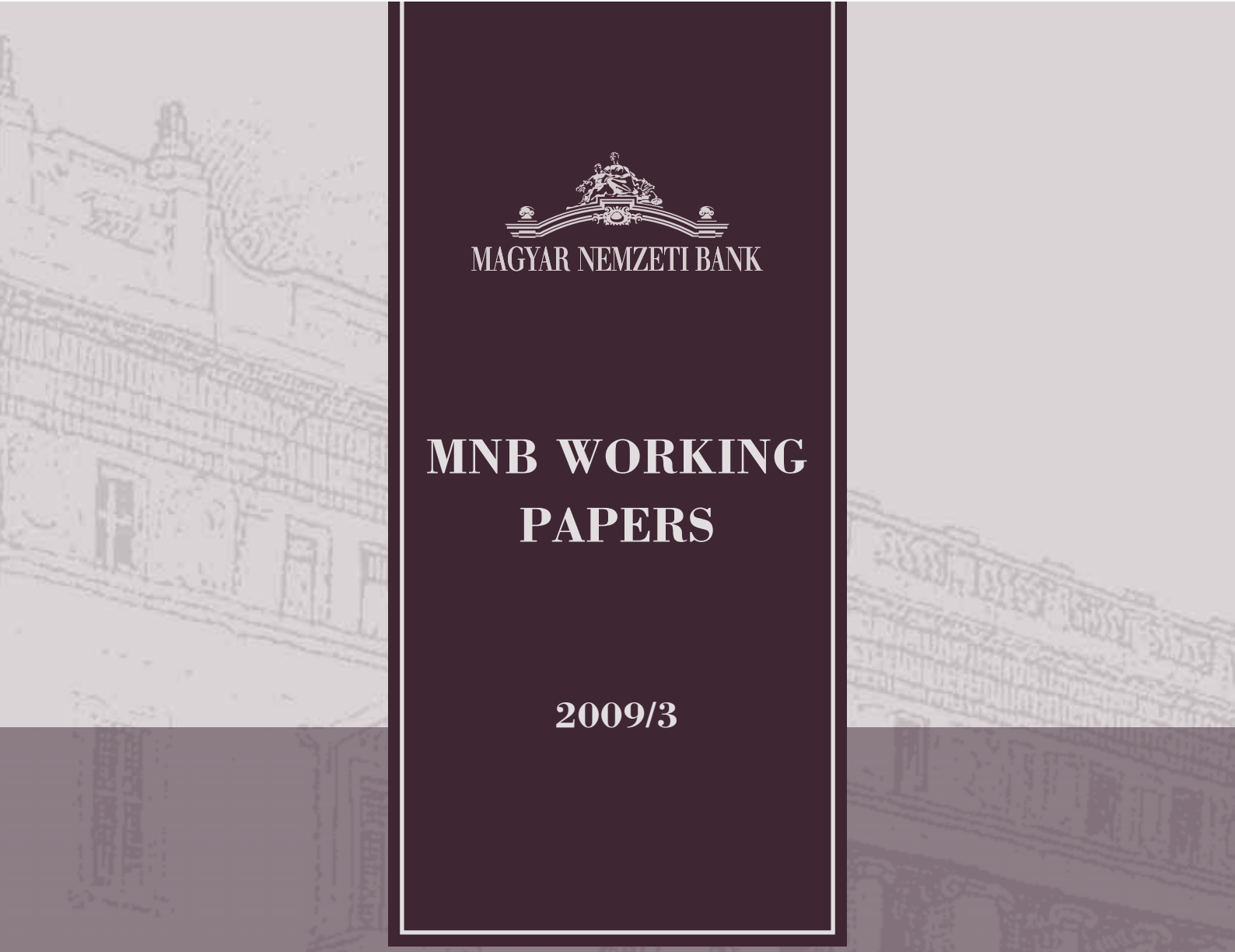

MAGYAR NEMZETI BANK

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Macroeconomic announcements, communication and order flow on the Hungarian foreign exchange market

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September 2009

MNB Working Papers 2009/3

Macroeconomic announcements, communication and order flow on the Hungarian foreign exchange market*

(Hogyan hatnak egymásra a makrogazdasági információk, a devizapiaci tranzakciók és az árfolyam a forint/euro piacon?)

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Published by the Magyar Nemzeti Bank

Szabadság tér 8–9, H–1850 Budapest

http://www.mnb.hu

ISSN 1585 5600 (online)

* The authors wish to thank Áron Gereben and Antonio Scalia for helpful suggestions. All remaining errors are ours.
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Contents

Abstract

We investigate the relation between the EUR/HUF exchange rate on the one hand and news announcements and order flow on the other hand using intraday data. We extend the existing literature on foreign exchange market microstructure by considering a small open transition economy. We find that the intraday exchange rate – independent from whether we focus on the mean or the volatility – depends on both news announcements and order flow. We conclude that news on the EUR/HUF market are transmitted directly via immediate reactions to news announcements as well as indirectly via order flow. We decompose the news' total effect on exchange rate and find that order flow accounts for approximately three quarters, compared to one quarter for direct news impact. Although the HUF has been pegged to the EUR, the exchange rate reacts qualitatively very similarly to exchange rates of major currencies as reported in the literature, but quantitatively we observe a remarkable difference: the share of the indirect channel is higher on the EUR/HUF market. Furthermore we extend the commonly used news by communication of central bankers and significantly improve the explanatory power of the regressions. Our results imply that macroeconomic and microstructure variables together can explain a non-negligible part of high frequency exchange rate movements and central bank communication is an important determinant of the EUR/HUF rate.

JEL: F31, G14, G15
Keywords: microstructure, order flow, exchange rate, macroeconomic news, central bank communication.

Összefoglalás

Írásunkban a forint–euro árfolyam, a fundamentumok és a devizapiaci tranzakciók közötti kapcsolatrendszert elemezzük napon belüli adatok felhasználásával. Az elemzés egy kis, nyitott, feltörekvő piaci gazdaságra történő alkalmazással egészíti ki a devizaárfolyamok mikrostruktúra-megközelítésének – jellemzően főbb devizákkal foglalkozó – irodalmát. Empirikusan megmutatjuk, hogy a makrogazdasági hírek, bejelentések és az egyirányú tranzakciókból származó vételi/eladási nyomás egyaránt befolyásolja mind az árfolyam szintjét, mind a volatilitását (ingadozását). Eredményeink visszaigazolják a nemzetközi tapasztalatokat: a makrogazdasági bejelentések hatása részben közvetlenül, az árfolyam azonnali elmozdulásával, részben közvetetten, a hír által kiváltott devizapiaci tranzakciók információközvetítő hatásán keresztül épül be az árfolyamba. Ugyanakkor az egyes közvetítő csatornák relatív fontosságát tekintve érdemi eltérés mutatkozik a szakirodalomban jellemzően elemzett főbb devizákhoz képest. A makrogazdasági hírek árfolyamra gyakorolt teljes hatásának dekomponálása alapján a hatás háromnegyed részét a devizapiaci tranzakciók közvetítik, miközben a hír közvetlen hatása csak egynegyed részt tesz ki. Tanulmányunkban a makrogazdasági hírek, bejelentések körét kibővítettük az irodalomban hagyományosan vizsgált makrogazdasági indikátorok – infláció, GDP stb. – mellett a jegybanki kommunikációt megjelenítő változókkal is. A jegybank kommunikációjának bevonásával a becslések magyarázó ereje szignifikánsan javult, modellünk az árfolyamváltozás számottevő részét képes megmagyarázni. Ebből arra következtethetünk, hogy az árfolyam alakulásában – legalábbis magas frekvencián – a jegybanki kommunikáció nem elhanyagolható szerepet játszik.

1 Introduction

During recent years there has been a growing interest in the microstructure of financial markets and the relations between exchange rates, news and order flow. Whereas traditional macroeconomic models assume that news are directly transmitted to prices, the microstructure approach explicitly assigns an important role to the process of trading.

The key concept is the order flow, showing a close empirical relation to the exchange rate (see e.g. Lyons, 2001; Evans, 2002; Payne, 2003). The order flow is defined as the difference between trades initiated by the buyer, and trades initiated by the seller of an asset. Therefore order flow can be described as buying (or selling) pressure on the market. Order flow significantly differs from the turnover on the market. There are situations where the order flow is almost zero, if trades are symmetrically initiated by buyers and sellers, although the turnover is high and vice versa.

Whereas in traditional asset market models information is assumed to be common, the microstructure approach claims that information exists that is not shared by all market participants and/or is interpreted differently by them (see e.g. the models by Kyle, 1985; Glosten and Milgrom, 1985; Evans, 1995; Evans and Lyons, 2006b). Thus, the trading mechanism itself becomes an important feature. However, the microstructure approach does not insist that it is not the fundamentals, which drive prices, but it focuses on the way potentially dispersed information about fundamentals is transformed to prices. Although some standard assumptions of perfect markets are relaxed within this framework (i. e. perfect information, perfect competition), the market may still be regarded as efficient in the sense, that prices reflect all known information. It implies that within both frameworks the market reaction to public news announcements is expected to occur within very short time.

As dealers may revise their quotes based on news as well as on the quotes they receive from other dealers, one may distinguish three different relations between news, order flow and the exchange rate (Evans and Lyons, 2006a; Sager and Taylor, 2006). First, the information content of announcements, that is publicly available and evaluated in a similar manner by at least most of the traders (the 'common-knowledge' part of macro news) affects prices directly and immediately. This channel directly corresponds to what one would call a traditional exchange rate model. Second, there may be news that is not unambiguous and difficult to interpret or not publicly available, so there can be a component of news that is not common-knowledge. In this case, private information is dispersed and transmitted to prices via order flow (see also Evans and Lyons, 2002a; Osler, 2006). We refer to this channel as the indirect effect of macro news intermediated by the induced order flow. Third, order flow unrelated to news announcements due to changing hedging or liquidity demands, or changing risk tolerances (Evans and Lyons, 2002a) may also affect the exchange rate.

The relations between the different sources of exchange rate variation are illustrated in Chart 1. The main difference between the microstructure approach and traditional asset price models is therefore that trading is considered as a substantial part rather than an auxiliary activity to price formation and therefore deserves particular attention.

The recent empirical literature shows that particularly the first two channels of price impact are present on foreign exchange markets: there is a vast empirical literature showing a significant relationship between high-frequency exchange rates and news (Almeida et al., 1998; Andersen and Bollerslev, 1998a; Melvin and Yin, 2000; Andersen et al.; 2003; Bauwens et al., 2005) and between exchange rates and order flow (Lyons, 1995; Payne, 2003; Yao, 1998). More recent papers simultaneously analyze the relation between the exchange rate, news and order flow.

Love and Payne (2008) come for major exchange rates to the conclusion that news affects both, the exchange rates as well as the order flow within a very short time, only one third of the news content immediately being impounded to prices, a result that is roughly confirmed by Evans and Lyons (2006) for the USD/DEM rate. Both studies also find a significant increase of the impact of order flow on prices around news announcements.

Evans and Lyons (2005), too, find for the USD/EUR that the impact of news on the order flow is stronger than on exchange rate returns. Furthermore, they identify delays in the direct impact of news on the exchange rate and even longer ones for the impact on order flow. In contrast, Berger et al. (2005) find a very quick reaction of the order flow on news, within one minute.

Cai et al. (2001) turn to the volatility of the JPY. They conclude that in 1998 order flow played a more important role than news announcements and mainly contributed to the extraordinarily high volatility of the yen. Dominguez and Panthaki (2005) come to the conclusion that both, scheduled and unscheduled news affect the volatility of the USD/EUR and the USD/GBP rates. Frömmel et al. (2008) find that the relation between order flow, news and the volatility of the EUR/USD rate depend on the counterpart of one particular FX dealer.

While most of the literature focuses on exchange rates between the 'big four' USD, EUR (DEM), JPY and GBP, and there are some papers dealing with smaller developed markets, such as the market for the Swedish (Lindahl and Rime, 2006) or Norwegian krona (Rime, 2001), just fewer papers deal with microstructure of financial markets in Central and Eastern European Countries (CEEC) (Hanousek and Podpiera, 2003 on the Czech stock market; Derviz, 2003 and Scalia, 2008 on the efficiency of FX interventions, Menkhoff and Schmeling, 2008 on the Russian FX market). However, the small FX market of a transition economy may show different characteristics than the markets for the major currencies. Besides the well known facts that transition economies are characterized by large capital flows and frequent interventions by the central banks there are two main characteristics that are directly linked to market microstructure: first, markets in transition economies are much smaller, thus less liquid. Second, there may be more private information in the market. This may be due to the lower news coverage, the low number of market participants, the more dynamic economic environment or simply structural deficits in an evolving market. Both factors, liquidity and private information, are key determinants of a markets microstructure.

Another strand of literature focuses on the impact of central bank interventions and communication on the exchange rate. A basic insight of the research on central bank interventions (for surveys see e.g. Sarno and Taylor, 2001; Vitale, 2007) is that interventions are able to move the exchange rate. They affect the first two moments of the exchange rate (Scalia, 2008) and the impact is usually stronger in emerging countries than in developed countries (Canales–Kriljenko, 2003). This may be due to less sterilization, the market's size and organization.

Besides direct interventions central bank communication may also be seen as a form of intervention, that is – although less obvious at first sight – able to affect the exchange rate as well (Ehrmann and Fratzscher, 2007). There is a huge amount of research providing some ambiguous empirical evidence on an impact of central bank communication on the exchange rate (Fatum and Hutchinson, 2002; Fratzscher, 2004; Ehrmann and Fratzscher, 2007; Jansen and de Haan, 2005a; Jansen and de Haan, 2005b; the survey in Blinder et al., 2008). The impact of verbal interventions or communication stems from their role in anchoring expectations on future monetary policy, i.e. the signalling or expectation channel of monetary policy (Sarno and Taylor, 2001), but also by functioning as a coordination advice for market participants (Reitz and Taylor, 2008). Thus, communication may complement intervention (Beine, Janssen and Lecourt, 2004) or substitute it (Fratzscher, 2008).

Due to the more dynamic economic environment in a transition economy, verbal interventions may be more effective than in developed markets. However, again most of the work deals with developed markets, mostly for the Fed, the ECB, the Bank of England and the Bank of Japan, and there are only few papers that focus on transition economies: Rozkrut et al. (2007) find for the Czech Republic, Hungary and Poland, that speeches about monetary policy affect the exchange rate. Égert (2007) finds influence of central bank communication for Hungary, but not for other CEEC. He also concludes that the Hungarian National Bank (MNB) used actual interventions very rarely, but mainly relies on verbal interventions. Gábriel and Pintér (2006) show on a daily frequency that mainly MNB communication related to the future path of the interest rates and the economic outlook were successful in influencing the EUR/HUF rate, the effects of exchange rate communication are ambiguous and small.

The contribution of our paper to the literature is threefold:

First, we focus on a small, less liquid market in a transition economy. Our aim is to analyze, how much the results differ from those for the major foreign exchange markets. One could expect a higher importance of order flow due to a higher share of private information and a less stable and predictable economic environment.

Second, we use a broader data set of news, covering not only quantitative macroeconomic announcements, but also communication variables. Again, the less stable economic environment, including uncertainty about monetary policy may lead some importance of central bank communication, as it may anchor expectations. We also depart from most of earlier studies

in that we analyze the effects of the Hungarian quantitative news series individually and thus are able to compare the importance of different news announcements.

Third, we had access to an outstanding quality database containing very detailed data from the Reuters D2000-2 trading system, covering a period of two years, which is substantially longer than most of those used in the relevant literature on order flow (e.g. 8-month-long period of Love and Payne, 2002; 4-month-long periods of Evans and Lyons, 2006; or Frömmel et al., 2008). We will use data with a frequency of one and ten minutes as well.

The outline of the paper is as follows: In section 1 we have given a brief overview on the role of order flow in the trading process and recent empirical work. After describing the data in section 2, we present the empirical results in section 3. The empirical analysis comprises four subsections: First, we address the question whether scheduled macroeconomic news releases have an immediate impact on exchange rate and on order flows. Second, we investigate the exchange rate-order flow linkage and its sensitivity to news announcements. In section 3.3 we decompose the news impact into a direct part and an indirect part transmitted by order flow. Finally, we analyse the longer-term relationship between news, order flow and exchange rates in section 3.4. Section 4 summarizes and concludes.

2 Data set

The data set used in this study covers the whole years of 2003 and 2004 and contains exchange rate, order flow and macroeconomic news release data. Our whole data set consists of three parts: the exchange rate data including the order flow, macroeconomic announcements (quantitative data) and communication data (qualitative data). We will describe them briefly in the subsequent subsections.

2.1 ORDER FLOW AND EXCHANGE RATE DATA

The data for the exchange rate and the order flow stems from the Reuters D2000-2 electronic trading system[1]. As the competing electronic trading system EBS provides services on the EUR/HUF market only since February 2006 and the direct bilateral interdealer trading is steadily loosing ground in the FX market (Rime, 2003) our data set can be assumed to cover most of the whole interdealer EUR/HUF market[2].

This part of our data contains details of all the posted quotes (time-stamp, entry type, price, quantity entered, quantity traded, etc.) and the executed trades (time-stamp, trade price, quantity), but no information about the identity of market participants.

A number of additional advantages should be noted. First, with the help of "entry type" variable, which can be regarded as a buy/sell indicator, the initiator of the trade can be determined quite easily without having to make uncertain assumptions. Second, unlike in many other papers (Lyons, 1996; Love and Payne, 2002) the size of the trades is known, therefore order flow measures can be computed more accurately, without any distortion.

Following the literature (Andersen et al., 2002; Bauwens et al., 2005; Berger et al., 2005) we exclude weekends and public holidays from the data set due to the lack of trades and quotes during these days. For the same reason we drop the periods from 17:30 CET to 08:00 CET next morning each day. There are few short time periods when the Reuters data feed was broken, or other data problems occurred. We have removed these periods as well.

These data, which are accurate to the second decimal of the second, are then aggregated to two different frequencies: We use 1-minute frequency to analyse (1) the impact of five specific scheduled Hungarian quantitative news items on exchange rate returns and order flow, (2) the linkage between order flow and exchange rate movements and (3) the joint dynamics of exchange rate, order flow and pre-scheduled news. We use a 10-minute frequency to explore the relationship between an extended set of news, order flows, exchange rate returns and volatility. This distinction is due to the characteristics of the news variables and will be discussed in detail later. From these aggregated price series, we do then calculate the returns as 100 times the difference of the log prices. We use the quote series instead of the real transactions, as the number of real transactions in the EUR/HUF market seems to be scarce for working such high frequencies.

The order flow is obtained by subtracting the seller-initiated traded quantities from buyer-initiated traded quantities occurred within the given interval of 1 respectively 10 minutes. In the Reuters D2000-2 a trade may occur, because two limit orders are paired by the system, or because a market order hits an existing limit order (which is the case in more than 75 per cent of all cases). In the first case the last limit order, the one that causes the trade, is regarded to as the initiating order, whereas in the latter case the market order is the initiating one. This is in line with the microstructure literature (Berger et al., 2005).

Doing so we get 293,550 observations for the 1-minute analysis and 29,355 for the 10-minute analysis left. Summary statistics of the return and order flow series are presented in Table 1. Chart 2 shows the distributions of the order flow series at 1- and 10-minute frequencies.

[1] For a full description of characteristics and tendencies of spot FX market segments and the features of the available data see Lyons (2001).

[2] For a more extended specification of the given Reuters D2000-2 database, including a detailed description of data and a comparison to other datasources see Gereben and Kiss M. (2006), where the same database is used as here.

2.2 MACROECONOMIC ANNOUNCEMENTS

This part of the news database consists of 5 quantitave news items containing the exact time, the announced value and the market expectations for the included fundamentals. According to previous examinations, to the results of the existing literature and to our intuition, four Hungarian macroeconomic variables are selected (CPI, GDP growth, budget deficit and current account deficit), whose effects on the EUR/HUF market can be regarded as relevant. We also include the Monetary Council meetings in this subset, as base rate decision are regarded as one of most important information among fundamentals (Kiss M., 2004; Pintér and Wenhardt, 2004).[3] For a brief description of the variables see Table 2.

We define the "news" component of these macro variables as the difference between the actual values and the expectations that are extracted from the regular monthly survey conducted by Reuters Hungary among 15-25 market analysts. The only exception is Monetary Council's rate decision. This question has become standard in the survey only during 2005, so for our sample period no expectation data are available. Therefore, we use the change in the short-term (3-months) government bond benchmark yield as the measure of surprise, which is in line with the expectations hypothesis.

We use this *surprise* or *news* component of the macroeconomic announcements in absolute terms as well as in a standardized manner that enables us to compare the relative impact of announcement categories. This approach has turned out to be standard in the empirical literature (Balduzzi et al., 2001; Andersen et al., 2003; Love and Payne, 2008):

$$S_{i,t} = \frac{A_{i,t} - E\left[A_{i,t}\right]}{\hat{\sigma}} \tag{1}$$

where A_{it} is the announced value of data *i*, $E[A_{i,t}]$ is the expected value of data *i*, and $\hat{\sigma}$ is the sample standard deviation of $A_{i,t}$–$E[A_{i,t}]$.[4]

An announcement is regarded as "positive/good" (positively signed) if it implies the appreciation of the forint (i.e. lower-than-expected inflation or deficit figures, restrictive base rate decisions) and is regarded as "negative/bad" analogously.[5]

As all these mentioned news items are pre-scheduled, i.e. market participants know the hour and minute of their release in advance and may react within a very short time, an analysis at the high frequency of one-minute intervals seems to be most appropriate to capture their effects on the exchange rate. Our methodology is based on the approach of Love and Payne (2008), but with some necessary modifications.

2.3 COMMUNICATION VARIABLES

The second part of our news database includes qualitative and (mainly) non-scheduled news items concerning central bank communication. We use news headlines reported on Reuters screen and all kind of written communication by the MNB to create the variables describing central bank communication. We include only those items in the database containing some kind of guidance about the future stance of monetary policy, and each statement counted only one time, when it is mentioned first. Three main (monetary policy related) topics determine the content of the MNB's communication: exchange rate (for example, hints on the preferred exchange rate level, intervention), policy rate (hints on the short-term interest rate path), economic outlook.

[3] Of course, we included the meetings, when the decision was no change. However, we excluded from the examination the decisions of the extraordinary meetings, as they were announced unexpectedly under turbulent market circumstances, therefore market must have reacted to them in a very different way than to scheduled interest rate changes. In addition, we excluded the so-called non-ratesetting meetings, as well, because according to the communicated policy Monetary Council is not expected to make an interest rate decision at these meetings.

[4] In the empirical part of the paper we report results for both the absolute and the standardized measures of surprise, where it is meaningful and has additional information content.

[5] Different theoretical exchange rate determination models differ in their predictions concerning the expected direction of the exchange rate response of news surprises. For example, central bank reaction function model predicts appreciation after higher-than-expected inflation data, while the same surprise is expected to cause depreciation according portfolio-balance approach (for more details see Hoffman and Schlagenhauf, 1985). We used an event-study analysis to the classification, where the expected direction of the exchange rate response was not unambiguous. Our experiences were consistent mainly with the portfolio-balance model.

Similarly as for the quantitative news in subsection 2.2, we transform the communication dataset into 3 dummy variables, according to the "sign" of the news. Positive and negative news sum up to approximately 73 per cent of the selected statements, while we consider the rest of the communication as being neutral.

We take into account that the same statement can carry different meanings at different points in time. We code the pieces of news from the market participants' point of view, so the sign of statements is determined compared to market expectations. The comparison to market expectations is most important in case of interest rate communication, as a rising/declining interest rate path was often present in expectations. Accordingly, we consider hints on a smaller cut than the anticipated interest rate cut as tightening[6].

We have performed the encoding of statements as follows: Four people compiled the data set, and then two of them again checked the coding. Several people independently reviewed doubtful cases to reduce the subjectivity of the coding as far as possible. This procedure already hints at this news category being a natural candidate for indirect price impact via order flow as suggested by Evans and Lyons (2006), due to its narrative and sometimes-controversial character.

Only part of the communication (some pieces of written communication) is pre-scheduled. Most of the communication news items appear without announcement in the Reuters newswire screen. This makes it difficult to determine the exact time when these pieces of information arising from the central bank reach the market. For this reason, we conduct the part of the analysis including communication variables at a lower, ten-minute frequency.

[6] As for the macroeconomic announcements, the difference between the three-month benchmark and the policy rate is considered as the anticipated interest rate cut.

3 Empirical analysis

Due to the aforementioned attributes of our news variables the empirical analysis embraces two different time aggregation frequencies – 1-minute and 10-minute intervals –, and according to characteristics of the specified approaches we used different methodological approaches – event study, VAR and conventional regression analysis – to analyse how news, order flow and exchange rate interdepend from each other. We proceed in four steps:

First, as a preliminary exercise we analyze the direct impact of news announcements on the EUR/HUF rate, without considering the role of order flow.

Second, we investigate the relation between the exchange rate and order flow, and whether this relation changes during news release times.

Third, we decompose the impact of news on the exchange rate into a direct and an indirect effect by means of a VAR. The first three steps are performed in line with Love and Payne (2008) and applied to data at the frequency of one-minute intervals.

Fourth, we add the communication variables to our system of equations and turn to a lower frequency of ten-minute intervals. This approach covers effects on exchange rate returns as well as on the volatility of exchange rates and is in line with, inter alia, Cai et al. (2001), Dominguez and Panthaki (2006) and Frömmel et al. (2008).

3.1 THE IMMEDIATE IMPACT OF MACROECONOMIC NEWS ON EXCHANGE RATE AND ORDER FLOWS

Following the approach by Love and Payne (2008), as a first step, we analyse the impact of the surprise content of macroeconomic announcements on exchange rate returns and on order flows separately. Both traditional exchange rate models and microstructure models imply that the market reaction to public macroeconomic news announcements is expected to occur within very short time. Therefore, we begin our empirical analysis by testing two hypotheses, namely whether the surprise component of the included announcements has significant influence on the EUR/HUF exchange rate (equation 2) and on order flow (equation 3). We follow the commonly used approach by Andersen et al. (2003) and Berger et al. (2005) and separately estimate the following equations for exchange rate returns and order flow:

$$\Delta p_{t,n} = \alpha^{p} + \sum_{i=k}^{l} \beta_{i,m}^{p} N_{t-i,n,m} + \varepsilon_{t,n} \tag{2}$$

$$OF_{t,n} = \alpha^{of} + \sum_{i=k}^{l} \beta_{i,m}^{of} N_{t-i,n,m} + \eta_{t,n} \tag{3}$$

where $\Delta p_{t,n}$ is 100 times the logarithmic change in the exchange rate from time *t-1* to time *t* on day *n*, $OF_{t,n}$ is order flow in the same interval, in terms of million euro, and $N_{t,n,m}$ is the surprise component of news category *m*, $\varepsilon_{t,m}$ and $\eta_{t,m}$ are the error terms.[7]

We show results for each news category (CPI, GDP growth, C/A, budget deficit, base rate decision) and for absolute as well as standardized news measures separately for a short event window with $k=3$, and with $l=-1$ minutes[8].

[7] We use OLS for our estimations and correct the coefficient variance/covariance matrix using Newey-West standard errors to compensate for autocorrelation and heteroscedasticity. This does, however, not substantially change the overall picture.

[8] Actually, we estimated the equations for $k=60$ and $l=-10$. There were, however, few significant coefficients and no clear pattern. Furthermore we only show the results for the absolute measure as those for the relative measure are basically the same. We only refer to them in text if necessary. All results not shown here are available from the authors on request.

In Table 3. we report estimates for specifications with the absolute news measures. At a first glance, the overall picture is that most of the macro news have significant immediate impact on returns as well as on the order flow. The comparatively low R^2 imply that macroeconomic information accounts for only a small proportion of exchange rate variation. However, this is partly due to the small number of news releases relative to the number of observations, as well and in line with the literature (Love and Payne, 2002; Andersen et al., 2003).

Four out of the five announcements significantly affect both, the exchange rate as well as the trading pattern. In the majority of cases the coefficients are significant and well-signed in the minute(s) right after the announcement. The only exception is GDP releases, where – potentially due to the only eight GDP data releases in our sample – our data do not give evidence of impact of GDP news neither on returns nor on order flow within short time. The effect of GDP news, if there is any, must be slight, disperse and slowly impounded.

For the other news categories (CPI, budget deficit, C/A and monetary council meetings) we find similar patterns: there is an immediate impact on the return as well as the order flow, these coefficients are signed as expected. For instance for CPI surprises we find that 1 percent higher than expected inflation causes almost half a percent depreciation of the Hungarian currency, and euro purchases/forint sales worth 17,2 million euro on average in the minute immediately following the release. For CPI, C/A and the monetary council meetings we also find that the effects of a surprise last for several minutes.[9]

The standardized measures indicate that CPI surprises have the strongest impact: One "unit" of CPI surprise implies about more than 4 million euro net one-sided trading. Furthermore, it causes an almost three times higher change in exchange rate, than the second powerful one, the base-rate decision surprise. This latter even has twice more influence on exchange rate than budget deficit and current account deficit surprises, which have approximately the same effect on exchange rate in the terms of the size of the impact.

3.2 THE SENSITIVITY OF EXCHANGE RATE-ORDER FLOW RELATIONSHIP TO NEWS RELEASE TIMES

In the preceding analysis we showed that news about fundamentals do not only influence exchange rate determination, but also trigger net buying or selling pressure on the currency in accordance with the sign of the surprise. Thus, one should expect that order flow is correlated with exchange rate returns, at least around news announcements. Therefore, we turn to the examination of the potential connection between order flow and exchange rate.

First we estimate the following benchmark equation (4) to answer the question whether there is a relationship at all[10]:

$$\Delta p_{t,n} = \alpha^{bm} + \beta^{bm} \cdot OF_{t,n} + \varepsilon_t \tag{4}$$

As the effect of order flow on exchange rate originates in conveying private or dispersed information, the association between order flow and exchange rate may be quite different in the immediate aftermath of macro news releases. This can be justified by theoretical models as Kyle (1985), where the market maker's price sensitivity changes around news releases. There are theoretical justifications for both, a weaker as well as a stronger connection between the exchange rate and order flow when news is published:

If the new information is not ambiguous and is interpreted similarly by most of the market participants, then trades convey less information about the fundamental value of the asset in the presence of news. Market makers may then update their beliefs and change their quotes according to this unambiguous information instead of depending upon the noisy trading. This attitude can cause a temporary disconnection between exchange rate and order flow. In addition, as liquidity and trading activity are assumably higher around news releases (see Chaboud et al., 2004; Fleming and Remonola, 1999), due to the larger volumes placed in the order book, a unity of trade might cause less price movement.

[9] In few cases, even a lead is significant, which may indicate position taking in advance (monetary council meetings) or just relate to the early release time or 8:30 a.m. (C/A) when the trade intensity is low (Gereben and Kiss M., 2006).

[10] As earlier, here we also used OLS and corrected the coefficient variance/covariance matrix using Newey-West standard errors to compensate for autocorrelation and heteroscedasticity.

On the other hand, if traders disagree about the interpretation of a given piece of news, well-informed or "smart" market participants are believed to trade more intensively around news releases. In this case dealers pay more attention to trading activity, and increase the probability of private information content of one-sided flows. Under these circumstances a positive (negative) order flow more probably indicates that the informed traders consider the asset more valuable (less valuable) than its actual market price. Moreover, the previously demonstrated results from subsection 3.1 suggest a stronger connection, as well.

Still following Love and Payne (2008) we use dummy variables to determine the answer by decomposing the impact of order flow into two components: a "usual" part, and another one related to news release time. However, we depart from them in the manner, that we let the additional impact differ across different kind of news items, as well, and we estimate the following specifications for all included macro variables separately:

$$\Delta p_{t,n} = \alpha + \beta_m \cdot OF_{t,n} + \sum_{i=-k}^{k} \gamma_{i,m} \cdot OF_{t,n} \cdot I(i)_{t,m} + \eta_{t,n} \tag{5}$$

where $I(i)_{t,m}$ is a dummy variable indicating that a news release concerning macroeconomic variable m occurred in period t. We adopt an event-study approach and estimate equation (5) only on announcement days, broken down by announcement type.[11]

Regarding the results of equation (4) as a benchmark, we can now compare, whether the explanatory power of the model can be improved by letting the coefficients of order flow differ from its usual level around news releases, and differ by announcement types. We set k to 5, namely under the expression "around news releases" we mean the five minutes before and after the announcements. Our estimation results for the benchmark regression and the five announcements separately are presented in Table 4 and Table 5, respectively.[12]

First, order flow plays a significant role in exchange rate determination in the Hungarian FX market and corroborates previous results on the EUR/HUF market obtained from daily data (Gereben et al., 2006) as well as the literature on other exchange rates (see inter alia Evans and Lyons, 2002a). The parameter of order flow is positive and highly significant, the R^2 is 16%.[13] A net excess of forint buyer-initiated trades is worth 1 million (in the base currency of euro) leads to about 0.01 percent appreciation of the forint (Table 4).

We run the regression over two subsamples (the year of 2003 and 2004) to check the robustness of the connection. The value of order flow parameter β is the same in the subsamples as in the whole sample, so the regular impact of order flow on exchange rate seems to be robust.

Second, as expected, the order flow parameter significantly changes at announcement times. All order flow coefficients are highly significant (in the majority of the cases at 1%) and positive (Table 5), interestingly even in the case of GDP, for which we did not find significant coefficients in the previous subsection. This means that order flow has a significantly larger impact on the exchange rate, consequently it conveys additional private information about the fundamentals in the minute, when scheduled public information reaches the market. The substantially increased R^2 show a close relation between order flow and the exchange rate.

Consequently, these results provide evidence that around news announcements order flow plays a larger role in exchange rate determination than at other times. If we put together this result and the previously found conclusion, that news strongly influences order flow, we may assume that the total impact of new public information is transmitted to exchange rates partially via order flow. In the following, we further explore this issue.

[11] We also estimated equation (5) only for announcement days, broken down by announcement type. Berger et al. (2005) apply this event-study approach similarly, but do not use dummy variables and estimate the regressions only in the minute after the releases.

[12] As well as in the previous section, due to convenience reasons we only report the results for $i=-1$ to 1.

[13] However, it should be noted that the statistical power of the benchmark regression is lower to some extent (R^2=16%), than is commonly found in the empirical literature. This is probably due to the 1-minute frequency and the relatively low trading activity in Hungarian FX market compared to the big markets (EUR/USD, JPY/USD etc.), as on average there is only one trade in every third minute. This view is confirmed by the fact that the R^2 was particluarly low during the first year of our sample, when trading activity was much lower on the the EUR/HUF market (Gereben and Kiss M., 2006) and speculative attacks against the band took place.

3.3 DECOMPOSING THE CHANNELS OF THE NEWS' IMPACT – A MULTIVARIATE VAR ANALYSIS

Now we carry on with the decomposition of exchange rate responses to news into direct and indirect (intermediated) parts, and try to measure the contribution of order flows to total exchange rate responses to news. For analysing this issue and testing the order flow intermediating role we estimate a VAR model for exchange rate changes and order flows, as follows.

$$\begin{bmatrix} \Delta P_t \\ OF_t \end{bmatrix} = \alpha + \begin{bmatrix} \beta \\ 0 \end{bmatrix} \cdot OF_t + \sum_{i=1}^{l} \Gamma_i \begin{bmatrix} \Delta P_{t-i} \\ OF_{t-i} \end{bmatrix} + \sum_{l=1}^{6} \sum_{j=0}^{k} \Theta_{l,j} N_{l,t-j} + \varepsilon_t \tag{6}$$

In this system, we allow contemporaneous order flows to have an effect on the price quotations, but the flows are not affected by the contemporaneous returns. This assumption seems to be a reasonable economic restriction, as the market is less liquid than the markets for major currencies, and within the 1-minute frequency we are analysing the number of trades is very limited. So we do not expect almost simultaneous feedback trading, which would allow the order flow to respond to price movements at a frequency of less than a minute. We further assume, that the structural form innovations, $(\varepsilon_{1,t}, \varepsilon_{2,t})$ are independent. This allows us to estimate the equation separately by OLS[14].

Table 6 summarizes the results and for brevity, we only report the results for the first five lags, the contemporaneous order flow and the news.[15] There is a relatively strong and persistent high-frequency negative autocorrelation in returns, while the high-frequency order flow exhibits positive autocorrelation. The contemporaneous order flow affects the returns as expected: a net forint purchase of 1 million euros goes along with an appreciation of the forint by 0.94 basis points. Lagged flows have a similar but smaller effect. The order flow exhibits positive dependency on recent returns up to 8 lags: forint appreciation leads to forint purchases and vice versa, which can be interpreted as an indication of positive feedback trading in the market. News affect the order flow significantly: all types but the GDP announcements have a significant contemporaneous effect, and several types of news affect the flows for several minutes. The coefficients are in line with intuition: positive surprises (good news) lead to an increase in net forint purchases, and with one exception the lagged effects have the same sign. The direct effect of news on the exchange rate is less pronounced: only the surprise content of the CPI announcement has a significant effect. But in this case the effect is strong: a one-standard deviation positive surprise causes the EUR/HUF rate to appreciate by 27.34 basis points.

To highlight the particular effect of CPI surprises as the obviously most effective news category, and the role of the order flow, Chart 3 shows the (cumulative) impulse responses of the exchange rate and the order flow to a CPI announcement. We follow Love and Payne (2008) and compare the actual IRF of the exchange rate returns to a hypothetical IRF, which would prevail if the news had no affect on the order flow.[16] The hypothetical impulse response shows the direct effect of the news shock on the exchange rate returns, and the difference between the actual and the hypothetical impulse responses indirect impact via the order flow.

The share of the direct and indirect components is given in Table 7. At the time of the announcement the direct channel dominates, 93.7% of the change in the exchange rate can be attributed to the news announcement directly. The share of the order flow has in the impounding the news into the prices increases rapidly over the time: 5 minutes following the announcement it amounts to almost 60%, and stabilizes around 57%, indicating that order flow indeed plays a substantial part in processing news, even in the presence of a strong direct effect.

To our best knowledge we are the first who do this kind of decomposition for an emerging market, so the comparison of our results is possible only with developed markets. Evans and Lyons (2006a) found that around two-thirds of news' total effect can be linked to trading activity in the USD/DEM market. They rejected the test for whether the direct channel is

[14] This departs from Love and Payne (2008), as they allow for contemporaneous effects, and impose a multivariate GARCH structure on the residuals to identify the structural parameters.

[15] The lag lenghts were selected according to the Schwartz information criterion.

[16] In our framework this means computing IRF from a model where the θ coefficient in the order flow equation is restricted to 0. This hypothetical model still allows for the order flow to influence the exchange rate, but assumes that neither the size of the order flow nor its effect on the returns changes following a news announcement.

more important than the indirect channel, concluding order flow accounts for at least half of the effect of macro news on exchange rate. Love and Payne (2008) examined three big FX markets and showed that on average one third of the new information is transmitted via order flow. In general, our result is in line with the findings of international literature, although the share that order flow has in incorporating news into prices is even higher in our case than it was found concerning big FX markets.

3.4 LONGER-TERM INTERDEPENDENCE OF NEWS, ORDER FLOW AND EXCHANGE RATE

As the inclusion of communication variables requires a ten-minute frequency we move on to explore the longer-term relationship between exchange rate, order flow and fundamentals.

3.4.1 Methodology

We measure volatility following the approach by Andersen and Bollerslev (1998a), which has become a standard in high-frequency analysis and is commonly used in the recent literature (see inter alia Cai et al., 2001; Dominguez and Panthaki, 2006; Frömmel et al., 2008) and calculate the volatility of ten-minute returns. The approach is based on the model

$$\Delta p_{t,n} - \mu = \sigma_n \cdot \sigma_{t,n} \cdot z_t \tag{7}$$

where μ is the unconditional mean of the return process, σ_n is the contribution of the daily volatility level to the return volatility and $\sigma_{t,n}$ consists of high-frequency contributions, in particular an intraday pattern, day of the week effects, which are reported for exchange rates in previous empirical work (see inter alia Andersen and Bollerslev, 1998; Cai et al.; 2001), and the impact of various kinds of news.

After the equation is squared and expressed in logs it evolves to

$$h_{t,n} = 2 \cdot log \frac{|\Delta p_{t,n} - \mu|}{\sigma_n} = c + p(t) + \sum_{k=1}^{4} \gamma_k \cdot day_k + \alpha \cdot X_{t,n} + u_{t,n} \tag{8}$$

where $p(t)$ is the above mentioned intraday volatility pattern, day_k are dummies capturing potential day-of-the-week effects and $X_{t,n}$ is a set of further determinants, including news, central bank activities and order flow, which will be specified later.

The daily volatility level σ_n is usually obtained by estimating a GARCH model based on daily data. We do, however, vary the approach: while Andersen and Bollerslev (1998a) use a standard GARCH(1,1) model with normally distributed conditional variances to the daily volatility[17], we apply a model with t-distributed errors. We do this because it is known (see e.g. Hughes Hallett and Anthony, 1997; Frömmel and Menkhoff, 2001) that managed exchange rates as the EUR/HUF show a much higher kurtosis than the flexible USD/DEM rate analyzed by Andersen and Bollerslev (1998a). In this case the use of a conditionally normally distributed GARCH-process may lead to the underestimation of the "true" volatility. The results of the daily volatility and the intraday volatility estimations are illustrated in Chart 4. The estimated conditional volatility shows a huge increase in January and again in June 2003, when the market was characterized by turmoil due to speculative pressure on the forint.

The intraday pattern is simpler than the one usually found for the USD/EUR or USD/DEM market[18]. However, the figure shows a clear pattern. One can easily distinguish the start from a very low activity level in the morning, the peak between 9:00 and 9:20 a.m., when Hungary's main macroeconomic news are usually published and trading starts getting more active, the subsequent slowdown during lunchtime and the repeated increase in the afternoon when the US markets open.

[17] Andersen and Bollerslev (1998b) show that even in the case of a continuous-time price process the GARCH-model provides accurate forecasts.

[18] For the intraday pattern we use a HP filter, which describes the pattern sufficiently well. We did, however, fit several possible trend functions and concluded that no one figures out the data better. As Melvin and Yin (2000) point out, if the pattern is simpler than the one in, for instance, Anderson and Bollerslev (1998) there is a priori no need to work with the more complex flexible Fourier form, and may consider using a simpler pattern.

For analyzing the effects of news on volatility we estimate the following system of equations, taking into account the relation between order flow (of) and volatility (h):

$$\begin{aligned} h_{t,n} &= \omega_1 + \alpha p(t) + \beta_0 \left|OF_{t,n}\right| + \sum_{h=1}^{2} \beta_h \left|OF_{t-h,n}\right| + \sum_{i=1}^{2} \gamma_i h_{t-i,n} + \sum_{j=1}^{4} \zeta_j day_j + \sum_{k=1}^{K} \sum_{l=-m}^{m} \delta_{k,l} N_{k,t-l,n} + \varepsilon_{t,n} \\ OF_{t,n} &= \omega_2 + \sum_{h=1}^{2} \beta_h \left|OF_{t-h,n}\right| + \sum_{i=1}^{2} \gamma_i h_{t-i,n} + \sum_{k=1}^{K} \sum_{l=-m}^{m} \delta_{k,l} N_{k,t+l,n} + \eta_{t,n} \end{aligned} \tag{9}$$

where the variables $N_{k,t,n}$ cover, as in the previous section, various types (k) of news as well as lags. The news variables may affect order flow as well as volatility. Again, the volatility depends contemporaneously on order flow, whereas order flow itself may react to volatility with a delay of one interval only. Note that we use absolute order flow in the volatility equation, as volatility is a one-sided measure.

The equation looks similar for the conditional mean, there are, however, some small differences. First, we refer to the signed order flow instead of the absolute one, as the return shows a distinctive direction and so does the signed order flow (positive values of the order flow mean that market participants seek to buy forint and sell euro). Second, there is no need to include day of the week effects and an intraday pattern. Therefore, the equations (9) evolve to:

$$\begin{aligned} \Delta p_{t,n} &= \omega_1 + \beta_0 OF_{t,n} + \sum_{h=1}^{2} \beta_h OF_{t-h,n} + \sum_{i=1}^{2} \gamma_i \Delta p_{t-i,n} + \sum_{k=1}^{K} \sum_{l=-m}^{m} \delta_{k,l} N_{k,t-l,n} + \varepsilon_{t,n} \\ OF_{t,n} &= \omega_2 + \sum_{h=1}^{2} \beta_h OF_{t-h,n} + \sum_{i=1}^{2} \gamma_i \Delta p_{t-i,n} + \sum_{k=1}^{K} \sum_{l=-m}^{m} \delta_{k,l} N_{k,t+l,n} + \eta_{t,n} \end{aligned} \tag{10}$$

In the case of the return analysis including lagged returns to the order flow equation is even more appealing as it explicitly allows for the existence of feedback trading, i.e. market participants react on recent price changes for exploiting (potentially small and short) trends.

3.4.2 Results

The estimation results for the equations (9) are given in Table 7. It is obvious that in the order flow equation there is a strong negative relation between present absolute order flow and lagged volatility, and at the same time there is positive autocorrelation of the absolute order flow. Similarly, in the volatility equation positive autocorrelation of the volatility and some negative relation is present between the volatility and lagged absolute order flow. Furthermore, a highly significant intraday pattern can be observed in volatility. We do not find a day of the week effects.

These results are in line with the empirical literature. Intraday volatility patterns are a well-know feature of FX markets, as well as positive autocorrelation observable in financial variables, such as volatility, order flow, etc. (Andersen et al., 2003; Bauwens et al., 2005; Froemmel et al., 2007). The negative relation between (present/lagged) order flow and (lagged/present) volatility is reasonable, as well. Both variables can be regarded as a measure of market uncertainty about an asset's fair value. If the volatility is increasing showing higher uncertainty, then trades will be more probably symmetrically initiated by sellers and buyers, and the chances of one-directional pressure on the asset (which is shown by absolute order flow) should be less in the following period(s). Similarly, the higher selling/buying pressure occurs in the market, that means, the more traders (the smarter, or those having private information) agree on the overvalued/undervalued price of the asset, which may cause a decrease in the uncertainty about asset's value.

Monetary policy meetings, especially when the base rate is changed, apparently significant affect both, absolute order flow and volatility. Prior to the meetings, the absolute value of order flow, i.e. the one-sided trading activity, and volatility increase and decrease after the meeting. We interpret this as position taking in expectation of the meeting's decision. Whereas the variable *meeting* does not distinguish, whether there was an interest rate decision, this is captured by the following variables. Accordingly, a change in the base rate causes the buying or selling pressure to be higher after the meeting, which reflects the position taking due to the new interest rate settings. In contrast, there is only little impact on order flow before the interest rate decision. Interestingly, volatility tends to be low prior to interest rate cuts.

Macro news announcements do not imply aggressive one-sided trading. The only exception is the interval 20 minutes after positive news has been published, when the one-sided trading seems to be more intense than other times. This phenomenon can be due to the lower frequency, as we have seen previously that the impact of news releases on order flow emerges within very short time. Thus, some of the effects may have already been offset. In contrast, there is a measurable direct effect of news on volatility. The impact is especially strong in the case of negative news items: while volatility decreases before the releases, as everybody expects the figures, volatility increases considerably contemporaneously and after the announcements, as the surprise triggers heavy trading. The reaction on positive news is less unambiguous, but still consistent with our previous results: there is an increase in volatility only 10 minutes after the publication.

It seems that there is no clear-cut tendency concerning the effects of central bank communication. The significance and the sign of the parameters vary along the relative time and the type of the communication. Moreover, as central bank communication is not pre-scheduled in the most of the cases, it is not expected to have significant impact on the market prior to the events. Thus, we can draw just a cautious conclusion: Four significant and relevant parameters indicate that central bank communication (essentially negative communication) might decrease the uncertainty in the market.

The intensity of trading, measured with the number of deals conducted is positively related both to the absolute order flow and volatility. The explanatory power of the order flow regression is very impressive with an R^2 higher than 65%, that means two thirds of market pressure stemmed from asymmetrically initiated trades can be explained by fundamentals, such as macro news, monetary policy decisions and communication, and lagged/contemporaneous values of volatility, absolute order flow and trades variables. Meanwhile in the case of volatility regression the R^2 shows that the mentioned variables account for 16% of price variability, which can be regarded as relatively high, as well.

The estimation results for the returns are presented in Table 8. The order flow equation shows significant negative autocorrelation of the order flow, and a strong negative relation between present order flow and lagged returns. This may be caused to some amount by negative feedback trading present on the Hungarian FX market.[19] On the other hand, returns are negatively autocorrelated, while there is significant positive (negative) relation between the returns and the contemporaneous and first (second) lag order flow.

Monetary policy meetings can coincide with either appreciation or depreciation after the meetings depending on the relative time, and around the meetings net forint purchases are observable. One has, however, to keep in mind that the variable meeting captures very different meetings, including those with and without decision, which may be surprising or not. Again, a look at the interest rate decisions seems to be more informative, as interest rate changes significantly affect both the returns and the flows.

Interest rate cuts mainly coincide with depreciation of the forint, the only exception is 10-minute lead prior to the decision. The impact of rate cuts on order flows is not fully consistent along the time: both buying and selling pressure can be observed. In contrast, the impact of interest rate hikes on order flow is unambiguous: hikes cause aggressive one-sided trading on the HUF buy side. In accordance with this, if the Monetary Council increases the base rate, the forint tends to appreciate. The reaction on interest rate changes is therefore almost fully consistent with theory, and shows a close relation between the news and both, order flow as well as volatility.

The results on macroeconomic announcements are mainly consistent with theory, too: The strongest reaction follows positive news on the Hungarian economy, i.e. news those are expected to cause an appreciation of the forint. They are linked up, with a lag of about ten minutes, with buying pressure and accordingly with appreciation of the forint. Together with results from the previous section it is shown that news do not show only a very short-lived effect on volatility during the most recent minutes after publication of the news, but also have an ongoing impact on the exchange rate after publication of the news. The impact of negative news is also visible, but less strong. Whereas the order flow shows significant sales after the news, there is only a slight, albeit not significant depreciation of the forint. Therefore we find a strong asymmetric behaviour of market participants.

[19] Csávás and Varga (2006) find that depending on the sample period both negative and positive feedback trading is observable in the Hungarian FX market.

Central bank communication seems to affect more intensively the trading process, than the exchange rate movements. Though, as it could be seen earlier, it is also true in this equation system, that the significance and the sign of the parameters differ depending on the relative time and the type of the communication. This is in line with the in general more ambiguous character of this "news" category and the fact that they are not scheduled. The latter point makes it even difficult to explain the significance of leads, but this may also be due to the difficult timing of communication events.

Positive communication, however, appears to imply forint purchases and appreciation, there seems to be some kind of overshooting, as part of the initial purchases are offset within the next ten minutes. Neutral communication implies some negative order flow and depreciation, while negative communication goes along with forint sales. The reaction of the exchange rate, is only slightly significant, but wrong-signed.

The results on the communication variables demonstrate the importance of central bank communication for the EUR/HUF exchange rate and are in line with Rozkrut et al. (2007), Égert (2007) and Gábriel and Pintér (2006).

We experience a relatively low explanatory power of the order flow equation, but on the contrary the fit of the exchange rate return equation may be considered rather good (R^2=22%). Together with the previously found consequences these results imply that macroeconomic and microstructure variables together can explain a non-negligible part of exchange rate movements and the characteristics of the trading activity on the EUR/HUF market.

4 Conclusions

During recent years the analysis of order flow has become an important issue, being extensively debated in academia as well as by policy makers.

Our study adds to this discussion by complementing earlier empirical papers. While most of the earlier studies focus on exchange rates between the world's major currencies, we consider the exchange rate of a small open economy, characterized by a less liquid market and comparatively high capital flows, and raise the question, whether the role of order flow in this market is the same as for the major ones. To make the results comparable we conduct our analysis in the standard framework of order flow analysis.

Our results regarding the relation between news, order flow and exchange rate seems to be qualitatively independent from the size of the market, in the sense that we find a strong immediate reaction of the EUR/HUF exchange rate to news and also a strong relation between the exchange rate and order flow as reported in the literature. Order flow itself can explain a significant part of exchange rate variation. In addition, the order flow – exchange rate relation changes significantly around news releases, namely order flow has additional information content and stronger impact on exchange rate (i.e. the same magnitude buying/selling excess causes larger appreciation/depreciation), when scheduled public information reaches the market.

Overall, our study supports the notion that although the exchange rate has been kept in a band to the euro, the relation between order flow, news and exchange rate does not differ in its basic structure. This is even more remarkable as our sample covers a period of a strong pressure on the forint.

However, although the results are qualitatively the same, they are not comparable in quantitative terms. Not surprisingly, the importance of order flow seems to be higher than it was found in major currency markets. Decomposing exchange rate responses to news into direct and indirect (intermediated) parts, we quantify the contribution of order flows to total exchange rate responses to news. Our results suggest that three quarters of total price reaction are intermediated by order flow, whereas the share for major markets is usually estimated as 30-50 per cent.

The differences are even more striking for the communication variables. In contrast to most other currencies they seem to play an important role in the EUR/HUF market, reflecting the experience that the MNB relied on verbal intervention rather than on actual interventions in most times (Égert, 2007).

Both differences of the EUR/HUF market – higher importance of order flow and relevance of communication – may be attributed to the presence of private information due to the factors mentioned in the introduction.

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Charts and tables

Table 1

Order flow and exchange rate returns summary statistics

Horizon	h = 1 min		h = 10 minutes	
	Returns	Order flow	Returns	Order flow
Number of observations	293 550	293 550	29 355	29 355
Mean	0.00004	0.005720	0.00046	0.0574
Standard Deviation	0.31	1.15	0.21	5.18
Skewness	-0.50	0.21	-0.59	6.78
Kurtosis	63563	308	3347	369
JB normality test	4.94e+13	1.14e+09	1.37e+10	1.64e+08
Proportion positive	0.53	0.51	0.51	0.50
Autocorrelation of order 1	-0.308	0.218	-0.409	0.137
Autocorrelation of order 2	-0.184	0.129	-0.007	0.074
Autocorrelation of order 3	0.000	0.089	-0.002	0.053

Table 2

Description of news announcements

	Observations[1]	Source[2]	Release time[3]	Sign[4]
Consumer price index	24	CSO	9:00	-1
GDP growth	8	CSO	9:00	+1
Current account balance	24	MNB	8:30	+1
Public sector balance	24	Ministry of Finance	Varies: 17:00 or 10:00	+1
MPC meetings - base rate decisions	42	MNB	14:00	+1

Notes:

[1] *Total number of observations in the sample period.*

[2] *CSO: Central Statistical Office, MNB: Magyar Nemzeti Bank (the central bank of Hungary).*

[3] *Central European Time.*

[4] *+1 (-1) if greater than expected news is assumed to coincide with appreciation (depreciation) of Hungarian forint.*

Table 3

The effects of macroeconomic announcements on exchange rate and order flow

(absolute measure of surprises)

News variable (unit of surprise)	Dependent variable	Constant	1-min-lead	Release minute	1-min-lag	2-min-lag	3-min-lag	R^2 (adj)
CPI (1%)	returns	0.001	0.006	**-0.490*** **	0.044	**0.047** **	**0.026***	0.13
		(1,70)	(1.19)	**(-5.40)**	(0.43)	**(2.10)**	**(1.88)**	
	order flows	0.06	0.27	**-17.200*** **	-3.06	0.26	0.59	0.09
		(1.17)	1.16	**(-8.60)**	(-1.06)	(0.42)	(0.61)	
GDP (1%)	returns	-0.001	0.000	0.019	-0.009	0.034	0.025	0.00
		(-0.84)	(0.01)	(1.04)	(-1.11)	(0.98)	(0.76)	
	order flows	0.016	-0.000	-0.528	-1.279	0.45	2.37	0.00
		(0.11)	(-0.01)	(-0.58)	(-1.22)	(0.95)	(1.52)	
BD (100 billion HUF)	returns	-0.004	0.010	**0.021** **	-0.006	0.011	0.001	0.01
		(-0.05)	(0.84)	**(2.06)**	(-0.44)	(1.14)	(0.45)	
	order flows	2.246	0.094	**1.453** **	0.051	0.449	0.392	0.01
		(0.42)	(0.25)	**(2.06)**	(0.10)	(0.72)	(1.31)	
CA (100 million EUR)	returns	-0.047	**-0.008*** **	0.005	**0.002***	**0.001** **	**0.001** **	0.01
		(-0.18)	**(-8.17)**	(1.04)	**(1.76)**	**(2.20)**	**(2.35)**	
	order flows	-3.598	**-0.227*** **	0.167	**0.152*** **	**0.207*** **	**0.158*** **	0.02
		(-0.82)	**(-9.02)**	(1.02)	**(3.72)**	**(11.45)**	**(3.87)**	
MC meeting (10 bp)	returns	**0.001*** **	0.020	**0.014** **	-0.006	0.001	-0.004	0.04
		(3.26)	(1.31)	**(1.96)**	(-0.48)	(0.21)	(-1.58)	
	order flows	**0.101***	**0.760***	**1.449*** **	**0.902***	**0.238** **	**0.653*** **	0.10
		(3.97)	**(1.89)**	**(3.50)**	**(1.80)**	**(2.27)**	**(2.82)**	

*Asterisks refer to level of significance, ***: 1 per cent, **: 5 per cent, *: 10 per cent.*

Table 4

The effect of order flow on exchange rate

		constant	OF	R^2 (adj)
Eq (4)	Whole sample	0.000 (1.42)	**0.010*** (34.63)**	0.16
	2003	0.000 (0.55)	**0.010*** (20.31)**	0.12
	2004	0.000 (1.54)	**0.010*** (32.00)**	0.26

*Asterisks refer to level of significance, ***: 1 per cent, **: 5 per cent, *: 10 per cent.*

Table 5

The sensitivity of order flow parameter to news releases

	Announcement	Constant	Order flow	OF*I(-1) (1 min lead)	OF*I(0) Release time	OF*I(1) (1 min lag)	R^2 (adj)
Eq (5)	CPI	-0.000	**0.008*** **	0.012	**0.012*** **	-0.006	0.26
		(-0.40)	**(21.38)**	(0.24)	**(5.44)**	(-1.49)	
	GDP	-0.002	**0.009*** **	**-0.008*** **	**0.006** **	0.007	0.20
		(-1.38)	**(6.49)**	**(-5.56)**	**(2.46)**	(0.50)	
	BD	-0.000	**0.008*** **	0.001	**0.013*** **	0.001	0.23
		(-0.42)	**(5.36)**	(0.25)	**(6.94)**	(0.12)	
	CA	0.000	**0.010*** **	0.022	**0.023*** **	0.001	0.16
		(0.03)	**(2.73)**	(1.08)	**(4.50)**	(0.21)	
	MC meeting	0.000	**0.011** **	**0.045*** **	**0.028*** **	-0.002	0.28
		(0.61)	**(7.60)**	**(3.99)**	**(5.55)**	(-0.97)	

*Asterisks refer to level of significance, ***: 1 per cent, **: 5 per cent, *: 10 per cent.*

Table 6

VAR results

Dependent variable	OF	Return
return		
1-min-lag	**-0.020****	**-0.627*****
2-min-lag	**-0.028*****	**-0.670*****
3-min-lag	**-0.031*****	**-0.596*****
4-min-lag	**-0.031****	**-0.565*****
5-min-lag	**-0.026***	**-0.525*****
OF		**-0.009*****
1-min-lag	**0.189*****	**-0.005*****
2-min-lag	**0.069*****	**-0.005*****
3-min-lag	**0.036*****	**-0.005*****
4-min-lag	**0.030*****	**-0.004*****
5-min-lag	**0.012*****	**-0.004*****
Surprises		
Budget deficit	**-1.447*****	0.006
2-min-lag	**-0.640****	
Current account	**-0.872*****	-0.019
1-min-lag	**-0.660*****	
2-min-lag	**-0.749*****	
3-min-lag	**-0.540*****	
CPI	**-3.826*****	**0.273*****
2-min-lag	**0.448***	
GDP	**0.204**	0.017
3-min-lag	**-1.160*****	
MT	**-1.097*****	0.041
1-min-lag	**-0.609*****	
2-min-lag	**0.320***	
3-min-lag	**-0.828*****	
4-min-lag	**-1.618*****	
8-min-lag	**0.898*****	
9-min-lag	**-0.404****	
Trade	**-18.200*****	-0.065
2-min-lag	**-14.882*****	
3-min-lag	**4.985***	
D_MT(1)	**-0.380****	
R^2 (adj.)	0.061	0.320
DW	2.003	2.004

*Asterisks refer to level of significance, ***: 1 per cent, **: 5 per cent, *: 10 per cent.*

Coefficients for leads and lags are only shown if significant at least at the ten per cent level.

Table 7

Regression on volatility and absolute order flow

Dependent variable	$\|OF_{t,n}\|$	$h_{t,n}$
const	**0.211*** **	**-0.463*** **
Intraday pattern		**0.908*** **
Volatility		
10-min-lag	**-0.010** **	**0.094*** **
20-min-lag	**-0.009** **	**0.033*** **
|OF|		**0.064*** **
10-min-lag	**0.060*** **	-0.004
20-min-lag	**0.015** **	**-0.026*** **
Monday		0.010
Tuesday		-0.014
Thursday		-0.022
Friday		0.033
Monetary policy		
Meeting	**-2.010*** **	0.076
10-min-lead	**0.734** *	**1.220** **
10-min-lag	**-1.148*** **	0.512
20-min-lag	**-0.654** *	0.285
Interest rate down	**-0.217*** **	**-0.022** **
10-min-lead	-0.009	**-0.054*** **
20-min-lead	**0.070*** **	**-0.022*** **
10-min-lag	**0.015** **	**-0.026*** **
20-min-lag	**0.021*** **	-0.010
Interest rate up	**-0.016*** **	0.008
10-min-lag	**0.011** *	**-0.045*** **
20-min-lag	**0.038*** **	-0.001
Macro news Hungary		
Negative news[1]	0.000	**1.533*** **
10-min-lead	-0.141	**-0.931** **
20-min-lead	0.068	-0.562
10-min-lag	0.363	**1.255** **
20-min-lag	0.499	**0.927** **
Positive news[1]	-0.373	0.343
10-min-lag	-0.501	**1.138*** **
20-min-lag	**0.907** **	-0.275
Communication		
Positive communication[1]	0.412	0.792
20-min-lead	**0.841** *	-0.108
10-min-lag	**-0.721** *	0.206
Neutral communication[1]	**-0.685** *	0.211
10-min-lead	**0.801** **	0.121
20-min-lag	**0.752** *	-0.472
Negative communication[1]	-0.528	-0.173
10-min-lag	0.437	**-1.046** **
20-min-lag	**1.153*** **	**-1.060** **
Trades	**0.690*** **	**0.160*** **
10-min-lag	**-0.088*** **	-0.006
R^2 (adj.)	0.652	0.156
DW	2.003	2.003

*Asterisks refer to level of significance, ***: 1 per cent, **: 5 per cent, *: 10 per cent.*

Coefficients for leads and lags are only shown if significant at least at the ten per cent level

[1] Negative news and communication events are those which are assumed to imply depreciation of the forint, and vice versa.

Table 8

Regression on returns and order flow

Dependent variable	OF	Return
const	**0.063****	-0.000
return		
10-min-lag	**-4.192*****	**-0.146*****
20-min-lag	**-0.981****	**-0.033*****
OF		**0.007*****
10-min-lag	**-0.126*****	**0.0002***
20-min-lag	**-0.031*****	**-0.0002***
Monetary policy		
Meeting	-0.941	**-0.056*****
10-min-lead	0.412	0.015
20-min-lead	**2.060*****	0.003
10-min-lag	**1.876****	**0.035*****
20-min-lag	0.899	**0.031*****
Interest rate down	**0.039*****	**-0.004*****
10-min-lead	**-0.251*****	**0.001*****
20-min-lead	**0.234*****	**-0.001*****
10-min-lag	**0.126*****	**-0.001*****
20-min-lag	**-0.060*****	-0.000
Interest rate up	**0.024*****	**0.002*****
10-min-lead	**0.021****	**0.000**
20-min-lead	-0.012	0.000
10-min-lag	**0.152*****	**-0.001*****
20-min-lag	**0.042*****	**0.001*****
Macro news Hungary		
Negative news[1]	-0.033	-0.003
10-min-lead	-0.114	0.002
20-min-lead	0.310	0.007
10-min-lag	**-1.679*****	-0.012
20-min-lag	-0.910	0.001
Positive news[1]	-0.778	-0.010
10-min-lead	-0.013	0.017
20-min-lead	-0.053	**-0.028****
10-min-lag	**2.588*****	**0.067*****
20-min-lag	**1.523***	**0.037*****
Communication		
Positive communication[1]	0.424	-0.008
10-min-lead	**3.556*****	**0.040*****
20-min-lead	-0.783	0.002
10-min-lag	**-1.684****	0.006
20-min-lag	**2.409*****	**-0.019***
Neutral communication[1]	-0.034	-0.008
10-min-lead	**-2.703*****	**-0.020***
20-min-lead	0.190	-0.016
10-min-lag	-0.905	0.014
20-min-lag	-0.036	-0.010
Negative communication[1]	0.029	**0.017***
10-min-lead	**-2.207*****	0.002
20-min-lead	0.796	0.014
10-min-lag	0.765	0.014
20-min-lag	**-1.995*****	0.011
R^2 (adj.)	0.065	0.222
DW	2.005	2.003

*Asterisks refer to level of significance, ***: 1 per cent, **: 5 per cent, *: 10 per cent.*

[1] Negative news and communication events are those which are assumed to imply depreciation of the forint, and vice versa.

Chart 1

Determinants of price variations

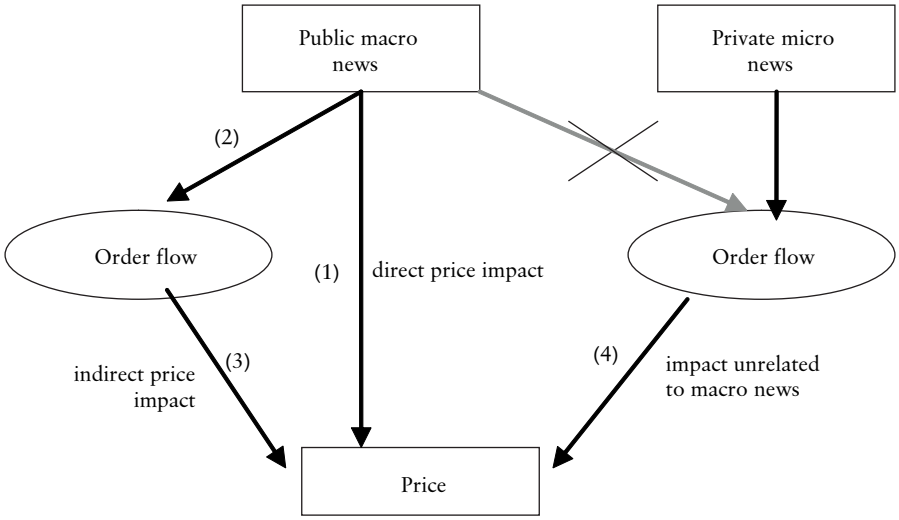
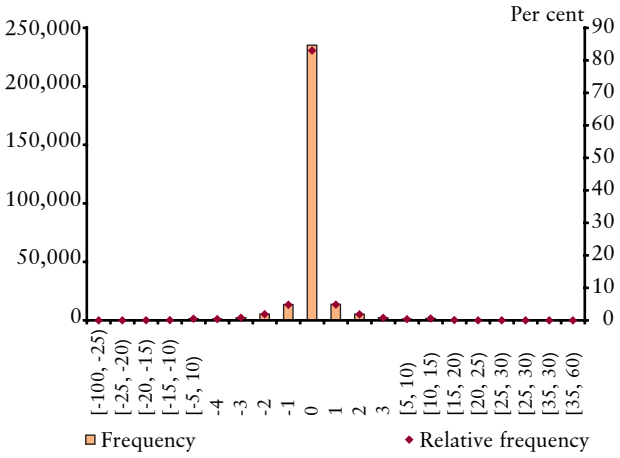
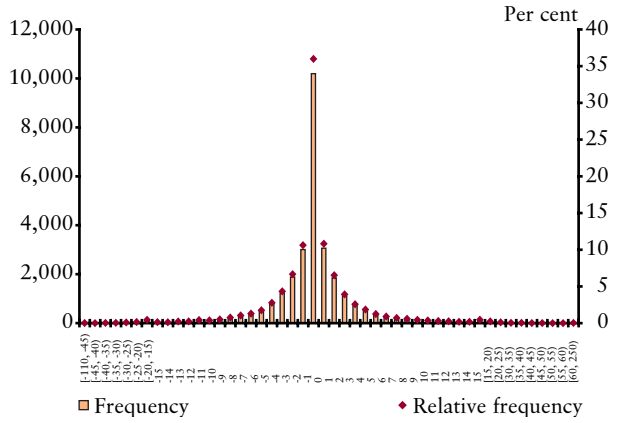


Chart 2

Frequency distribution of the order flow series



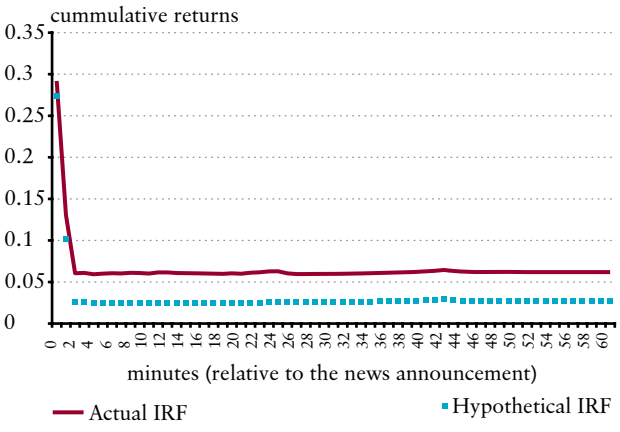
at 1-minute-frequency



at 10-minute-frequency

Chart 3

Impulse response functions



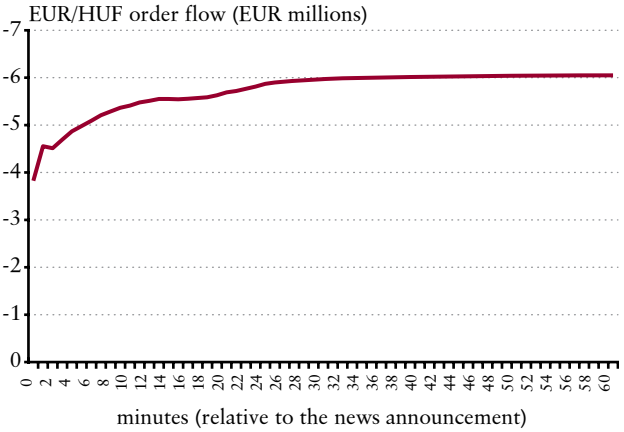
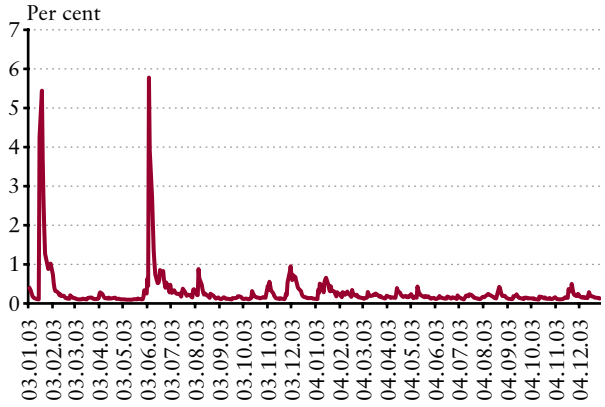
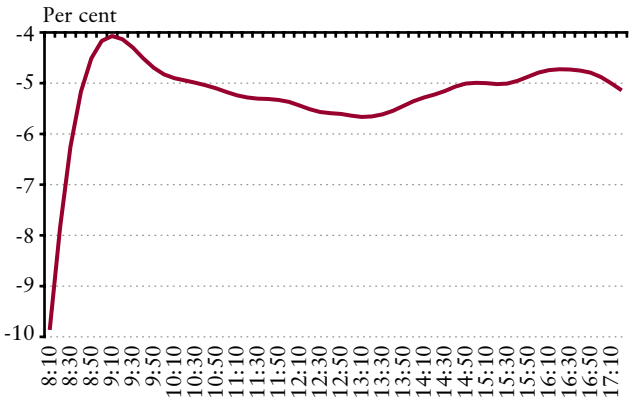


Chart 4

Seasonal patterns of volatility



Daily GARCH volatility level



Intraday volatility pattern

MNB Working Papers 2009/3
Macroeconomic announcements, communication and order flow on the Hungarian foreign exchange market

Print: D-Plus
H–1037 Budapest, Csillaghegyi út 19–21.