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The impact of macro news and central bank communication on emerging European forex markets

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ABSTRACT

We employ a two-stage empirical strategy to analyze the impact of macroeconomic news and central bank communication on the exchange rates of three Central and Eastern European (CEE) currencies against the euro. First we estimate the nominal equilibrium exchange rate based on a monetary model. Second, we employ a high-frequency GARCH model to estimate the effects of the news and communication along with the estimated exchange rate misalignment on the exchange rate as well as its volatility. The analysis is performed during the pre-crisis (2004–2007) and crisis (2008–2009) periods. CEE currencies react to macroeconomic news during both periods in an intuitive manner that corresponds to exchange rate-related theories. However, the responsiveness of the currencies to central bank verbal interventions becomes important only during the crisis period.

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1. Introduction and motivation

Whether and how financial markets react to the various types of information flowing into them has long been a subject of intense research. Blinder et al. (2008) document the clear influence of central bank communication on financial markets in developed countries. Andersen et al. (2007) produce similar evidence with respect to macroeconomic announcements. Empirical evidence on the effects of these two types of news has also been provided specifically for exchange rates (Andersen et al., 2003; Barndorff-Nielsen and Shephard, 2006; Ehrmann and Fratzscher, 2007; Evans and Lyons, 2008). Most of the research focuses on developed countries, however. We contribute to the literature by focusing on European emerging markets and show that their currencies are responsive to both macro news and central bank communications in general but their responsiveness differs in the periods before and during the crisis.

Exchange rates, similar to other financial market instruments, are quite responsive to developments in the real economy that are channeled to the market via macroeconomic news releases. Cavusoglu (2010) surveys the relevant literature and provides extensive evidence that developments in macroeconomic fundamentals are important for exchange rate movements. Similar to stocks, negative news have a larger impact than positive news of the same magnitude (Andersen et al., 2003; Galati and Ho, 2003; Laakkonen, 2007). These effects change over time (Galati and Ho, 2003) and differ with the specific type of macroeconomic news (Edison Hali, 1997; Ehrmann and Fratzscher, 2007). Evans and Lyons (2008) and Laakkonen (2007) argue that a large part of the effects of macroeconomic news should be attributed to order flows and Fratzscher (2006) and Laakkonen (2007) show that macroeconomic news releases have produced about 15% of the exchange rate variation.

From the mid-1990s monetary authorities, especially in the US and the Eurozone, began to favor verbal interventions on account of foreign exchange sales and purchases (Fratzscher, 2006). Further, since the beginning of the financial crisis in 2008 it has become evident that for numerous central banks their communication has become an important tool for policymaking as well as expectations management. The impact of central bank verbal communications has become highly relevant during the recent period of turmoil with zero bound interest rates limiting traditional monetary policy steps and verbal interventions might represent one of the important policy channels.

Central bank communication became more important in influencing the exchange rate via the coordination channel (Cavusoglu, 2010). Official statements of the ECB about the euro-dollar exchange rate were shown by Fratzscher (2004, 2006) to have both short- and long-run effects on the exchange rate, plus they were effective even without being accompanied by actual interventions. Even rumors about actual interventions were shown by Dominguez and Panthaki (2007) to cause exchange rates to move. On the other hand, (Jansen and De Haan, 2005) showed that the effect of verbal statements by national central banks in the Eurozone was small and short-lived, in particular if combined with the release of macroeconomic news. Similarly, Siklos and Bohl (2008) find that actual interest rate moves had a larger impact on the exchange rate than verbal interventions, a feature hinting at deeds being more important than words. They point out that the estimation techniques used have a bearing on the conclusions and that the way central bank statements are coded in empirical works also matters. Still, verbal interventions by central banks tend to reduce exchange rate volatility in a number of developed as well as emerging economies (Fratzscher, 2004; Fišer and Horváth, 2010; Lahaye et al., 2007; Goyal and Arora, 2012).[2]

What is the empirical evidence for the CEE region? Exchange rates are known to be volatile in emerging markets (Bleaney and Francisco, 2007), including those in the CEE region (Kočenda and Valachy, 2006). However, they are much less explored than those of the developed markets and one of the main reasons for this is the lack of data (Cavusoglu, 2010). So far, we know very little

[2] We do not examine the determinants of the forex interventions as this is done in the literature providing opposite insights to our analysis. From the perspective of the CEE countries, Horváth (2007) finds that inflation targeting adopted in the Czech Republic worked as a binding constraint on the occurrence of the forex interventions.

about how the findings from developed markets apply to CEE markets. In terms of central bank communication, Égert (2007) employed an event study framework and finds that interventions coupled with central bank communication and backed by interest rate news have quite a lasting effect on the exchange rate of the Czech,[3] Hungarian and Polish currencies. Similarly, Gábriel and Pintér (2006) report a smoothing effect of central bank communications on the Hungarian forint and Fišer and Horváth (2010) show a reduction in the volatility of the Czech koruna due to verbal communication.

In this paper, we augment the relevant literature by analyzing the impact of macroeconomic news and central bank communication on CEE currencies for which data on macroeconomic and central bank news are available, notably the Czech Republic, Hungary and Poland. In this respect, we fill the gap in the literature by analyzing the effects of macroeconomic news and central bank communication in Central Europe as this topic is grossly under-researched despite the fact that the region attracts considerable amounts of foreign financial capital (Jotikasthira et al., 2010)[4] and spillovers from financial turmoil in advanced markets result in a loosening of exchange rate policies in emerging markets (Coudert et al., 2011). We contribute several novelties. First, we use a monetary model to calculate the nominal equilibrium exchange rate to be used in high-frequency exchange rate models. Second, the determinants of short-term exchange rate movements are studied using a set of accurately identified macroeconomic news and central bank communications not employed in the exchange rate analysis of CEE currencies so far. Third, we use a non-linear modeling framework, which allows the exchange rate to move back to monetary equilibrium at different speeds depending on the size of the deviation from equilibrium. The paper describes our modeling strategy in Section 2, the data in Section 3, and empirical results in Section 4. Conclusions are offered in Section 5.

2. Modeling strategy

Our modeling strategy has two stages in which we follow the approach of Égert (2010). First, we use the monetary model to compute long-run equilibrium exchange rates. Second, we estimate high-frequency exchange rate models by incorporating the deviation from the monetary equilibrium, macroeconomic news, central bank communication and a set of control variables. The idea of the two-stage approach is to produce daily interpolations of the long-term exchange rate, in line with monetary fundamentals, from which deviations can be observed easily. In fact, it is current practice to evaluate the long-term real exchange rate (also termed equilibrium real exchange rate) by estimating a reduced form real exchange rate model. The problem with this approach is that it gives the deviations of the real exchange rate from its estimated long-run values, and that deviations can be corrected either via changes in the nominal exchange rate or changes in domestic or foreign prices. Therefore, it is more convenient to estimate a nominal exchange rate model where adjustments to equilibrium can occur only through changes in the nominal exchange rate (Crespo-Cuaresma et al., 2005).

An easy way to obtain long-term values of the exchange rate for modeling high frequency exchange rates is to use a moving average or a trend obtained on the basis of a filtering technique. This is a similar method to that of Fidrmuc and Horváth (2008), who use the deviations from a long-term average of daily exchange rates in a conditional volatility equation. Our approach expands theirs by using the deviations from long-term values in the mean equation and providing a more structural assessment of the long-term value of the nominal exchange rate, which incorporates information with regard to the underlying fundamentals.

[3] Using econometric estimates, Geršl and Holub (2006) provide some evidence that the Czech central bank's market interventions, in various periods between 1997 and 2002, had a statistically significant, short-lived and economically not very important impact on the exchange rate of the Czech currency and its volatility.

[4] Jotikasthira et al. (2010) show that developed-country-domiciled mutual and hedge fund holdings account for about 14–19% of the free-float adjusted market capitalization in Central Europe; specifically, 16.59% in the Czech, 16.98% in the Hungarian and 13.29% in the Polish equity markets.

2.1. Monetary equilibrium

The monetary model of the exchange rate is used to estimate the nominal equilibrium exchange rate.[5] A basic monetary model including relative money supplies, relative real GDP and the interest rate differential is considered:

$$e_t = (m_t - m_t^*) - \beta_1(y_t - y_t^*) + \beta_2(i_t - i_t^*), \tag{1}$$

where e_t is the nominal exchange rate, expressed as units of domestic currency over one unit of foreign currency (an increase means a depreciation of the domestic currency). m, y and i are money supply, real output and short-term interest rates. In this paper, the euro area represents the foreign country. Eq. (1) shows that a relative rise in money supply results in a currency depreciation. An increase in relative real income causes depreciation. Regarding the effects of the interest rate, a rise in the long-term interest rate differential causes currency depreciation, in line with the uncovered interest parity condition. We extend the basic model by including the productivity differential and the relative price of non-tradable goods with respect to tradable goods to capture the Balassa-Samuelson effect (see Clements and Frenkel, 1980; and Crespo-Cuaresma et al., 2005).

As the variables in levels turn out to be $I(1)$ processes (see Section 3 on data sources and definitions),[6] we subsequently use dynamic ordinary least squares (DOLS) to estimate the long-run relationship. Stock and Watson (1993) show that DOLS accounts for the endogeneity of the regressors and the serial correlation in the residuals by incorporating the lags and leads of the regressors in first differences:

$$Y_t = \beta_0 + \sum_{i=1}^{n}\beta_i X_{i,t} + \sum_{i=1}^{n}\sum_{j=-k_1}^{k_2}\gamma_{i,j}\Delta X_{i,t-j} + \varepsilon_t, \tag{2}$$

where k_1 and k_2 denote leads and lags, respectively. The length of leads and lags is determined on the basis of the Schwarz information criteria. The presence of cointegration is assessed upon the stationarity of the residuals obtained from the long-term relationship ($Y_t = \beta_0 + \sum_{i=1}^{n}\beta_i X_{i,t} + \varepsilon_t$). We also make use of the error correction term as a test of cointegration, as Kremers et al. (1992) argue that it is more powerful than the residual-based Dickey–Fuller test. Furthermore, we cross-check cointegration using Johansen's trace statistics.

2.2. High-frequency exchange rate modeling

We incorporate the monetary equilibrium into our model of exchange rate returns (Δe_t).[7] Our linear specification is the following:

$$\Delta e_t = \alpha + \sum_{j=1}^{n}\beta_j Z_{j,t} + \sum_{i=1}^{4}\delta_i D_{i,t} + \varepsilon_t, \tag{3a}$$

$$\sigma_t^2 = \zeta + \sum_{j=1}^{n}\psi_j Z_{j,t} + \sum_{i=1}^{4}\lambda_i D_{i,t} + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2, \tag{3b}$$

[5] An easy way to obtain the long-term values of the exchange rate for modeling high-frequency exchange rates is to use a moving average or a trend obtained on the basis of a filtering technique. It appears, however, more appropriate to evaluate the long-run nominal exchange rate in a more structural way. It is current practice to evaluate the long-term real exchange rate (also termed the equilibrium real exchange rate) by estimating a reduced-form real exchange rate model. The problem with this approach is that it gives the deviations of the real exchange rate from its estimated long-run values, and that deviations can be corrected either via changes in the nominal exchange rate or changes in domestic or foreign prices. Therefore, it is more convenient to estimate a nominal exchange rate model where adjustments to equilibrium can occur only through changes in the nominal exchange rate. Finally, using an exchange rate monetary model for the above purpose is theoretically a more correct way and from a practical perspective it is also a better approach than using an average, a trend, or a random walk as argued by Crespo-Cuaresma and Hlouskova (2005). See also Poghosyan et al. (2008), who model the foreign exchange risk premium by first employing an affine structure model and then following with a GARCH type estimation.

[6] The augmented Dickey–Fuller test (ADF), the Philips-Perron test (PP), the Elliot–Rothernberg unit root test, the Stock unit root test and the Kwiatkowski, Phillips, Schmidt and Shin stationarity test (KPSS) are used to check the integration order.

[7] Returns are calculated as follows throughout the paper: $((e_t/e_{t-1})-1)\times 100$.

where Z contains the explanatory variables. The explanatory variables are taken in the conditional variance equation as they are (as raw data) but also in absolute values ($|Z|$). D_1, D_2, D_3, and D_4, are dummy variables that take the value of 1 on Tuesday, Wednesday, Thursday and Friday, and zero otherwise. These dummies are to capture a day-of-the-week effect often identified in the existing literature as an important phenomenon of daily exchange rate movements. This pattern has also been documented for CEE countries. Finally, ε^2_{t-1} and σ^2_{t-1} are the ARCH and GARCH terms that are needed because of the volatility clustering observed in the exchange rate return series.

Next, we allow for nonlinear effects in the explanatory variables as a function of the deviation from the monetary equilibrium (DEV). In fact, we look at whether deviations from the equilibrium are linked in a nonlinear fashion to changes in the exchange rate in the mean equation. The nonlinear model with one nonlinear variable can be written along the lines of the framework proposed by Hansen (1999):

$$\Delta e_t = \begin{cases} \alpha + \sum_{j=1}^{n-2}\beta_j \cdot Z_{j,t} + \sum_{i=1}^{4}\delta_i D_{i,t} + \varphi_{11} \cdot \mathrm{DEV}_t + \varepsilon_t & \text{if} \quad \rho \leq T \\ \alpha + \sum_{j=1}^{n-2}\beta_j \cdot Z_{j,t} + \sum_{i=1}^{4}\delta_i D_{i,t} + \varphi_{21} \cdot \mathrm{DEV}_t + \varepsilon_t & \text{if} \quad \rho > T \end{cases}, \tag{4a}$$

$$\sigma_t^2 = \zeta + \sum_{j=1}^{n}\psi_j Z_{j,t} + \sum_{i=1}^{4}\lambda_i D_{i,t} + \alpha\varepsilon^2_{t-1} + \beta\sigma^2_{t-1}, \tag{4b}$$

where ρ is the threshold variable and T denotes the threshold value of the threshold variable that separates the two regimes. The threshold variable is the deviation from equilibrium (DEV). Thus, a deviation from the monetary equilibrium is allowed to have a different effect on exchange rate returns depending on the distance of the exchange rate from its equilibrium value. Note that monthly deviations from the monetary equilibrium are linearly interpolated to daily frequencies. The errors are assumed to be white noise. The two-regime model can be easily extended to three regimes:

$$\Delta e_t = \begin{cases} \alpha + \sum_{j=1}^{n-2}\beta_j \cdot Z_{j,t} + \sum_{i=1}^{4}\delta_i D_{i,t} + \varphi_{11} \cdot \mathrm{DEV}_t + \varepsilon_t & \text{if} \quad \rho \leq T_1 \\ \alpha + \sum_{j=1}^{n-2}\beta_j \cdot Z_{j,t} + \sum_{i=1}^{4}\delta_i D_{i,t} + \varphi_{21} \cdot \mathrm{DEV}_t + \varepsilon_t & \text{if} \quad T_2 \geq \rho > T_1 \\ \alpha + \sum_{j=1}^{n-2}\beta_j \cdot Z_{j,t} + \sum_{i=1}^{4}\delta_i D_{i,t} + \varphi_{31} \cdot \mathrm{DEV}_t + \varepsilon_t & \text{if} \quad \rho > T_2 \end{cases}, \tag{5a}$$

$$\sigma_t^2 = \zeta + \sum_{j=1}^{n}\psi_j Z_{j,t} + \sum_{i=1}^{4}\lambda_i D_{i,t} + \alpha\varepsilon^2_{t-1} + \beta\sigma^2_{t-1}. \tag{5b}$$

The selection between linear and nonlinear models is made as follows. We first estimate the linear model and the two-regime model. A grid search with steps of 1% of the distribution is carried out to find the value of the threshold variable that minimizes the sum of squared residuals of the estimated two-regime model. Hansen (1999) shows that the null hypothesis of $\varphi_1 = \varphi_2$ can be tested using a likelihood ratio test. Given that the likelihood ratio test statistic does not follow a standard asymptotic distribution, as the threshold value is not identified under the null hypothesis, the distribution of the test statistic is obtained through bootstrapping based on random draws with replacements using 1000 replications (Hansen, 1999).

If the likelihood ratio test statistic rejects the null hypothesis of the linear model against the two-regime model (on the basis of the bootstrapped critical values), we also analyze whether there are three different regimes instead of two. A three-regime model is estimated using the two threshold values of the threshold variable that minimize the sum of squared residuals across the estimated models.[8] The bootstrap procedure described above is applied to the two-regime and three-regime models.

[8] The threshold from the two-regime model is held fixed and a grid search is used to identify the second threshold. We impose the restriction that the two thresholds should be separated by at least 10% of our sample observations and that the 10% of the sample is trimmed on both sides of the distribution. Once the second threshold is identified, a backward grid search is done to identify the first threshold, as suggested by Hansen (1999).

3. Data

3.1. Exchange rates and macroeconomic data

Daily exchange rate quotes of the CEE currencies (the Czech koruna, Hungarian forint, and Polish zloty) with respect to the euro at 14:15 Central European Daylight Time for the period 2004–2009 were downloaded from Datastream. Bubák et al. (2011) show that the exchange rate volatility of the three currencies under research exhibit different patterns before 2007 and after the outbreak of the world financial crisis. In our analysis, we therefore distinguish two subsample periods: before the crisis (2004–2007) and during the crisis (2008–2009).[9] The monetary model is estimated on monthly data from 1995 to 2009/10. A detailed description of the monthly data is provided in the Data Appendix. In the following sections we further introduce the data on central bank communications (Section 3.2) and macroeconomic announcements (Section 3.3).

3.2. Central bank communication about exchange rates

Oral (verbal) central bank intervention is an official statement by the central bank expressing the bank's views on an over- or undervaluation of the exchange rate with respect to macroeconomic fundamentals (Fratzscher, 2006). Oral (verbal) interventions may influence the exchange rate via the coordination or signaling channel. The coordination channel involves coordinating individual expectations to converge on models driving an exchange rate toward parity level (Sarno et al., 2001). The signaling channel provides the market with information about future monetary and intervention policies and relevant macroeconomic fundamentals (Mussa, 1981).

Central bank statements specifically related to exchange rates were obtained from Factiva (a Dow Jones company), relying on a targeted search. The following combinations of keywords were used for specific countries. Czech Republic: (exchange rate AND koruna) AND (Czech National Bank OR CNB OR central bank OR governor); Hungary: (exchange rate AND forint) AND (National Bank of Hungary OR Central Bank of Hungary OR central bank OR governor); Poland: (exchange rate AND zloty) AND (National Bank of Poland OR NBP OR central bank OR governor). In Table 1 we show examples of central bank communications together with the date and the expected or desired effect of the particular statement on exchange rates. The statements enter our specification as dummy variables coded 1 for the day of identified statements and zero otherwise. We do not differentiate whether the statement was made by a board member, vice-governor or a governor, as the communication data are not frequent enough to allow for effective differentiation.[10]

Statements worded to strengthen or weaken a currency should be regarded as aiming to affect the exchange rate level, while statements on stability are meant to dampen exchange rate volatility. From Table A.1 in the Appendix we can see that central bank communication about exchange rates is not very frequent. This is not surprising because all three countries target inflation and central bank communication is primarily focused on inflation and interest rates, as witnessed in the selected statements shown in Table 1. Czech National Bank statements were primarily aimed to weaken the currency or keep it stable. This is an intuitively reasonable distribution, as the Czech currency has been steadily appreciating over time and therefore only a few comments were meant to strengthen its value. In the case of the Hungarian forint, an overwhelming majority of comments was intended to reduce volatility, while much fewer were aimed to strengthen or weaken the currency. This communication activity fully corresponds to the exchange rate arrangement whose purpose was to

[9] This division also corresponds to the worldwide decline of stock markets after December 2007 and to the fact that the NBER designated the US to be in recession from December 2007 to June 2009.

[10] We collect and code verbal interventions in a similar manner to Fratzscher (2004, 2006), and in the same spirit we refrain from written central bank communication in the form of, for example, monetary policy minutes or voting records. These documents are usually issued with a time lag after the key information (from a monetary policy meeting) has been communicated verbally during a press conference. Hence, any key information in its verbal form precedes its written form. Further, as argued by Gábriel and Pintér (2006), "market participants react to news that reach them, rather than to the central bank's intentions directly." Finally, since all three countries under research target inflation, most of the discussion contained in written communication is centered on interest rates and inflation, and not on the exchange rate.

Table 1
Examples of the communication of the central banks under research (communication quotes from the Factiva database).

Date	Central bank communication	Expected effect on exchange rate
1 January 2006	(Czech NB Vice-governor) Singer said the currency was now markedly stronger than the bank had assumed in its most recent inflation outlook from October.	Weaken
20 May 2009	The Czech economy probably experienced the worst of its downturn in the first quarter of this year and the crown exchange rate is stabilizing, the central bank's Vice-Governor Mojmir Hampl said on Wednesday. "We are happy that the high volatility on the Czech crown has stabilized a bit."	Stable
7 February 2005	"This means that the central bank does not wish to influence the forint's exchange rate by releasing net foreign currency amounts related to the budget onto the market," it said in a statement after a non-rate setting Monetary Council meeting	Stable
21 October 2008	Central bank Deputy Governor Ferenc Karvalits told the Reuters Central European Investment Summit the currency's fall was not justified by Hungary's economic fundamentals. "We are ready to defend the currency if its weakness puts the central bank's inflation goal or financial stability goals at risk."	Strengthen
29 June 2005	The bank said the zloty exchange rate in June was broadly in line with the one assumed in the bank's quarterly inflation report published last month.	Stable
20 January 2009	"We should still conduct anti-inflationary policy. But we have to move in a way that won't speed up the weakening of the zloty," Wasilewska-Trenkner told daily Gazeta Prawna in an interview. Wasilewska-Trenkner said on Monday zloty weakening was not justified by economic fundamentals.	Strengthen

Source: Factiva database (Thomson Reuters).

keep the forint stable with respect to the euro. Until March 2008 the Hungarian Central Bank managed the forint under a ±15% fluctuation band with respect to the euro and generally expressed heightened concern about the forint exchange rate (Kočenda and Poghosyan, 2009). Communications of the National Bank of Poland were more frequent than in other countries and relatively equally distributed among the three types of statements, with the smallest number trying to weaken the zloty. Finally, we do not include similar communications by the ECB in our analysis. First, we are interested primarily in the reaction of the CEE currencies to communications of the respective CEE central banks. Second, communications of the ECB related to exchange rates would be aimed at the euro, which is not the topic of our analysis.

3.3. *Macroeconomic announcements*

We gathered data on ten types of macroeconomic announcements (news) that are divided into three categories. These are announcements on prices (CPI, PPI), real economy (industrial production, real GDP growth, retail sales, trade balance, current account, unemployment), and monetary policy (monetary aggregate, interest rate). For each country we have announcements originating in the respective country. Macroeconomic news from the Eurozone are captured by changes in the euro/dollar cross rate. The macroeconomic announcements used in this paper are reported by Bloomberg and Reuters with a clearly defined calendar and timing of news releases. Reuters also reports the market expectations of specific news, the so-called consensus forecasts of financial market analysts, which constitute a proxy for market expectations similar to the one used in Andersen et al. (2007).[11] The announcements are usually reported on a monthly basis with the exception of the GDP, which is reported quarterly.

[11] Data on market expectations do not always coincide with the date of news releases. Expectations may change between the publication of market expectation and that of news releases. However, market analysts tend to interpret macro news in the light of earlier market forecasts and empirical researchers usually implicitly assume no change in expectations between those dates (see e.g. Evans and Lyons, 2008). Further, similar to other researchers in the field, we are unable to account for announcements for which market expectations are not formed and not made publicly available.

The above arrangement is particularly important since it enables us to analyze the effect of news from its *excess impact* perspective. Because financial markets form expectations about scheduled important news, it is not the news itself that matters but how it differs from what the market expects it to be (market consensus). The news deviation, or its excess, may then affect exchange rates. Based on the approach of Hanousek and Kočenda (2011) we construct a dataset of announcements in the following way. There are news associated with indicator i in the form of various macroeconomic releases or announcements that are known ahead of time to materialize on specific dates t.[12] The extent of such news is not known but expectations on the market form a forecast. The excess impact of a news announcement is then defined as the deviation of the news from the prior market expectations. Further, since announcements are often reported in different units, we standardize them to allow a meaningful comparison (see e.g. Andersen et al., 2007). Formally, the excess impact news variable, or surprise as termed by Andersen et al. (2007), is labeled as xn_{it} and defined as $xn_{it}=(sn_{it}-\mathrm{E}_{t\text{-}1}[sn_{it}])/\sigma_i$, where sn_{it} stands for the value or extent of the scheduled announcement i at time t, $E_{t-1}[sn_{it}]$ is the value of the announcement for time t expected by the market at time $t-1$ and σ_i is the sample standard deviation of the announcement i. The standardization does not affect the properties of the coefficients' estimates, as the sample standard deviation σ_i is constant for any announcement indicator i. Hence, the macroeconomic announcements enter our estimation as follows: they have a non-zero value on the day of the announcement, coded in a way that a positive surprise is a value of any given macro news in excess of market expectations, and take the value of zero on days without announcements. This form also eliminates the issue of different units the news are reported in as described above.

4. Empirical results

We first report the results of the long-term monetary model estimation in Table 2. In the first stage we estimate the basic monetary model comprising the exchange rate, relative money supply and relative output. We then augment the benchmark model by adding additional explanatory variables: the interest differential and proxies for the Balassa–Samuelson effect (the relative price of non-tradable goods and the labor productivity differential). We select the model for each country where the variables are cointegrated and where the coefficients are statistically significant and have the expected sign. The error correction terms from the DOLS models are negative and statistically significant, a feature evidencing weak cointegration. Coefficients of the explanatory variables are all statistically significant and exhibit intuitively correct signs.

In the second stage we estimate the high-frequency GARCH models. The first observation, reported in Table 3, is the absence of strong nonlinearities in our data. For all countries and periods, the bootstrapped p-values show that the null hypothesis of the linear model cannot be rejected against the alternative hypothesis of a two-regime model. In Tables 4 and 5 we report the estimate results of the linear model and show a different degree of responsiveness during the pre-crisis and crisis periods.[13] For each currency, we estimate GARCH(1,1) models with both the mean and conditional variance equations augmented by the set of news, central bank communications, day-of-the-week-effect dummies and the control variables (country risk premium, short-term interest differential and the euro-dollar cross rate). Further, the linear, two-regime and three-regime models are estimated to allow for differences due to a) nonlinearity in deviation from monetary equilibrium and b) the alternative interpolation of the monthly deviation series to a daily frequency (linear and cubic interpolation). Based on our model specification tests (Hansen, 1999) we estimate models where a deviation from the monetary equilibrium is compared to the actual fit and linear interpolation to daily frequency is used.[14]

[12] There is also news in the form of an unexpected announcement that can be understood as a truly exogenous shock or surprise. The number of such news is negligible and we do not consider them in the present study.

[13] We estimate our model for the pre-crisis period (2004–2007), the crisis period (2008–2009), and the whole span (2004–2009). These results are not reported but are available upon request.

[14] We use linear interpolation. This means that we do not have the same value for the long-term exchange rate within a month, but we have changing values within a month that move from one monthly figure to the other via linear interpolation.

Table 2
Estimation results of the monetary model.

(a) Estimation results for the monetary model for the CZK/EUR exchange rate (Czech Republic), 1995–2010

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
UR (SIC)	−2.335	−3.967**	−3.584	−4.007*	−3.786	−3.914	−3.992	−3.971
ECT	−0.017	−0.069***	−0.060**	−0.093***	−0.097**	−0.096***	−0.063**	−0.092***
$r=0$	24.84	23.87	46.69*	39.1	62.14	50.16	77.52***	70.61**
$r=1$	8.05	4.28	23.46	16.29	38.71	27.07	49.31**	39.51
CONST	0.023**	0.058***	−0.029***	0.017*	1.002***	0.350***	−0 477***	−0.041
M3	0.456***	−0.063	0.373***	−0.114**	0.400***	−0.060	0 425***	−0.101
GDPR	−1.568***		−1.422***		−1.216***		−1.247***	
IP		−0.876***		−0.776***		−0.706***		−0.751***
IRS			0.012***	0.006***	0.006***	0.005***	0.014***	0.006***
CPIPPI					−1.015***	−0.336***		
PROD							0.459***	0.057
	ECM	**ECM**	**ECM**	**ECM**	**ECM**	**ECM**	**ECM**	**ECM**
NoOBS	164	178	164	178	164	178	164	178
R^2adj.	0.004	0.035	0.056	0.093	0.077	0.099	0.049	0.085
SIC	−5.373	−5.487	−5.402	−5.526	−5.4	−5.509	−5.37	−5.493
	BASE	**BASE**	**BASE**	**BASE**	**BASE**	**BASE**	**BASE**	**BASE**
	160	177	164	177	164	178	164	178
R^2 adj.	0.837	0.869	0.888	0.893	0.933	0.89	0.897	0.884
SIC	−2.862	−3.238	−3.358	−3.371	−3.815	−3.376	−3.393	−3.32

(b) Estimation results for the monetary model for the HUF/EUR exchange rate (Hungary), 1995–2010

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
UR (SIC)	−2.94	−3.778*	−3.034	−3.812	−4.055	−4.955**	−3.577	−5.874***
ECT	−0.074***	−0.111***	−0.084***	−0 122***	−0.137***	−0.139***	−0.121***	−0 121***
$r=0$	37.26***	76.03***	56.91***	91.13***	78.66***	126.43***	74**	98.89***
$r=1$	12.83	46 74***	23.41	54.54***	41.87	75 11***	38.48	62.85***
CONST	−0.068***	−0.092***	−0.092***	−0.092***	0.925***	0.960***	0.825***	0 371***
M3	0.710***	1 275***	0.683***	1.290***	0.907***	0.907***	0.926***	1 342***
GDPR	−1.686***		−1.671***		−0.893***		−2.007***	
IP		−1.112***		−1.132***		−0.201*		−1.120***
IRS			−0.001	0.000	0.003***	0.002*	0.007***	0.003*
CPIPPI					−0.977***	−1.022***		
PROD							−0 919***	−0.476***
	ECM	**ECM**	**ECM**	**ECM**	**ECM**	**ECM**	**ECM**	**ECM**
NoOBS	183	189	183	189	183	189	177	179
R^2	0.098	0.144	0.15	0.19	0.492	0.385	0.129	0.195
R^2 adj.	0.083	0.13	0.131	0.173	0.478	0.369	0.104	0.172
SIC	−5.199	−5.15	−5.231	−5.183	−5.716	−5.431	−5.185	−5.158
	BASE	**BASE**	**BASE**	**BASE**	**BASE**	**BASE**	**BASE**	**BASE**
NoOBS	183	188	183	188	183	189	177	178
R^2adj.	0.829	0.876	0.833	0.881	0.95	0.924	0.871	0.884
SIC	−3.026	−3.23	−2.999	−3.205	−4.153	−3.588	−3.204	−3.153

(c) Estimation results for the monetary model for the PLN/EUR exchange rate (Poland), 1995–2010

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
UR (SIC)	−2.980	−3.080	−3.080−3	−3.142	−3.227	−3.234	−2.895	−2.96
ECT	−0.041**	−0.046**	−0.042**	−0.048**	−0.072**	−0.084***	−0.046**	−0.046**
$r=0$	64.75***	61.38***	91.63***	91.78***	119.42***	118.75***	152 77***	155.69***
$r=1$	8.92	12.19	23.08	23.17	48.37**	46.55*	76.15***	80.61***
CONST	−0.048***	−0.040***	−0.030*	−0.006	2.960***	2 932***	−0.303*	−0.288*
M3	0 272***	0.248***	0.259***	0.238***	0.259***	0.66***	0.189***	0.192***
GDPR	−0.300**		−0.381***		−0.433***		−0.163	
IP		−0.107**		−0.166***		−0.217***		−0.074

Table 2 (*Continued*)

(c) Estimation results for the monetary model for the PLN/EUR exchange rate (Poland), 1995–2010

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IRS			−0.002	−0.003	−0.003***	−0.004***		0.000
CPIPPI					−2 947***	−2.882***	0.001	
PROD							0.239	0.233*
	ECM	**ECM**	**ECM**	**ECM**	**ECM**	**ECM**	**ECM**	**ECM**
NoOBS	183	191	183	191	183	190	177	179
R^2adj.	0.086	0.133	0.084	0.134	0.385	0.388	0.089	0.139
SIC	−4.657	−4.739	−4.632	−4.718	−5.007	−5.038	−4.615	−4.676
	BASE	**BASE**	**BASE**	**BASE**	**BASE**	**BASE**	**BASE**	**BASE**
	183	191	183	191	183	190	177	179
R^2adj.	0.298	0.332	0.312	0.348	0.798	0.794	0.312	0.351
SIC	−2.076	−2.114	−2.051	−2.094	−3.232	−3.198	−1.971	−1.986

Notes: ECT denotes the error correction term, while UR is the residual based cointegration test. ECM indicates that the reported statistics refer to the error correction model and the long-run relationship estimated using DOLS, respectively.
M3 is monetary aggregate. GDPR is real GDP interpolated linearly from quarterly to monthly frequency. IP is industrial production.
IRS is short-run interest rates. CPIPPI is the relative price of nontradable goods over that of tradable goods, proxied by the CPI to PPI ratio.
PROD is labour productivity calculated using industrial production and employment in industry. All variables (except interest rates) are taken in logs and as the differential against the corresponding Eurozone variable.
* Denote statistical significance at the 10% levels.
** Denote statistical significance at the 5% levels
*** Denote statistical significance at the 1% levels.

Table 3
Testing for nonlinearity in the deviation from monetary equilibrium.

	2004–07			2008–09			2004–09		
	CZK	HUF	PLN	CZK	HUF	PLN	CZK	HUF	PLN
	Nonlinearity – bootstrapped *p*-values								
Test no. 1	0.287	0.369	0.531	0.208	0.251	0.075	0.608	0.005	0.800
Test no. 2	0.388	0.071	0.68	0.209	0.468	0.640	0.176	0.283	0.234

Notes: Test no. 1: H0: linear vs. H1: 2-regime nonlinearity.
Test no. 1: H0: 2-regime nonlinearity vs. H1: 3-regime nonlinearity.
Bold figures indicate statistical significance at the 5% level.

As for macroeconomic news during the pre-crisis period (2004–2007), the single most important macroeconomic announcement seems to be news about producer price inflation: the coefficients associated with this variable are statistically significant across all three currencies (Table 4). Improved price development (inflation below expectations) contributes to an appreciation of the Czech and Polish currencies. This finding is in accordance with PPP theory. The coefficient is counter-intuitively positive for the Hungarian currency, however. This finding might be associated with the fact that the Hungarian forint has been subject to an exchange rate regime which managed to make the forint stable *vis-à-vis* the euro. Still, the evidence on the effect of price news on the three currencies is in line with the purchasing power parity hypothesis: lower prices are compensated by a strengthening of the domestic currency, which in turn keeps the real exchange rate stable. Finally, the sensitivity of the exchange rate to the news on producer price inflation is intuitively appealing, as the manufacturing sectors in the three countries are quite import-intensive and trade with the EU is substantial. As all three countries are inflation targeters, the influence of CPI news is understandably missing.

Statistically significant coefficients associated with news on current accounts are found for the Hungarian and Polish currencies. These negative coefficients are in line with the theory, suggesting that under regular circumstances improvements in current account balances lead to an increased inflow of foreign currency to a domestic country and to the strengthening of the domestic currency

Table 4
Coefficient estimates from the high frequency model, mean equation: Exchange rate responsiveness during the pre-crisis period (2004–2007).

Variable	Czech koruna	Hungarian forint	Polish zloty
Constant	−0.004	−0.138*	0.003**
Δe_{t-1}	−0.025	−0.026	0.092**
Macroeconomic surprises			
CPI	−0.053	−1.018	−0.016
PPI	−0.173*	0.330**	0.024**
GDP	−0.022	0.000	−0.006
Current account	0.007	−1.229**	0.014**
Trade balance	0.006	−0.113	0.000
Industrial production	0.000	0.000	−0.001
Retail sales	−0.002	0.403	0.009**
Unemployment	0.156**	0.000	0.000
Money	0.000	0.000	0.000
Policy rate	−0.05	−1.823	−0.036*
Central bank communication			
Strengthen	−0.025	−0.325	−0.004
Weaken	−0.018	0.352	0.006**
Stable	−0.005	−0.533	−0.006*
Day-of-the-week dummies			
Tuesday	0.007	0.076	0.003*
Wednesday	0.000	0.169*	0.006**
Thursday	−0.001	0.176*	0.003
Friday	−0.007	0.112	0.002
Controls			
USD/EUR cross rate	−0.145	−12.929**	−0.112
Interest rate differential	−0.002	0.019	0.002
Emerging market risk	0.003**	0.109**	0.002**
Deviation from monetary model	0.003	2.742*	−0.004

* Denote statistical significance at 1%.
** Denote statistical significance at 5%.

exchange rate (Dornbusch and Fischer, 1980). Further, news on improved retail sales lead to an appreciation of the Polish currency. A surprise increase in retail sales directly translates into increased demand for tradable goods and the currency to pay for them. However, the coefficient value indicates that in Poland the proportion of imported goods to domestic goods is almost equal as the coefficient is relatively small. In addition, the importance of this specific real factor (retail sales) is in line with the evidence in Kočenda and Poghosyan (2009), who show its positive effect on the risk premium of the Polish zloty.

The surprise component of unemployment announcements results in a depreciation of the Czech currency to an extent comparable to that of the producer price index. This is somewhat puzzling as lower unemployment should strengthen the currency. Finally, a positive surprise in the key interest rate is reflected in the appreciation of the Polish zloty.

The effect of central bank communications on the Polish currency is limited. Statements intended to weaken the currency seem to contribute to a marginal appreciation instead. This counter-intuitive result could be explained by market expectations on currency strengthening no matter what the central bank wishes. Communications aimed at the stability of the exchange rate produce the same effect, both in terms of direction and magnitude. Comments intended to strengthen the currency are not associated with a significant coefficient. The responsiveness of the Polish zloty is in line with the findings of Rozkrut et al. (2007), who show that the Monetary Policy Committee's view on the zloty is more balanced than views of central bankers in the Czech Republic and Hungary with respect to their own currencies.

The Czech and Hungarian currencies do not show responses to central bank communications, as the respective coefficients are insignificant. Fratzscher (2008) shows that communications produce

Table 5
Coefficient estimates from the high frequency model, mean equation: Exchange rate responsiveness during the pre-crisis period (2008–2009).

Variable	Czech koruna	Hungarian forint	Polish zloty
Constant	−0.009	0.018	0.003
Δe_{t-1}	0.043	−0.044	0.055
Macroeconomic surprises			
CPI	0.106	−3.52	−0.031**
PPI	−0.063	0.037	0.01
GDP	−0.189**	0.000	−0.114**
Current account	−23.511	2.928	0.007
Trade balance	−0.049	1.866	0.000
Industrial production	0.000	0.000	−0.001
Retail sales	0.006	−1.448	0.001
Unemployment	0.791	0.000	0.000
Money	0.000	0.000	−0.012
Policy rate	−0.094	8.888	0.113
Central bank communication			
strengthen	−0.122**	−0.309	0.001
weaken	0.014	−1.700**	0.006
stable	0.02	0.556	−0.108**
Day-of-the-week dummies			
Tuesday	−0.004	−0.161	−0.005
Wednesday	0.028	0.211	−0.002
Thursday	0.03	0.195	−0.003
Friday	−0.001	0.249	−0.005
Controls			
USD/EUR cross rate	−1.907**	−54.551**	−0.574**
Interest rate differential	−0.02	0.027	−0.002
Emerging market risk	0.001	0.117**	0.002**
Deviation from monetary model	−0.092	4.647	−0.084*

* Denote statistical significance at 1%.
** Denote statistical significance at 5%.

less impact and are less effective when the exchange rate is close to the equilibrium level and market uncertainty is low. The Czech currency steadily appreciated from 2004 to 2007 in line with equilibrium and experienced slight ups and downs during the crisis. However, its development over time has been remarkably stable. The Hungarian currency was under an arrangement that imposed stability on the forint with respect to the euro and this stability was achieved during 2004–2007. Hence, the lack of responsiveness to central bank communication is in line with the above argument. For Hungary it is the dual nature of the monetary policy framework during the period in question (inflation targeting and exchange rate stability with respect to the euro) that further complicates the effectiveness of central bank communications.

The control variables complete the picture: day-of-the-week effects are present, emerging market risk tends to weaken all three currencies and the dollar/euro cross rate affects only the Hungarian forint.

The overall lack of statistically significant coefficients for the Czech currency might be caused by the fact that the Czech koruna is traded more heavily on the international forex market than the other CEE currencies. This means that there is less room for the effects of news and verbal interventions and more weight given to market forces. Further, the Czech koruna enjoys a large degree of confidence among knowledgeable international money managers and investors. Over the twenty years of transformation, the Czech koruna appreciated in value with respect to all major currencies and is almost considered a new safe haven for currency traders.[15]

[15] Many economic statistics support this perception, unlike in the cases of the Polish zloty or the Hungarian forint, as documented by Bloomberg.

Results for the crisis period (2008–2009) are reported in Table 5. The pattern of the responses to both macroeconomic announcements as well as central bank communications radically changes in this period. It seems that during the severe crisis, markets ceased to react to macroeconomic news and currencies responded only to the most important information about economic development: news about real GDP growth. Surprise improvements in real output growth create a strong appreciatory effect on the Czech and Polish currencies, while lack of variation precludes inference for the Hungarian forint. An exception from the general lack of responsiveness during the crisis is the positive surprise in consumer prices that delivers a strengthening effect on the Polish zloty. The above findings reflect those of Cai et al. (2009), who show that in nine emerging markets (including our three CEE countries) market uncertainty lowers responsiveness to macro news during the pre-crisis period (2000–2006). We conjecture that our strong result on the lack of responsiveness of the exchange rate to news during the crisis is due to the exceptionally harsh character of the past crisis. During this time most of the economic news published in the media and by news agencies focused on a potential recession and low economic growth. Other fundamentals are easily overlooked and news on GDP growth seems to be all that matters. When assessed from a different angle, during the severe crisis potentially less important fundamentals do not matter as much as during the calm days because of the stronger impact of contagion coming from other markets. Alternatively, the CEE countries were hit by the global crisis through the fall in external demand, prompting a negative GDP shock, and their financial systems remained largely stable. Therefore, they experienced a real, rather than a nominal, financial shock. Hence, in line with the above, the markets were sensitive to the GDP news rather than to detailed news related to finer points in economic development.

In terms of central bank communications the results differ completely from those found before the crisis began, because during the crisis period all currencies reacted to central bank communications. In particular, strengthening announcements produced the desired responses for the Czech koruna. On the other hand, weakening announcements delivered strong appreciation effects for the Hungarian forint. This result is surprising; it might indicate that markets either misinterpreted the announcement or did not care, and therefore other effects dominated.[16] Communications aimed at the stability of the currency produced an appreciatory effect in the Polish zloty. In any event, it seems that during the crisis markets do care what central banks have to say.

Control variables intuitively fit the pattern indicated by the results on macroeconomic news and central bank communications. Day-of-the-week effects vanish, emerging market risk remains present and spillovers carried via the dollar/euro cross rate grow even stronger and become statistically significant for all three currencies.

5. Conclusions

In this paper, we analyzed the impact of macroeconomic news and central bank communications on currencies in emerging markets of Central and Eastern Europe (CEE). In our two-stage modeling strategy we first estimated variants of the monetary model to calculate the nominal equilibrium exchange rate, allowing for a nonlinear return of the exchange rate to the monetary equilibrium depending on the size of the deviation from equilibrium. Next, we integrated equilibrium exchange rates into high-frequency GARCH-type models accounting for the effects of macroeconomic announcements and central bank communication. We provided evidence on the determinants of the short-term exchange rate movements of CEE currencies by including a large set of accurately identified macroeconomic news and central bank communications that have not been employed in exchange rate analysis of the CEE currencies so far.[17]

[16] We have identified only four weakening statements made by the Hungarian central bank in 2009 and none in 2008. Two of those statements are short and clear and two of them are complicated communications involving other economic variables such as inflation, exports, imports, etc.

[17] The reaction of exchange rates might differ with different degrees of central bank independence, differences in the extent of foreign exchange denominated loans in the countries under research (the share of foreign currency loans is limited in the Czech Republic compared to Hungary and Poland), timing of the news and communications, and time between releases. These issues were not analyzed due to data limitations, but they open avenues for further research.

Our results show the absence of strong nonlinearities in our dataset. The results also show remarkably different patterns of how CEE exchange rates react to macroeconomic news announcements and central bank communications before and during a severe economic crisis. During the pre-crisis period (2004–2007), the three CEE currencies in general responded to various macroeconomic news in an intuitive manner, corresponding to exchange rate-related theories. During the crisis (2008–2009), the relationships broke down and the currencies reacted to news on the key economic indicator (real GDP growth). Heightened uncertainty seems to narrow the vision of the markets toward this key economic indicator as contagion from other markets impact specific countries' forex markets. In terms of central bank communications there is a lack of responsiveness during the pre-crisis period (with the exception of the Polish currency). All currencies react to verbal central bank interventions during the crisis period, however.

We provide evidence that the exchange rates of the CEE currencies are responsive to both macro news and central bank communications in general but this responsiveness differs significantly during pre-crisis and crisis periods. Detailed responses vary across currencies and we conjecture that the exchange rate regime and monetary policy conduct affect these responses. Further, the extent to which particular currencies are traded on the international foreign exchange market might be a potential explanation behind these differences as well. Finally, our results show that exchange rate-related verbal communication of central banks does matter when markets experience high uncertainty, while during calmer days markets are less attentive.

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Appendix A

See Table A.1

Table A.1
Number of central bank communications per year.

	Czech koruna			Hungarian forint			Polish zloty		
Year	Strengthen	Weaken	Stable	Strengthen	Weaken	Stable	Strengthen	Weaken	Stable
2004	1	2	8	2	1	10	6	4	4
2005	0	4	4	1	4	11	2	6	2
2006	0	8	0	6	1	12	1	2	1
2007	1	6	1	0	3	15	2	1	2
2008	0	12	3	9	0	9	2	2	2
2009	5	4	6	13	4	11	8	0	8

Data appendix: Monetary model (2004:m1-2009:m12).

NOMINAL EXCHANGE RATES

Monthly averages of domestic currency/euro obtained from Eurostat; Datastream codes: HNESXECU; CZESXECU; POESXECU

MONEY SUPPLY

M2 for the Czech Republic and M3 for the Eurozone, Hungary and Poland, obtained from Eurostat; Datastream codes: HNOMA013B; CZFM21TNA; POOMA013A; EMOMA013B

SHORT-TERM INTEREST RATE (3-month T-bill)
3-month money market rates for the Czech Republic, Poland and the Eurozone and 3-month T-bills for Hungary, data obtained from IFS/IMF; Datastream codes: HNI60C; CZESSFON; POESSFON; EMESEFI3R

PRODUCTIVITY DIFFERENTIAL
Industrial production in manufacturing divided by employment in manufacturing. Productivity in the services sector is assumed to equal 0.

INDUSTRIAL PRODUCTION
Industry in the CEE countries and in manufacturing for the Eurozone. Data obtained from IFS/IMF for the CEE countries and from Eurostat for the Eurozone; Datastream codes: HNI66..CE; CZI66..CE; POI66..BH; EKESIMANG

EMPLOYMENT IN INDUSTRY/MANUFACTURING
Industry in the CEE countries and in manufacturing for the Eurozone. Datastream codes: HNOEM009P; CZI67...F; POOEM004P; EKESEMANG

PRICES, CPI and PPI
Obtained from IFS/IMF for CEE countries. Datastream codes: CPI: HNI64...F; CZI64...F; POI64...F; EMEBCPALE; PPI: HNI63...F; CZI63...F; POI63...F; EKPROPRCF

NOMINAL GDP (interpolated linearly from quarterly to monthly)
OECD Quarterly National Accounts database for the Czech Republic, Hungary and Poland and OECD Main Economic Indicators database for the Eurozone. Datastream, codes HN GDP CURA; CZ GDP CURA; PO GDP CURA; EM GDP CURA

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