the three micro-structural variables in more detail, the trading volume and the exchange rate volatility were decomposed into their expected and unexpected components. For the decomposition of the total trading volume, which could not be rejected as stationary in the observed period, an AR(5)-GARCH(2,1) model was found to be appropriate (Appendix 3, Table 1). The model reasonably accounted for intra-week pattern, intra-month pattern and some standard annual seasonality of the trading volume, as well as for its autocorrelation and conditional heteroscedasticity. An AR(1) model found in similar studies would be appropriate for the mean equation if it was not for an apparent multiplicative weekly pattern that was conveniently captured by an AR(5) term. As usual, the fitted volume from this model is taken as the expected volume, while the residuals of the mean equation are treated as the unexpected volume in the further analysis.

The decomposition of the exchange rate volatility was performed much more mechanically, but the exchange rate was not regressed on a constant in the mean equation as found in some other empirical studies. The reason for this is that the exchange rate in the period studied exhibited a slightly more complex univariate pattern, and an AR(3)-GARCH(2,1) model (Appendix 3, Table 2) was found to be appropriate for modelling its auto-covariance structure and conditional heteroscedasticity. The conditional variance series from the estimated model was then used as the expected volatility in the spread analysis.

With the total volume decomposed into its expected and unexpected components, the first of the two theoretical relationships was tested. The regression of the volatility on the expected and the unexpected volumes, for each of the two measures of volatility, was performed using the GARCH-M(1,1) model, so that

the effect of the unexpected volume on the volatility can be assessed, while controlling for the effect of the expected component of the volatility on itself. As is usual in the microstructure approach, an exchange rate variable (the EUR/USD rate) and an interest rate variable (the spread between the three-month ZIBOR[4] and EURIBOR) were added to the mean equations. The two models yielded similar results (Appendix 3, Tables 3a and 3b). The interest rate variable was highly insignificant in both specifications and so was dropped from the final models.

The models confirmed the positive relationship between the unexpected volume and the unexpected volatility in the Croatian kuna spot market, as well as the negative relationship between the expected volume and the unexpected volatility, as predicted by Tauchen and Pitts (1983). We interpret the first result in a usual way, as a sign that, at least in the period analyzed, both the unexpected volatility and the unexpected volume in the Croatian FX market were driven by the arrival of new price-sensitive information on the market. More importantly, from the policy point of view, the second result also indicates that the market liquidity had increased in this period, as one would expect from looking at the steadily growing trading volume (see Figure 4). In the context of recent events in Croatia, it seems very likely that most of the unexpected exchange rate variability attributable to information effects (unexpected trading volume) in the past few years was caused by a mix of macroeconomic and political indicators determining the speed of Croatia's EU accession. Interestingly, these same factors are probably to be credited for the rise in the market liquidity (expected trading volume) as they are the ones that contributed most to the opening of Croatia's financial markets.

The regression of the spread on the expected volatility and on the expected and the unexpected volume presented a challenge, even though the series passed the standard stationarity check. However, the best univariate model for the Croatian kuna spread is the ARMA(1,1) process that yields a near unit root for the AR term with the MA root near –1. Following the literature, we had to treat the spread as a non-stationary series in the further analysis. Thus, we regressed the expected volatility in one model and the expected and the unexpected volume in the second model on the spread in differences rather than in levels. The models (Appendix 3, Tables 4a and 4b) were designed by augmenting the ARMA(2,1) model that gave a reasonable univariate fit to the differenced spread variable with the explanatory variables in the form of change of the expected volatility from the AR(3)-GARCH(2,1) model described in the second paragraph of this section and with the explanatory variables in the form of change of the expected and the unexpected volumes from the AR(5)-GARCH(2,1) model described in the first paragraph of this section.

The resulting models indicated a weak positive relationship between the expected (change in) volatility and the (change in) spread in the Croatian kuna mar-

4 ZIBOR is an acronym for the Zagreb Inter-Bank Offered Rate that represents average interest rates of the largest eight Croatian commercial banks quoted on the Reuters system daily at 11.00 hours.

ket, as predicted by the inventory-cost explanation of bid-ask spread determination. A much stronger relationship was found between the (change in) spread and the (changes in) trading volume: both components of the trading volume were found to be strongly negatively correlated with the spread. In the case of expected trading volume, this finding supports the economies of scale explanation of spread reduction due to an increase in market liquidity, while the negative relationship between the spread and the unexpected trading volume remains inexplicable. These findings bear consequences for policymaking, since the central bank is almost the sole regulator of the foreign exchange market in Croatia. Most prominently, it directly regulates limits on the FX exposures of domestic commercial banks, which also happen to be the largest FX dealers in the market. Thus, the nature of the above relationships is likely to respond to CNB policy changes related to the FX exposure limits for domestic banks.

The final part of the analysis consisted of testing whether trading volumes with different sectors impacted the bid-ask spread differently. For this purpose, a distinction between the expected and the unexpected volume was ignored, inspired partly by the previous model that found the unexpected volume to have no role in determining the spread. Once again, a model was designed by augmenting the ARMA(2,1) model that gave a reasonable univariate fit to the differenced spread variable with new explanatory variables. These variables were daily changes of the total volumes by six sectors: natural persons – cash, natural persons – deposits, legal persons, foreign banks, domestic banks and the central bank. To account for conditional heteroscedasticity, the model was also augmented with a GARCH(1,1) variance equation, producing an ARMA(2,1)-GARCH(1,1) model.

Since the examined model showed no role in the determination of the bid-ask spread for the trading volume with foreign banks, the central bank, and other domestic banks, these variables were dropped in the model selection process. However, the central bank intervention day dummy (instead of volume) proved significant. The finally selected model had a very reasonable in-sample fit (Appendix 3, Table 5), both in absolute terms and compared to the other models examined in this analysis. It showed that growth in non-cash trading with both natural and legal persons tended to decrease the spread, while cash trading increased it. These findings indicate the possibility that growing non-cash trading affects the FX market positively by increasing its liquidity, while the transaction costs associated with cash trading exceed the liquidity benefits of a growing trading volume in this market segment. The finding that trading with other banks does not affect the spread supports Lyons' theoretical models in which this trading segment only serves to balance dealers' open positions. Finally, the evidence that the spread decreases on the central bank intervention day, but this decrease is not proportionate to the intervention volume, implies that there is a role for central bank interventions in the microstructure of the Croatian FX market that needs to be studied further.

## 6 Conclusion: Policy Implications and Directions for Further Research

The preliminary results of the CNB research on the microstructure of the Croatian foreign exchange market presented in this paper indicate that some of the expected theoretical relationships between volumes, spreads and the volatilities in this market can be confirmed by the data. In particular, the models examined confirmed the expectations of a positive relationship between the unexpected volume and the unexpected volatility in the Croatian kuna spot market, and a positive relationship between the expected volatility and the spread, although the latter relationship was statistically much weaker. A much stronger, and also theoretically predictable, positive relationship was found between the spread and the expected trading volume. Furthermore, it was established that growth in non-cash trading tended to decrease the spread, while cash trading increased it, showing that the type of trading has consequences on market liquidity. Finally, evidence was found that the spread in the foreign exchange market decreases on the central bank intervention day, but also that this decrease is not proportionate to the intervention volume, implying that there is a role for central bank interventions in the microstructure of the Croatian FX market that needs to be studied further.

The descriptive analyses in this paper imply that further improvements can be expected by extending this research to the less aggregated data. Particularly, breaking down the trading volume by the sector of the transaction and introducing order-flows in the analysis should have some effect on the results, considering the strong descriptive evidence of widely different behaviour of volumes and order-flows (proxied by net-volumes) for different sectors. Secondly, the data available to the CNB allows the variables to be broken down by type of transaction (spot, swap, forward) and by currency, and that may also shed more light on the behaviour of the kuna exchange rate. Furthermore, analysis of exchange rate behaviour on the less aggregated data set would avoid the problem of methodological structural breaks in the computation of the CNB middle FX rate and thus enable the econometric analysis to be extended to the period before 2002. Finally, the role of central bank interventions in the Croatian foreign exchange market needs to be studied more thoroughly, as some results of this study indicate their non-trivial role in this market's microstructure.

Another interesting venue of research that requires a less aggregated dataset is bank-by-bank analysis of the trading behaviour of market-makers (i.e. commercial banks). This approach may reveal individual trading strategies of market-makers that may prove extremely useful in modelling daily exchange rate behaviour in a small foreign currency market such as Croatia's. Some research in this direction on the spot market is currently under way in the CNB. Other potentially useful further research will first require a richer CNB dataset. In particular, information on the initiating side in inter-bank transactions is essential for the design of the very important inter-bank order-flow time series; in addition, information on maturation dates of forward and swap transactions would enable an anal-

ysis that goes beyond simple analysis of trading volumes of the influence (if any) that trading in these two growing market segments has on the determination of the exchange rate in the spot market. Finally, considering the rise of non-banking financial intermediaries in Croatia in recent years, it is reasonable to believe that breaking down the "legal persons" sector into "non-bank financial institutions" and "other legal persons" could be essential for future analysis of the informational role that trading with different sectors has on individual dealers' (commercial banks') behaviour in the foreign exchange market. In this context, separating the data on banks' transactions with legal exchange offices from the data on cash trading with natural persons could prove helpful, as well.

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# Appendix 1

**Table 1** Formula for CNB Buy, Sell and Middle FX Rate from 1 October 1997

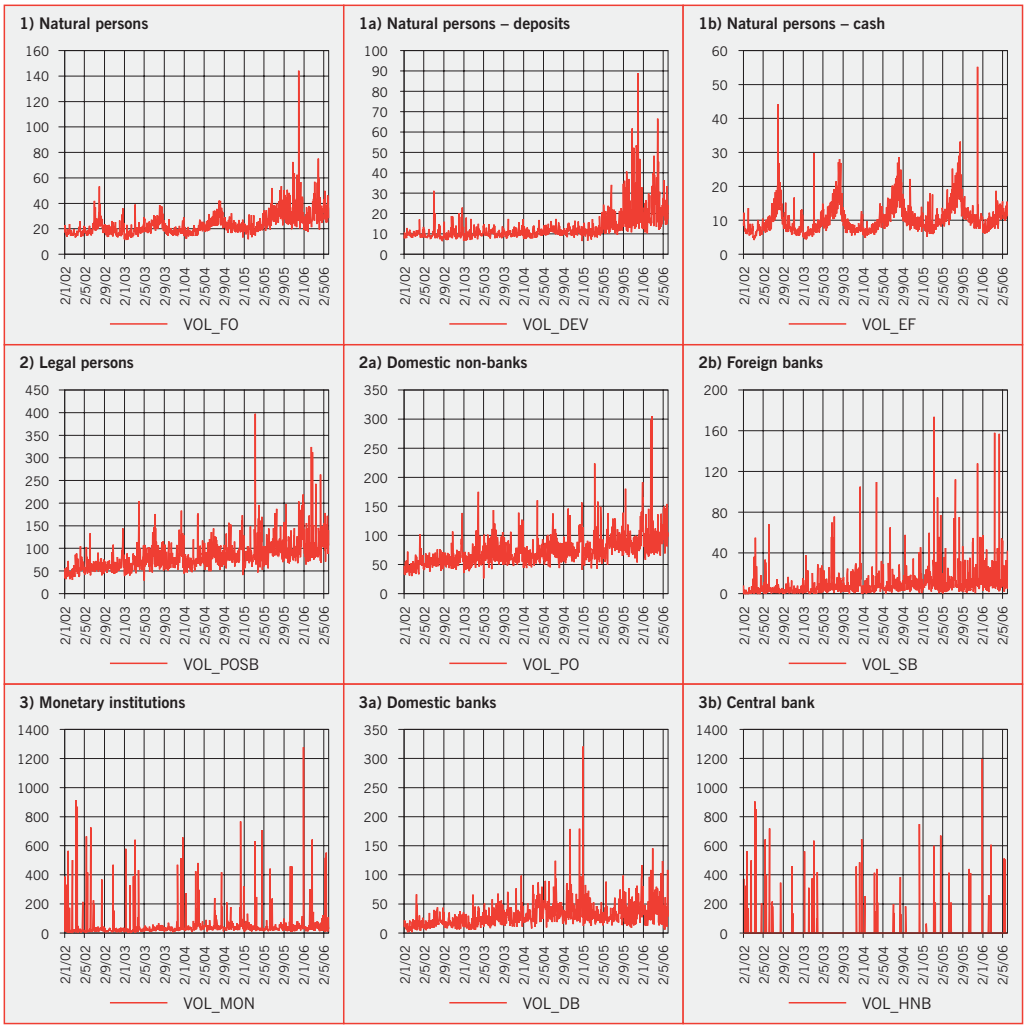
| | |
|---|---|
| **from 1/10/1997 to 31/12/1998** | $BR = \frac{(b\_lpfb * br\_lpfb) + (b\_np * br\_np)}{b\_lpfb + b\_np}$<br>$SR = \frac{(s\_lpfb * sr\_lpfb) + (s\_np * sr\_np) + (s\_db * sr\_db)}{s\_lpfb + s\_np + s\_db}$<br>$MR = \frac{(b\_lpfb + b\_np) * BR + (s\_lpfb + s\_np + s\_db) * SR}{b\_lpfb + b\_np + s\_lpfb + s\_np + s\_db}$ |
| **from 1/1/1999 to 5/3/1999** | $BR = \frac{(b\_lpfb * br\_lpfb) + (b\_np * br\_np) + (b\_db * br\_db)}{b\_lpfb + b\_np + b\_db}$<br>$SR = \frac{(s\_lpfb * sr\_lpfb) + (s\_np * sr\_np) + (s\_db * sr\_db)}{s\_lpfb + s\_np + s\_db}$<br>$MR = \frac{BR + SR}{2}$ |
| **from 8/3/1999 to 1/10/2001** | $BR = \frac{(b\_lpfb * br\_lpfb) + (b\_np * br\_np)}{b\_lpfb + b\_np}$<br>$SR = \frac{(s\_lpfb * sr\_lpfb) + (s\_np * sr\_np) + (s\_db * sr\_db)}{s\_lpfb + b\_np}$<br>$MR = \frac{BR + SR}{2}$ |
| **from 2/10/2001** | $BR = \frac{(b\_lpfb * br\_lpfb) + (b\_fxnp * br\_fxnp) + (b\_fcnb * br\_fcnb) + (0{,}5 * b\_db * br\_db)}{b\_lpfb + b\_np + 0{,}5 * b\_db}$<br>$SR = \frac{(s\_lpfb * sr\_lpfb) + (s\_fxnp * sr\_fxnp) + (s\_fcnp * sr\_fcnp) + (0{,}5 * s\_db * sr\_db)}{s\_lpfb + s\_np + 0{,}5 * s\_db}$<br>$MR = \frac{BR + SR}{2}$ |

| Key word | Description | Key word | Description |
|---|---|---|---|
| b_lp | legal persons purchase in euro | s_lp | legal persons sale in euro |
| b_db | domestic banks purchase in euro | s_db | domestic banks sale in euro |
| b_fb | foreign banks purchase in euro | s_fb | foreign banks sale in euro |
| b_fxnp | natural persons foreign exchange purchase in euro | s_fxnp | natural persons foreign exchange sale in euro |
| b_fcnp | natural persons foreign currency purchase in euro | s_fcnp | natural persons foreign currency sale in euro |
| b_lpfb | b_lp+b_fb | s_lpfb | s_lp+s_fb |
| b_np | b_fxnp+b_fcnp | s_np | s_fxnp+s_fcnp |
| br_lp | buy FX rate for 1 euro in kuna reached with legal persons on Croatian FX market | sr_lp | sell FX rate for 1 euro in kuna reached with legal persons on Croatian FX market |
| br_db | buy FX rate for 1 euro in kuna reached with domestic banks on Croatian FX market | sr_db | sell FX rate for 1 euro in kuna reached with domestic banks on Croatian FX market |
| br_fb | buy FX rate for 1 euro in kuna reached with foreign banks on Croatian FX market | sr_fb | sell FX rate for 1 euro in kuna reached with foreign banks on Croatian FX market |
| br_fxnp | buy FX rate for 1 euro in kuna reached with natural persons – foreign exchange on Croatian FX market | sr_fxnp | sell FX rate for 1 euro in kuna reached with natural persons – foreign exchange on Croatian FX market |
| br_fcnp | buy FX rate for 1 euro in kuna reached with natural persons – foreign currency on Croatian FX market | sr_fcnp | sell FX rate for 1 euro in kuna reached with natural persons – foreign currency on Croatian FX market |
| br_lpfb | weighted average br_lp and br_fb | sr_lpfb | weighted average sr_lp and sr_fb |
| br_np | weighted average br_fxnp and by_fcnp | sr_np | weighted average sr_fxnp and sr_fcnp |
| mr | CNB middle FX rate – accepted method | | |

Source: CNB.

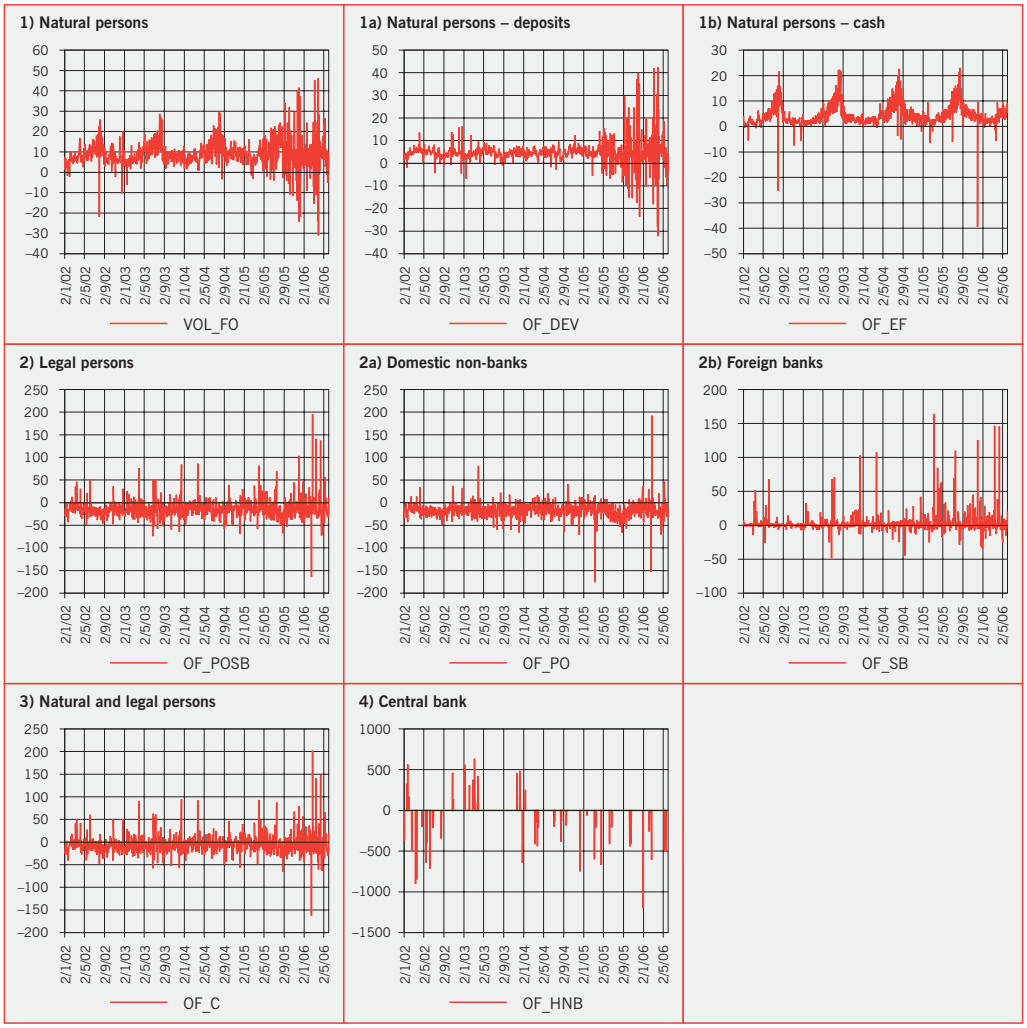
# Appendix 2

**Table 1** Trading Volumes in the Croatian FX Market, in million HRK



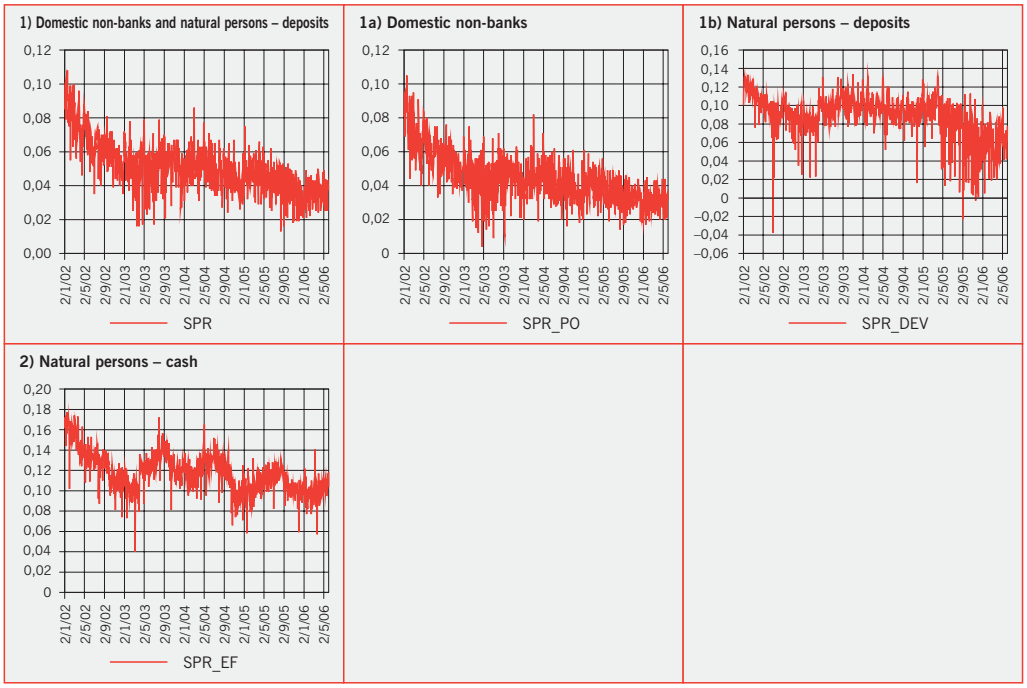

Source: CNB.

**Table 2** Net-Purchases of Foreign Currency by Domestic Banks, in million HRK



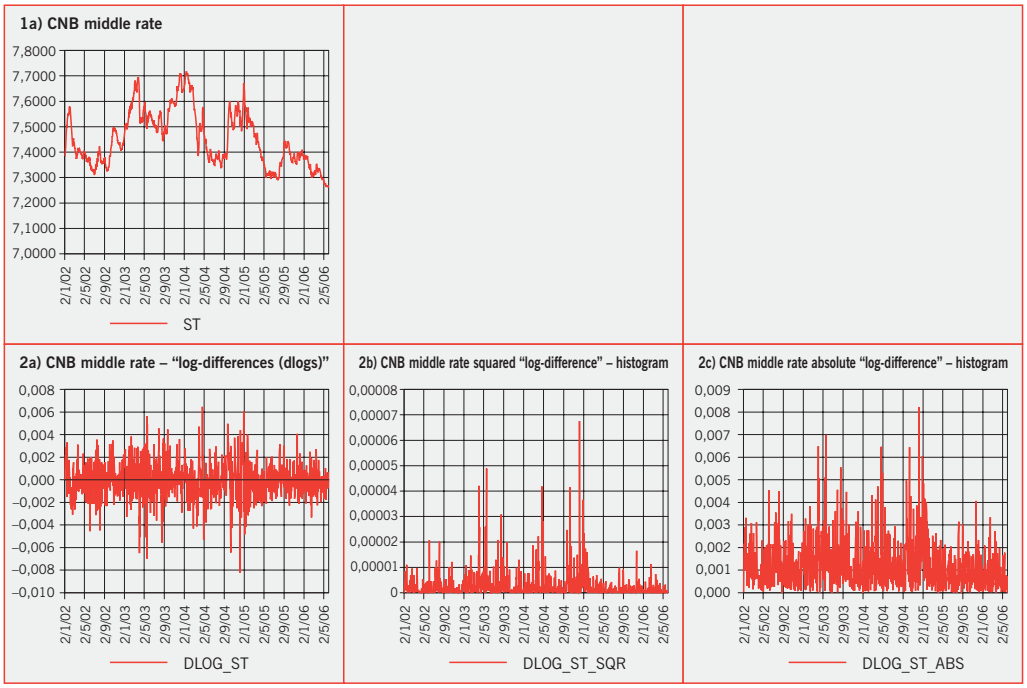

Source: CNB.

**Table 3** Bid-Ask Spreads in the Croatian FX Market, in kuna




Source: CNB.

**Table 4** Exchange Rate Volatility, in kuna units per 1 euro




Source: CNB.

# Appendix 3

**Table 1** Decomposition of Trading Volume

Dependent variable: VOLUME
Method: ML – ARCH
Date: 21/08/06 Time: 10:46
Sample (adjusted): 9/01/2002 31/05/2006
Included observations: 1105 after adjustments
Convergence achieved after 72 iterations
Variance backcast: ON
GARCH = C(10) + C(11)*RESID(–1)^2 + C(12)*RESID(–2)^2 + C(13)
*GARCH(–1)

| | Coefficient | Std. error | Z-statistic | Prob. |
|---|---|---|---|---|
| C | 54.00780 | 4.026834 | 13.41197 | 0.0000 |
| VOLUME(–1) | 0.230949 | 0.041349 | 5.585350 | 0.0000 |
| VOLUME(–5) | 0.111492 | 0.026924 | 4.140944 | 0.0000 |
| TIME | 0.067480 | 0.005544 | 12.17195 | 0.0000 |
| WEEKDAY=5 | –4.370371 | 2.130360 | –2.051470 | 0.0402 |
| DAYOFMONTH<12 | –4.178917 | 1.790770 | –2.333586 | 0.0196 |
| (MONTH>=7 AND MONTH<=8) | 10.10976 | 2.542355 | 3.976535 | 0.0001 |
| MONTH=12 | 15.35235 | 3.499509 | 4.387001 | 0.0000 |
| MONTH=1 | –8.174453 | 2.949007 | –2.771934 | 0.0056 |
| **Variance equation** | | | | |
| C | 1.065699 | 0.155731 | 6.843196 | 0.0000 |
| RESID(–1)^2 | 0.220545 | 0.036440 | 6.052273 | 0.0000 |
| RESID(–2)^2 | –0.227121 | 0.036042 | –6.301500 | 0.0000 |
| GARCH(–1) | 1.006969 | 0.001710 | 588.9318 | 0.0000 |
| R-squared | 0.477262 | Mean dependent var | | 138.7951 |
| Adjusted R-squared | 0.471517 | S.D. dependent var | | 51.82217 |
| S.E. of regression | 37.67307 | Akaike info criterion | | 9.820043 |
| Sum squared resid | 1549832. | Schwarz criterion | | 9.878956 |
| Log likelihood | –5412.574 | F-statistic | | 83.08326 |
| Durbin-Watson stat | 2.183976 | Prob(F-statistic) | | 0.000000 |

Source: CNB.

**Table 2** Decomposition of Exchange Rate Volatility

Dependent variable: DLOG(CNB_RATE)
Method: ML – ARCH
Date: 21/08/06 Time: 13:53
Sample (adjusted): 8/01/2002 31/05/2006
Included observations: 1106 after adjustments
Convergence achieved after 18 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*RESID(–1)^2 + C(7)*RESID(–2)^2 + C(8)
*GARCH(–1)

| | Coefficient | Std. error | Z-statistic | Prob. |
|---|---|---|---|---|
| C | –5.85E–05 | 6.10E–05 | –0.958979 | 0.3376 |
| AR(1) | –0.038828 | 0.035359 | –1.098128 | 0.2721 |
| AR(2) | 0.271815 | 0.029596 | 9.184111 | 0.0000 |
| AR(3) | 0.099765 | 0.032623 | 3.058158 | 0.0022 |
| | **Variance equation** | | | |
| C | 3.60E–08 | 1.70E–08 | 2.120755 | 0.0339 |
| RESID(–1)^2 | 0.235491 | 0.049918 | 4.717588 | 0.0000 |
| RESID(–2)^2 | –0.168718 | 0.049657 | –3.397674 | 0.0007 |
| GARCH(–1) | 0.919913 | 0.019345 | 47.55340 | 0.0000 |
| R-squared | 0.094382 | Mean dependent var | | –1.84E–05 |
| Adjusted R-squared | 0.088608 | S.D. dependent var | | 0.001632 |
| S.E. of regression | 0.001558 | Akaike info criterion | | –10.21249 |
| Sum squared resid | 0.002664 | Schwarz criterion | | –10.17626 |
| Log likelihood | 5655.507 | F-statistic | | 16.34737 |
| Durbin-Watson stat | 1.880034 | Prob(F-statistic) | | 0.000000 |
| Inverted AR roots | .64 | –.34–.21i | –.34+.21i | |

Source: CNB.

**Table 3a** Volume and Absolute Daily FX Returns

Dependent variable: ABS(DLOG(CNB_RATE))
Method: ML – ARCH (Marquardt) – Normal distribution
Date: 21/08/06 Time: 11:37
Sample: 9/01/2002 31/05/2006
Included observations: 1105
Convergence achieved after 89 iterations
Bollerslev–Wooldrige robust standard errors & covariance
Variance backcast: OFF
GARCH = C(6) + C(7)*RESID(–1)^2 + C(8)*GARCH(–1)

| | Coefficient | Std. error | Z-statistic | Prob. |
|---|---|---|---|---|
| @SQRT(GARCH) | 1.427682 | 0.188402 | 7.577832 | 0.0000 |
| C | –0.000126 | 0.000222 | –0.566764 | 0.5709 |
| VOLUME_UNEXP | 4.07E–06 | 8.74E–07 | 4.662735 | 0.0000 |
| VOLUME_EXP | –1.29E–06 | 6.48E–07 | –1.984253 | 0.0472 |
| EUR_USD_ABS | 0.024743 | 0.007857 | 3.149126 | 0.0016 |
| | **Variance equation** | | | |
| C | 3.64E–08 | 2.53E–23 | 1.44E+15 | 0.0000 |
| RESID(–1)^2 | 0.067975 | 0.018109 | 3.753689 | 0.0002 |
| GARCH(–1) | 0.895132 | 0.016425 | 54.49843 | 0.0000 |
| R-squared | 0.147307 | Mean dependent var | | 0.001229 |
| Adjusted R-squared | 0.141866 | S.D. dependent var | | 0.001071 |
| S.E. of regression | 0.000993 | Akaike info criterion | | –11.06739 |
| Sum squared resid | 0.001081 | Schwarz criterion | | –11.03114 |
| Log likelihood | 6122.735 | F-statistic | | 27.07313 |
| Durbin-Watson stat | 1.767623 | Prob(F-statistic) | | 0.000000 |

Source: CNB.

**Table 3b** Volume and Squared Daily FX Returns

Dependent variable: SQR(DLOG(CNB_RATE))
Method: ML – ARCH (Marquardt) – Normal distribution
Date: 21/08/06 Time: 11:39
Sample: 9/01/2002 31/05/2006
Included observations: 1105
Convergence achieved after 211 iterations
Bollerslev–Wooldrige robust standard errors & covariance
Variance backcast: OFF
GARCH = C(6) + C(7)*RESID(–1)^2 + C(8)*GARCH(–1)

| | Coefficient | Std. error | Z-statistic | Prob. |
|---|---|---|---|---|
| @SQRT(GARCH) | 1.639373 | 0.502101 | 3.265027 | 0.0011 |
| C | –4.84E–06 | 2.35E–06 | –2.061253 | 0.0393 |
| VOLUME_UNEXP | 3.03E–08 | 1.38E–09 | 21.99115 | 0.0000 |
| VOLUME_EXP | –2.90E–09 | 9.25E–12 | –313.8435 | 0.0000 |
| EUR_USD_SQR | 0.008390 | 0.002998 | 2.798302 | 0.0051 |
| | **Variance equation** | | | |
| C | 6.26E–12 | 6.58E–13 | 9.506376 | 0.0000 |
| RESID(–1)^2 | 0.117872 | 0.062792 | 1.877182 | 0.0605 |
| GARCH(–1) | 0.620035 | 0.085857 | 7.221737 | 0.0000 |
| R-squared | 0.086121 | Mean dependent var | | 2.66E–06 |
| Adjusted R-squared | 0.080290 | S.D. dependent var | | 5.16E–06 |
| S.E. of regression | 4.95E–06 | Akaike info criterion | | –21.74525 |
| Sum squared resid | 2.68E–08 | Schwarz criterion | | –21.70899 |
| Log likelihood | 12022.25 | F-statistic | | 14.76827 |
| Durbin-Watson stat | 2.012481 | Prob(F-statistic) | | 0.000000 |

Source: CNB.

**Table 4a** Volatility and the Bid-Ask Spread

Dependent variable: D(SPREAD)
Method: Least Squares
Date: 21/08/06 Time: 15:10
Sample (adjusted): 11/01/2002 31/05/2006
Included observations: 1103 after adjustments
Convergence achieved after 17 iterations
Backcast: 1/01/2002

| Variable | Coefficient | Std. error | T-statistic | Prob. |
|---|---|---|---|---|
| C | –4.81E–05 | 1.99E–05 | –2.421914 | 0.0156 |
| D(VOLATILITY_EXP) | 417.0381 | 244.5074 | 1.705626 | 0.0884 |
| AR(1) | 0.097835 | 0.032277 | 3.031140 | 0.0025 |
| AR(2) | 0.103351 | 0.032038 | 3.225910 | 0.0013 |
| MA(1) | –0.945462 | 0.010928 | –86.51972 | 0.0000 |
| R-squared | 0.422576 | Mean dependent var | | –5.16E–05 |
| Adjusted R-squared | 0.420472 | S.D. dependent var | | 0.012480 |
| S.E. of regression | 0.009500 | Akaike info criterion | | –6.470462 |
| Sum squared resid | 0.099101 | Schwarz criterion | | –6.447771 |
| Log likelihood | 3573.460 | F-statistic | | 200.8871 |
| Durbin-Watson stat | 1.990162 | Prob(F-statistic) | | 0.000000 |
| Inverted AR roots | .37 | –.28 | | |
| Inverted MA roots | .95 | | | |

Source: CNB.

**Table 4b** Trading Volume and the Bid-Ask Spread

Dependent variable: D(SPREAD)
Method: ML – ARCH
Date: 21/08/06 Time: 13:20
Sample (adjusted): 14/01/2002 31/05/2006
Included observations: 1102 after adjustments
Convergence achieved after 14 iterations
MA backcast: 1/01/2002, Variance backcast: ON
GARCH = C(7) + C(8)*RESID(–1)^2 + C(9)*GARCH(–1)

| | Coefficient | Std. error | Z-statistic | Prob. |
|---|---|---|---|---|
| C | –3.99E–05 | 1.79E–05 | –2.236125 | 0.0253 |
| D(VOLUME_EXP) | –5.12E–05 | 1.99E–05 | –2.573051 | 0.0101 |
| D(VOLUME_UNEXP) | –7.81E–05 | 4.65E–06 | –16.80760 | 0.0000 |
| AR(1) | 0.099164 | 0.033499 | 2.960247 | 0.0031 |
| AR(2) | 0.115644 | 0.032162 | 3.595628 | 0.0003 |
| MA(1) | –0.949085 | 0.009398 | –100.9833 | 0.0000 |
| | **Variance equation** | | | |
| C | 4.50E–07 | 3.59E–07 | 1.251987 | 0.2106 |
| ORESID(–1)^2 | 0.018920 | 0.006357 | 2.976330 | 0.0029 |
| GARCH(–1) | 0.974592 | 0.009116 | 106.9115 | 0.0000 |
| R-squared | 0.494302 | Mean dependent var | | –5.51E–05 |
| Adjusted R-squared | 0.490600 | S.D. dependent var | | 0.012485 |
| S.E. of regression | 0.008911 | Akaike info criterion | | –6.629794 |
| Sum squared resid | 0.086783 | Schwarz criterion | | –6.588919 |
| Log likelihood | 3662.016 | F-statistic | | 133.5460 |
| Durbin-Watson stat | 1.965704 | Prob(F-statistic) | | 0.000000 |
| Inverted AR roots | .39 | –.29 | | |
| Inverted MA roots | .95 | | | |

Source: CNB.

**Table 5** Trading with Different Sectors and the Bid-Ask Spread

Dependent variable: D(SPREAD)
Method: ML – ARCH (Marquardt) – Normal distribution
Date: 31/08/06 Time: 14:54
Sample (adjusted): 7/01/2002 31/05/2006
Included observations: 1107 after adjustments
Convergence achieved after 34 iterations
Bollerslev–Wooldrige robust standard errors & covariance
MA backcast: 1/01/2002, Variance backcast: ON
GARCH = C(9) + C(10)*RESID(–1)^2 + C(11)*GARCH(–1)

| | Coefficient | Std. error | Z-statistic | Prob. |
|---|---|---|---|---|
| C | 2.40E–05 | 2.32E–05 | 1.034518 | 0.3009 |
| D(VOLUME_NP–DEP) | –0.000282 | 4.79E–05 | –5.889019 | 0.0000 |
| D(VOLUME_NP_CASH) | 0.000236 | 8.18E–05 | 2.891277 | 0.0038 |
| D(VOLUME_LEGAL_PERS) | –0.000190 | 2.55E–05 | –7.447640 | 0.0000 |
| INTERVENTION_DUMMY | –0.001345 | 0.000437 | –3.080044 | 0.0021 |
| AR(1) | 0.137399 | 0.032551 | 4.221046 | 0.0000 |
| AR(2) | 0.121645 | 0.030584 | 3.977457 | 0.0001 |
| MA(1) | –0.959062 | 0.009461 | –101.3728 | 0.0000 |
| **Variance equation** | | | | |
| C | 9.30E–07 | 9.81E–07 | 0.948899 | 0.3427 |
| RESID(–1)^2 | 0.015646 | 0.010591 | 1.477348 | 0.1396 |
| GARCH(–1) | 0.969884 | 0.022493 | 43.11982 | 0.0000 |
| R-squared | 0.563261 | Mean dependent var | | –5.56E–05 |
| Adjusted R-squared | 0.559276 | S.D. dependent var | | 0.012485 |
| S.E. of regression | 0.008288 | Akaike info criterion | | –6.755954 |
| Sum squared resid | 0.075289 | Schwarz criterion | | –6.706177 |
| Log likelihood | 3750.421 | F-statistic | | 141.3506 |
| Durbin-Watson stat | 1.991689 | Prob(F-statistic) | | 0.000000 |
| Inverted AR roots | .42 | –.29 | | |
| Inverted MA roots | .96 | | | |

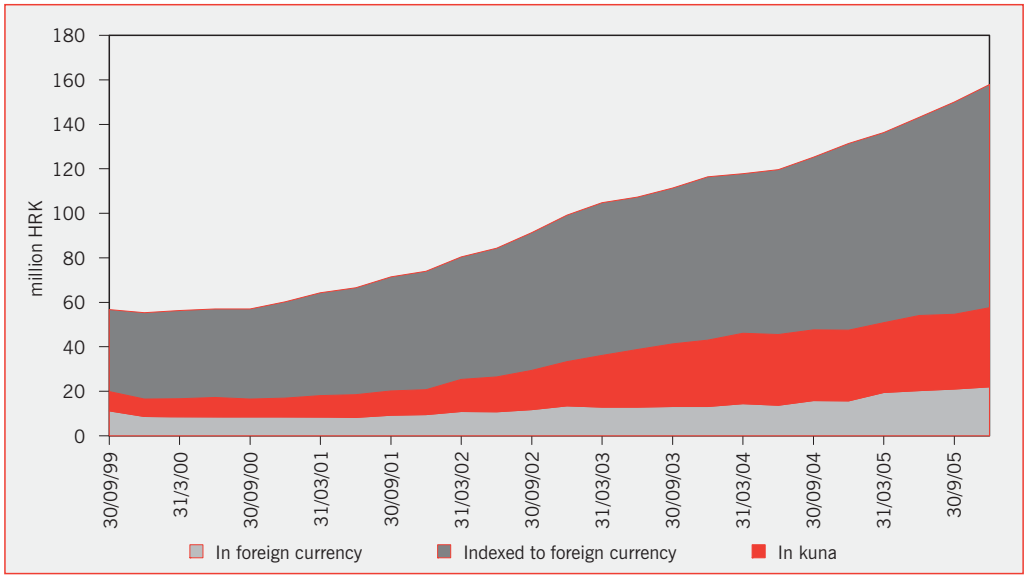
Source: CNB.

# Appendix 4

## The Official Foreign Exchange Rate

Every working day, the central bank of the Republic of Croatia (Croatian National Bank; further: CNB) announces the official list of domestic currency exchange rates (the CNB FX rates list). Therein, the unit values of selected world currencies are expressed in units of the domestic currency, kuna. On the next day (or after several days, if there is a weekend or a holiday), the kuna value of foreign currency stocks and transactions is calculated using the exchange rates from the CNB FX rates list formed the day earlier. The EUR/HRK exchange rate from the CNB FX rates list (the CNB middle FX rate), has a very important role in the Croatian economy. Due to a number of factors, the kuna has never been accepted as a measure of true value in Croatia; values were usually expressed in German Marks (DEM) until 2002 and since then in euros. Moreover, the largest share of financial obligations of natural persons, legal persons and even general government is denominated in euros, but payments are usually executed in kuna, using the CNB middle FX rate on the maturity day for conversion. Finally, the Republic of Croatia has a managed-float exchange rate regime, the results of which are usually evaluated through the movements of the CNB middle FX rate.

**Figure 1** The Currency Structure of Total Bank Loans




Source: CNB.

The CNB middle FX rate calculation is based on FX trades and FX rates realized in the FX trading of domestic commercial banks with other banks, natural persons, legal persons and foreign banks. Commercial banks are obliged to report their trading activities to the CNB on a daily basis. In their reports, trading data are expressed in original currencies and in kuna value. The first step in the calcu-

lation of the CNB middle FX rate is the conversion of transaction values from original currencies to euros, using the cross-EUR rate (the FX rate for euro from the Frankfurt FX market) valid on that day at 11:45. To get the volume weighted sell rate for that day, the EUR value of the total selling transactions from all banks is divided by their value in kuna. The same formula applies to the weighted buy rate. The arithmetic average of those two weighted averages is the CNB middle FX rate (for the euro).

The CNB middle FX rate for other currencies is calculated by crossing the calculated CNB middle FX rate for the euro with the cross-EUR rates that apply at 11:45 on the day this calculation is made. These middle FX rates are used for converting liabilities in foreign currency, customs and other taxes, to the domestic currency, as well as for statistical purposes. The CNB middle FX rates list is posted on the CNB Internet page before 14:00 every day, with the FX rates that refer to the next day. The CNB buy and the CNB sell FX rates are also published on that list, but they do not reflect the real rates in buying and selling of FX. They are calculated mechanically by deducting from or adding to the calculated middle FX rate a 0.3% spread.

The CNB middle FX rate methodology has been changed a few times. These changes have caused some structural breaks in the time series of the CNB middle FX rate. Some changes refer to trading coverage while others refer to mathematical formulas. The first statistical break was created in October 1997, when the coverage of trading counterparties to be reported to the CNB was widened. Because of that change, most of the central bank's detailed statistical data about the FX trading in Croatia starts on 1 October 1997. The second break happened on 1 January 1999, when inter-bank trading was included in the calculation of the buy FX rate. At the same time, the definition of the CNB middle FX rate was changed from a weighted average to the arithmetic average of the buy and the sell rate (calculated as in the second paragraph of this section). The third change took place on 5 March 1999, when the transactions on the inter-bank FX market were again excluded from the calculation of the FX buy rate. Finally, on 1 October 2001 the inter-bank trading was once again included in the calculation of the CNB middle FX rate; it has a weight of 0.5 on both the buying and selling sides.

These methodological changes make it impossible to display the CNB middle FX rate as a consistent time series since 1 October 1997 (see Appendix 1 for a more detailed chronology of changes to the CNB middle FX rate calculation). In addition, although the CNB middle FX rate is a very good approximation of the market FX rate, it is not a real market rate even when one ignores the statistical breaks: it always represents the market FX rate from two days before (or even more in case of a non-working day, or the first day after a weekend or a holiday). Moreover, the CNB gathers FX trading reports from commercial banks only, so the CNB middle FX rate may not be representative of some other unofficial FX markets for the kuna (though we judge these are negligible). Finally, the calculation of the CNB middle FX rate for the euro includes data on trading in all currencies, so the changes in the official FX rate actually reflect changes in the total sup-

ply and the total demand of kuna by FX traders and do not reflect (as one would expect) changes in the relative supplies of the kuna and the euro in the Croatian FX market.

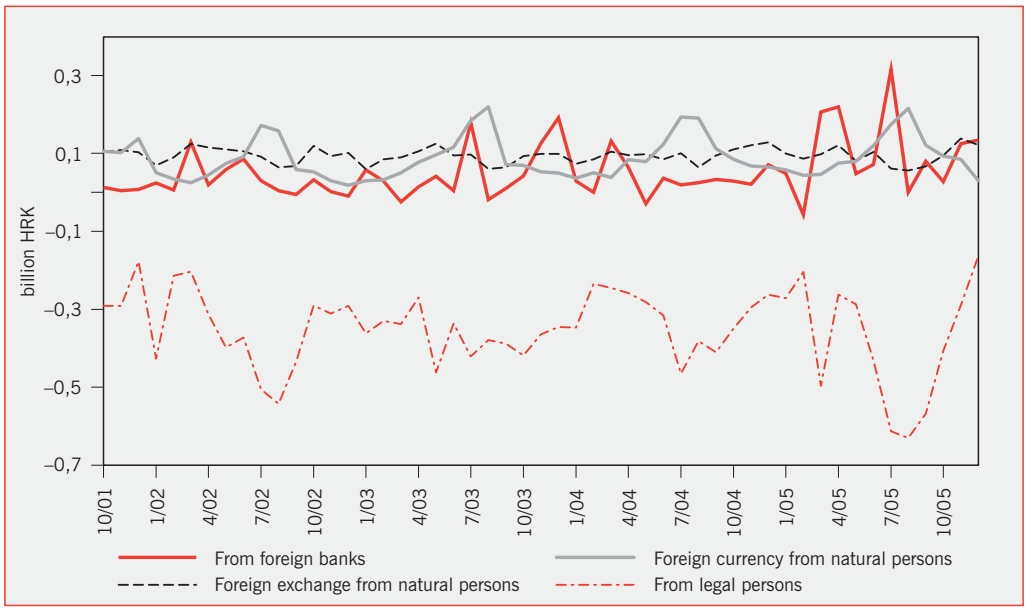
## The Market

The market makers in the Croatian FX market are commercial banks. The government and the central bank also have important but specific roles. The Croatian FX market consists of a non-cash segment, which pertains to transactions done mainly through banks, and a cash segment, which is mostly tied to small exchange offices and private trades. Private FX trade is very specific and non-transparent since it is impossible to know the exact volume of direct trade between natural persons.

The world's FX market is an over-the-counter (OTC) market in which the most important dealers are commercial banks. Trading with natural persons apart, this market gradually lost its physical shape and now rests mostly on electronic transactions that enable easier access to the market as well as lower costs. In Croatia, most FX trading is also done electronically; only trading with natural persons is done in person, but this is becoming increasingly electronic with the development of a personal Internet banking infrastructure.

In Croatia, commercial banks take part in FX trading with all sectors in the Croatian financial market: legal persons, natural persons, foreign banks and other domestic banks. With the exception of the inter-bank market, banks are actually intermediaries between the FX suficitary and FX deficitary segments of the financial market. Although it is not immediately obvious, most of the supply of foreign

**Figure 2** The Value of Monthly Spot Net-Buy of Foreign Exchange through Banks




Source: CNB.

currency in the Croatian FX market is indirectly created by the foreign borrowing of commercial banks. Since the foreign borrowings are cancelled with FX indexed loans in the recorded banks' FX positions, the combined effect of banks' foreign borrowing and their domestic credit activity is approximately neutral for the banks FX position.

In global relations, the most frequently used currency is the US dollar, with the euro taking the second place. In the Croatian FX market, the euro is the most frequently used currency for trading, which is hardly surprising considering that the largest players in the market are commercial banks owned by banks from the EMU region. Previously, the German Mark was very important in Croatia.

One of the main characteristics of the Croatian FX market is its shallowness (for more details see Appendix 4, part 2). Its structure has been very uniform (monotone) despite a continuous growth in trading volume, since almost all transactions were spot transactions until 2004. The FX swap market started to develop in 2004, and its trading volume amounted 28.6% of the total FX trading volume in 2005. The forward FX market doubled its trading volume in 2005 but is still by far the smallest segment of the Croatian FX market; it accounts for about 3.9% of the total FX trading volume.

The growth in trading volume of FX swaps in the last two years can most likely be explained by a rise in non-residential investments in Croatian financial markets: non-residents who are short of Croatian kuna for purchasing Croatian securities enter into FX swap deals for kuna that allow them to earn capital gains without exposing themselves to currency risk.

## The Central Bank

The Croatian National Bank has an important role in the Croatian FX market as its regulator. More importantly, the CNB runs its monetary policy primarily through the FX channel by performing occasional, unannounced, asymmetric and unsterilized (or partially sterilized) FX interventions. Each domestic bank licensed for conducting FX payments is allowed to take part in an intervention. Regardless of the public belief that the CNB has an important role in daily movements of the FX rate, it does not. It has an occasional impact on short-term movement of the FX rate in that it intervenes relatively rarely in the FX market, but with relatively big amounts. As a result, the CNB's share in the total annual FX trading volume is very small, but on the day (or the week or even the month) of the intervention, the FX trading volume between the CNB and banks is very large.

The CNB mostly uses spot transactions for conducting FX interventions, although it is allowed to use spot and swap transactions. It uses the multiple rates model by accepting a predefined amount of offers; it does not use the single rate model that would force it to accept all offers at that rate. The FX interventions are subject to quarterly projections of monetary policy accepted by the Council of the CNB, but it is the management of the CNB who is in charge of choosing the actual time and amount of an individual intervention. The intervention is conducted in

**Table 1** The Proportion of the CNB FX Interventions in the Total FX Trading Volume

| | In year | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| Foreign currency bought | 12,9 | 2,0 | 3,8 | 2,2 | 2,4 | 0,1 | 0,0 |
| Foreign currency sold | 0,7 | 3,1 | 6,2 | 4,8 | 0,4 | 2,1 | 2,5 |
| | In the month of intervention[a] | | | | | | |
| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| Foreign currency bought | 16,4 | 15,7 | 8,5 | 8,9 | 6,5 | 2,5 | 0,0 |
| Foreign currency sold | 0,9 | 7,4 | 9,7 | 8,5 | 4,0 | 4,2 | 4,9 |

[a] This shows the average amount of foreign currency bought from or sold to CNB from commercial banks in the months in which CNB was conducting an FX intervention.
Source: CNB.

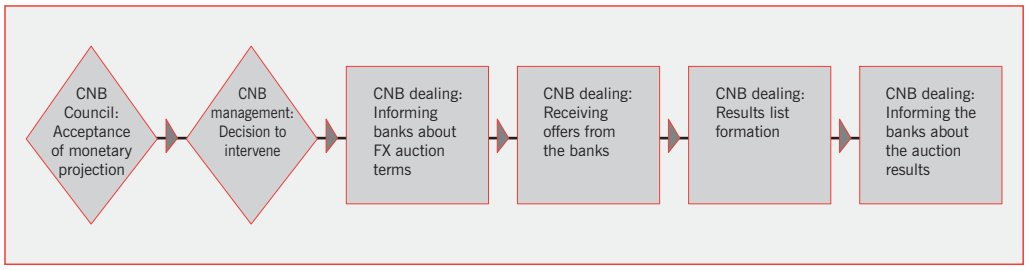
the form of an auction, and usually a Dutch auction model is used.[5] For administering auctions, the CNB uses the Reuters dealing system, telephone or telefax, but telefax is practically never used.

The most frequent type of CNB FX intervention is as follows. When the CNB dealers receive the order to conduct an FX intervention, they put the information about the intervention on the CNB Reuters site and contact the banks that are allowed to take part in the CNB FX intervention by telephone. The banks are then given one hour to place their offers. Each bank is allowed to place three offers for each foreign currency that is the object of the intervention and on each side of the intervention (buy or sell). Every offer that a bank makes is legally binding for the bank in the full amount. The minimum amount of each offer must be at least 300,000 EUR or 300,000 USD. After the offers are collected, the CNB creates a list of the auction results. If two banks have sent offers at the same FX rate and these offers combined exceed the amount the CNB is planning to accept, the CNB will partially accept both offers, proportionate to the amounts offered. At the end of the auction, the CNB dealers inform the banks about the results. Finally, the aggregated information about the conducted intervention is put on the CNB web site. This information includes the bought or sold amount of foreign currency and the average rate of accepted offers.

The CNB stands out as one of the most transparent central banks in the manner it conducts its FX interventions. This transparency also refers to the period after the intervention, because the CNB puts the information about the intervention on the CNB web site. This information shows that the CNB was mainly a buyer of FX from the commercial banks in the period from 1993 to 2005. Buying FX from banks was necessary in the first years of Croatian independence because of the need for creating international reserves; later, it was caused by appreciation pres-

5 The Dutch model of an auction is characterized by secrecy. This means that the bidder is not familiar with the offers his competition makes. The opposite auction model is the English type of auction, where bidders publicly compete among each other and are familiar with the prices offered by their competition.

**Figure 3** The Steps in Conducting a CNB FX Intervention




Source: CNB.

sures on the domestic currency. The CNB was a net-seller of foreign currency to commercial banks in only three years: 1998, 1999 and 2003. In 1998 and 1999, confidence in the domestic banking system was shaken by banking crises which caused a portion of foreign savings to pour abroad or be stored under mattresses. This created depreciation pressures on the domestic currency which forced the CNB to defend the kuna by selling foreign exchange. In 2003, the Ministry of Finance sold foreign exchange (that had come from abroad) only to the CNB and not to the banks as it used to do before that time. Thus, in order to satisfy their FX liquidity needs, the banks had to buy foreign currency from the CNB in far larger amounts than they used to before 2003.

## The Government

The CNB also conducts foreign exchange interventions with the government. It buys and sells foreign currency for the account of the government with the intention of decreasing the unwanted effects of a large direct inflow or outflow of foreign currency through the banking system. Even if the Ministry of Finance was to trade a large amount of foreign currency directly with banks, the shallow and undeveloped nature of the market means that the banks would not be able to absorb such supply or demand for foreign currency and the CNB would have to intervene anyway. The proportion of FX interventions that the CNB conducts with the Ministry of Finance is relatively large, especially in the years in which the privatization of public companies causes a large inflow of foreign currency or in the years in which repayment of foreign public debt causes large outflows of foreign currency).

**Table 2** Sectoral Distribution of CNB FX Interventions, in %

| | Foreign currency bought | | | Foreign currency sold | | |
|---|---|---|---|---|---|---|
| Year | 2002 | 2003 | 2004 | 2002 | 2003 | 2004 |
| Domestic banks | 83.09 | 13.67 | 74.58 | 98.44 | 82.5 | 11.72 |
| Ministry of Finance | 16.91 | 86.33 | 25.42 | 1.56 | 17.5 | 88.28 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

Source: CNB.

Another important government-related factor influencing developments in the Croatian FX market is foreign public debt policy. Although the Croatian government has started to replace foreign debt with domestic debt by issuing government bonds in the domestic market, there is still a substantial amount of outstanding foreign debt in the form of Croatian government bonds issued directly in foreign markets. The maturation of these bonds often contributes to a kuna depreciation due to the demand for foreign currency needed to pay out the creditors. On the other hand, the creation of new debt in foreign markets stimulates an appreciation of the kuna because of the foreign currency inflow.

## Commercial Banks

Commercial banks in Croatia use the Reuters dealing system in their everyday FX trading with large customers. If the client does not posses the required IT platform, the trading is done via telephone; in that case, all the conversations are recorded. The clients of the FX desk (the part of the bank's treasury in charge of FX trading) are domestic and foreign banks as well as other financial institutions (pension funds and investment funds). Trading with legal and natural persons for large amounts (for instance, larger than 400,000 kuna) is carried out at the clients' desk (the part of the FX desk in charge of trading with large clients). Trading with legal and natural persons for small amounts is carried out in the bank (or lately via electronic banking), using the FX rates on the bank's regular FX rates list.

Croatian banks conduct FX trading in their treasuries. The treasury usually has a front and back office, but larger banks also have a middle office. The front office usually includes a money market desk, a fixed income desk, an FX desk, a desk for corporate clients and a cash desk. The FX desk is generally responsible for internal quotations for the client's desk, creating regular FX rates lists, FX market making and the development of new products that could be offered to clients as part of the FX trading. The process of FX trading usually begins with identification of the bank's starting FX position. Changes in the FX position can invoke certain FX trading strategies because of the FX position rules in the current banking regulations. If a bank is too short in a certain currency, the dealers will probably be willing to buy that currency at a slightly higher price. On the other hand, if a bank is too long in a certain currency, its dealers will probably be willing to sell that currency at a slightly lower price. That way, the bank's starting FX position and its wanted FX position at the end of the day influences the choice of its beginning FX rates for that day.[6]

After defining their starting strategy (based on the bank's FX position), the FX dealers design their profit-making strategy on the FX market, which means find-

6 Even the largest Croatian banks do not have an "on-line" FX position. Usually the middle office calculates and delivers the FX position to FX dealers (if possible at the beginning of the working day, before the trading).

ing a way to buy at low prices and sell at high. In order to achieve this, they plan the wanted FX trading volume and select market segments where this plan is easiest to realize (some segments of the FX market, such as the inter-bank FX market, are suitable for larger trading volumes while other segments, such as trading with natural persons, is more suited for smaller trading volumes). The last step in the preparation stage is the quotation of the FX rates at which the dealers will make the transactions on the FX market. The FX rate on the inter-bank FX market is always quoted as the price of one currency (quoted currency) expressed in the second (base) currency. All large domestic banks have Reuters dealing system, and FX trading between banks is carried out exclusively by using this system.[7]

All large domestic banks have the Reuters dealing system, and FX trading between banks is carried out exclusively by using this system.[8] There are no written rules of conduct for FX dealers in Croatia, but banks generally respect the International Rules of Conduct (business ethics) and the practices of financial markets written by ACI (the international association of financial markets, of which ACI Croatia is a member). ACI Croatia organizes exams for ACI dealing certificates, which are unofficially recognized as certificates for FX dealers in Croatia. Trading on the Croatian FX market is active only between 08:00 and 16:30 on working days. The trading is global, which means that Croatian banks can trade with any bank in the world up to the limits set by their risk management units. The trading amounts are usually expressed in millions of euro although it is possible to trade with smaller amounts. Small banks in the Croatian FX market do not usually trade for speculative reasons but to carry out small transactions connected with their daily activities (or their client's daily activities) and with satisfying FX regulations.[9]

## Natural Persons

Natural persons are traditionally an FX surplus sector in the Croatian FX market. The main characteristic of this sector is its large share in the total cash trading as well as the impossibility of registering each cash transaction this sector makes. Natural persons often trade with foreign currency because they use it as the means of payment in large private trades. There are three ways in which they can trade with foreign currency. First, they can trade with a commercial bank.[10] Second, they can trade through licensed exchange offices. Licensed exchange offices are legal persons or entrepreneurs registered for conducting foreign currency

7 In global terms, the most used pair of currencies is EUR/USD, but in Croatia the most used pair of currencies is HRK/EUR.

8 Informing, quoting, negotiating and closing the deal is done through Ruters/Bloomberg platforms, whereas the physical transfer of currencies is done through the standard SWIFT network.

9 In the case of substantial FX rate volatility, small banks usually will not conduct risky transactions. They will rather fail to quote a price, quote the price very slowly or use a very large bid/ask spread.

10 The CNB statistics treat all transactions between banks and natural persons as spot transactions.

trades. Since January 2005, licensed exchange offices are obliged to use one of the CNB-licensed and secured computer programs. Each exchange office must conclude an agreement with a bank which defines the frequency of emptying the exchange office's cash box, that is, the number of times in a month (one time at least) that the exchange office will take the money to the bank for a repurchase. The agreement also defines the conditions under which the bank will buy foreign currency from the office at a certain discount. However, generally speaking, licensed exchange offices make their profit from trading with their clients and not from reselling the currency from their cash box to the bank they have an agreement with. Since 2 October 2001, transactions between banks and foreign currency exchange offices are reported by banks within cash transactions with natural persons. The third way natural persons trade foreign currencies is directly with other natural persons, and this portion of FX trading is naturally left unreported.

### Legal Persons

Legal persons usually trade with FX instruments through commercial banks where they have their business accounts. If a particular FX trade is small in amount, the legal person will in general have to make the transaction based on the regular FX rate; if it is large in amount, it could access the client's desk and get a better conversion rate. Legal persons are traditionally an FX deficitary sector because the value of Croatian goods imports is twice the value of exports, and a large number of Croatian legal persons need the foreign currency to pay instalments on their foreign debt.

The most significant change for the role of legal persons in the Croatian FX market took place in April 2001. Until then, they were allowed to buy foreign currency only to make foreign payments for goods and services purchased abroad. After that date, legal persons are allowed to buy foreign currency for payments abroad, for capital transactions (allowed by the law) and also for asset allocation. This meant that, up to 2001, Croatian legal persons could not control their FX risk. After that date, however, the largest Croatian companies started to form their own FX desks in their treasuries and started to actively protect themselves from FX risk.

### Liberalization and Further Developments in the FX Market

Regulation has had a significant influence on the development of the Croatian FX market. The regulations have undergone some changes over the last few years. In the first few years of the Croatian FX market, there was not a unique act to regulate it but some acts that regulated different segments of the market. Because of this non-transparent system, and in order to adjust the domestic regulation to the EU directives, the law was thoroughly changed in 2001. These changes allowed legal persons to grant foreign currency loans to domestic legal persons for the purpose of foreign payments. They also allowed legal persons to buy foreign cur-

rency for depositing in FX accounts and for currency conversion. The steps in reconciliation of foreign liabilities and foreign claims via cessions, assignments, set-offs, etc. were also liberalized. These changes had an immediate impact on the trading volume in the domestic FX market (22.5% increase in November 2001). In the same year, Croatia signed the Stabilisation and Association Agreement with the EU that demanded further liberalization of some segments of the country's capital account within four years after the contract took effect. It also obliged Croatia to ensure the complete liberalization of the capital account before becoming a full member of the EU (say, until 2009).

In further steps towards the liberalization of FX transactions in Croatia, a new Foreign Exchange Act was passed in 2003. The purpose of this act was to further reconcile the domestic law and the regulation and practices of the EU. The act regulates three main areas: business between resident and non-resident persons in foreign currency and in kuna, business between resident persons in foreign currency, and the unilateral assignment of assets from Croatia and into Croatia that does not have the characteristic of a business deal between a resident and a non-resident. The act allows non-resident persons to hold kuna and FX deposits in foreign banks. Thus long-term capital flow liberalization was almost completed in 2003. In the same year, the government announced a gradual liberalization of short-term capital flows.

In March 2005, the Foreign Exchange Act was changed again. It removed the obligation on non-residents to open a custody account in a bank and sign a statement which guarantees that they will not sell or post as collateral the securities purchased within the one-year period (except to another non-resident). It also removed the ban on non-residents from investing in domestic short-term securities with a remaining maturity of up to six months. The rule that non-residents are not allowed to buy shares of an investment fund whose statute requires that more than half of its portfolio has to be in the central bank or government bills was also removed. However, these constraints did not apply to countries with whom Croatia had an agreement of encouragement and mutual protection of investments (which referred to most of the EU countries). The residents of those countries could trade in securities issued in Croatia under the same rules as Croatian residents. Also, in the event of a substantial disruption in the foreign payments system, the Croatian National Bank reserved the right to introduce temporary (up to six months) restrictions on capital flows.

With regard to the rules for residents concerning investment in foreign financial instruments and investment funds, the most important change was the removal of the rule which stated in which countries residents can buy securities and shares in investment funds. This means that the issuer of securities does not have to be a member of the OECD, an international financial institution or an entity rated by an internationally recognized rating agency.

The substantial trading volume growth in the Croatian FX market in last few years has undoubtedly stimulated its liquidity. However, it is developing relatively slowly, which makes it illiquid and dependent on a small number of major players.

Thus the Zagreb Money Market company was unsuccessful in organizing an FX exchange, as was the Zagreb Stock Exchange in introducing FX term instruments and an FX futures market. Moreover, the Croatian banks did not exercise an option offered by the law between 1993 and 1999 to organize an FX exchange. However, the FX market liberalization has definitely contributed to a growth in trading volumes and a reduction in bid-ask spreads, and the Croatian FX market continues to develop in a favourable macroeconomic situation and without substantial FX rate volatility.

## The following Working Papers have been published:

| No. | Date | Title | Author(s) |
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# Guidelines to Authors

In its periodical publications *Working Papers, Surveys and Discussion Papers*, the Croatian National Bank publishes scientific and scholarly papers of the Bank's employees, visiting scholars, and other associate contributors.

After the submission, the manuscripts shall be subject to peer review and classification by the Manuscript Review and Classification Committee. The authors shall be informed of the acceptance or rejection of their manuscript for publication within two months following the manuscript submission.

Manuscripts are submitted and published in Croatian and/or English language.

Manuscripts submitted for publication should meet the following requirements:

Manuscripts should be submitted via e-mail, in magnetic or optical storage media (3.5-inch floppy, ZIP, CD) accompanied by one printed paper copy. The acceptable text formats are Word for Windows/Mac. RTF code page 437 or 852 format is preferred.

The first page of the manuscript should contain the article title, first and last name of the author and his/her academic degree, name of the institution with which the author is associated, author's co-workers, and the complete mailing address of the corresponding author to whom a copy of the manuscript with requests for corrections shall be sent.

Additional information, such as acknowledgments, may be included in the first page. If this information is extensive, it is preferred to incorporate it within the text, whether at the end of the introductory section or in the special section preceding the list of references.

The second page should contain the abstract and the key words. The abstract is required to be explicit, descriptive, written in third person, consisting of not more than 250 words (maximum 1500 characters). The abstract should be followed by maximum 5 key words.

A single line spacing and A4 paper size should be used. The text must not be formatted, apart from applying bold and italic script to certain parts of the text. Titles must be numerated and separated from the text by a double line spacing, without formatting.

Tables, figures and charts that are a constituent part of the paper must be well laid out, containing: number, title, units of measurement, legend, data source, and footnotes. The footnotes referring to tables, figures and charts should be indicated by lower-case letters (a,b,c…) placed right below. When the tables, figures and charts are subsequently submitted, it is necessary to mark the places in the text where they should be inserted. They should be numbered in the same sequence as in the text and should be referred to in accordance with that numeration. If the tables and charts were previously inserted in the text from other programs (Excel, Lotus…), these databases in the Excel format should also be submitted (charts must contain the corresponding data series).

The preferred formats for illustrations are EPS or TIFF with explanations in 8 point Helvetica (Ariel, Swiss). The scanned illustration must have 300 dpi resolution for gray scale and full color illustration, and 600 dpi for lineart (line drawings, diagrams, charts).

Formulae must be legible. Indices and superscript must be explicable. The symbols' meaning must be given following the equation where they are used for the first time. The equations in the text referred to by the author should be marked by a serial number in brackets closer to the right margin.

Notes at the foot of the page (footnotes) should by indicated by Arabic numerals in superscript. They should be brief and written in a smaller font than the rest of the text.

References cited in the text are listed at the last page of the manuscript in the alphabetical order, according to the authors' last names. References should also include data on the publisher, city and year of publishing.

Publishing Department maintains the right to send back for the author's revision the accepted manuscript and illustrations that do not meet the above stated requirements.

Printed paper copies and diskettes containing manuscript files shall not be returned.

All contributors who wish to publish their papers are welcomed to do so by addressing them to the Publishing Department, following the above stated guidelines.

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Croatian National Bank – *Quarterly Report*
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The Croatian National Bank also issues other publications such as, for example proceedings of conferences organized or co-organized by the CNB, books and papers or books and papers translations of special interest to the CNB as well as other similar publications.

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