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The impact of German macroeconomic data announcements on the Czech financial market

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Abstract:
This paper analyzes the impact of German macroeconomic news announcements on the Czech financial market – as proxied by EUR/CZK exchange rate returns – over three sub-periods: the financial crisis period (2008–2009), the post-crisis period (2010–11/2013) and the currency intervention period (11/2013-2014). Both symmetric and asymmetric models from the class of generalized autoregressive conditional heteroscedasticity (GARCH) models are applied. Macroeconomic shocks (GDP, ZEW, IFO, factory orders, industrial production, Purchasing manager's indexes (PMI) from service and production sectors) are constructed as deviations form expected values. The results suggest that announcement of German GDP and IFO index calm the exchange rate volatility during the 7-year total examined time period. Splitting the time series into 3 individual sub-periods the results suggest that announcements of GDP, factory orders decrease and announcements of industrial production, IFO index increase the conditional volatility during financial crises. Furthermore, announcements of GDP and ZEW index calm the exchange rate's conditional volatility during the post-crises period. Finally, announcements of GDP data and PMI index form production sector increase conditional variance during the central bank's currency interventions. Moreover, announcement of higher IFO index depreciates the CZK value during the post-crisis period.

Keywords: exchange rate volatility, heteroscedasticity, GARCH, EGARCH, macroeconomic news

Introduction and motivation

There is a fair amount of evidence demonstrating that foreign macroeconomic news announcements have a greater impact on emerging financial markets than domestic news. For instance, Andritzky et al. (2007) show that domestic news has a limited impact on bond spreads in several emerging markets, whereas changes in US interest rates exert a significant influence. I follow this idea and examine the impact of German macroeconomic news announcements on its neighboring country – a small open emerging economy – the Czech Republic. Germany and the Czech Republic are closely bound as trading partners, and the business cycles of the two countries are deeply intertwined. In fact, Germany is the Czech Republic's main trading partner and therefore represents a substantial amount of the foreign demand for Czech products and services. Consequently, German macroeconomic data releases inform Czech companies regarding foreign demand. Hence, I expect that news originating from Germany plays an important role in predicting the future conditions of the Czech economy. If so, the forward-looking Czech financial market should react to new macroeconomic data from the German economy. Finally, Hanousek et al. (2009) show that there is substantial positive spillover effects from the German financial market (as represented by the DAX30) to the Czech market (as represented by the PX50). Büttner and Hayo (2012) find that news regarding euro adoption is significant for the Czech financial market.

Firstly, this paper examines 7 German macroeconomic variables within a total period of 7 years, i.e., 2008–2014, and secondly it divides this total period into 3 different sub-periods: the financial crisis period (2008–2009), the post-crisis period (2010–11/2013) and the currency intervention period (11/2013–2014). Previous papers investigated either the impact of macroeconomic news on the conditional mean or conditional volatility of the CEE-3 exchange rates. This paper investigates both effects.

Examined German macroeconomic indicators are mostly related to industrial production.[1] The selection of macroeconomic variables was based on the assumption that the Czech and German economies are closely bound via this economic sector. Machinery and transport equipment is the largest item of Czech export to Germany accounting for more than 50 percent of total Czech goods export to Germany. The share of goods exports to Germany is 32% on average.[2] Moreover, in the last five years, Germany has accounted for more than 29 percent of Czech foreign trade turnover. Thus, the interdependence of Czech goods exports and German goods imports is very high. Given the Czech economy's strong links with Germany, economic developments in Germany feed through rapidly to the Czech economy via exports. A downturn in German demand has an immediate downward effect on Czech GDP growth. In the other words, the Czech Republic both benefits from German economic prosperity and suffers from its economic downturns. Thus, there is close correlation between the Czech and German business cycles. Additionally, Germany is the second largest source of foreign direct investment in the Czech Republic.[3]

Cavusoglu (2011) provides extensive evidence that macroeconomic fundamentals are important influences on exchange rate movements. In other words, the exchange rate is quite responsive to developments in the real economy. Therefore, the EUR/CZK exchange rate is chosen to represent the economic fluctuations related to German news announcements. Moreover, exchange rate is key fundamental variable in small open economies. Its price movements have a direct impact on import and export prices for both goods and services, i.e., inflation. Thus, the exchange rate plays a key role in achieving inflation target and maintaining price stability. This was demonstrated by the Czech National Bank's (CNB)

[1] Four forward-looking German macroeconomic indicators: the ZEW index, the IFO index, the PMIs for the service and manufacturing sectors separately; and three traditional macroeconomic indicators, i.e., factory orders, GDP (Gross domestic product) and industrial production are examined.
[2] Examined years 2005–2011.
[3] According to the Czech National Bank in 2012.

decision to launch currency interventions on 7th November 2013. At that time – the period characterized by low interest rates – the CNB decided to employ the exchange rate as an additional instrument to ease monetary conditions. The bank set a minimum CZK/EUR value at the level of 27,00 to achieve its inflation target of 2 percent, as measured by the annual increase in the consumer price index (CPI).

This paper measures the impact of news announcements as the deviation of the actual news value from the expected value. Results suggest that announcement of German GDP data decreases exchange rate volatility. Also Fišer and Horváth (2010) found that Czech macroeconomic data announcement has calming effect on the EUR/CZK conditional volatility. Moreover, German macroeconomic news releases show little impact on conditional mean of daily exchange rate returns. The results are consistent with Büttner and Hayo (2012) who found no evidence that Czech macroeconomic news affected the value of the EUR/CZK exchange rate. Furthermore, PMI indexes for the service and production sectors present no impact on both conditional mean and volatility at least at 5 percent level of statistical significance.

Autoregressive conditional heteroscedastic (ARCH) models advanced by Engle (1982) and generalized autoregressive conditional heteroscedastic (GARCH) models developed independently by Bollerslev (1986) and Taylor (1986) are frequently applied to estimate exchange rate volatility. Models from the GARCH family are used in this paper to examine the effects of German macroeconomic news announcements on the value and volatility of EUR/CZK exchange rate returns in the Czech Republic.

The main contribution of this paper is that it brings very recent evidence of macroeconomic news announcements on the conditional mean and conditional volatility of the EUR/CZK exchange rate. Moreover, it develops novel insights into the impact of foreign macroeconomic news releases on one of CEE-3 markets during the period of currency interventions. The Czech National Bank decided to use the exchange rate as a monetary policy instrument, and therefore to commence foreign exchange interventions, on 7 November 2013. It would not discontinue the use of the exchange rate as a monetary policy instrument before the second half of 2016. This means the CNB has undertaken to prevent excessive appreciation of the koruna below CZK 27/EUR. On the stronger side of the CZK 27/EUR level, the CNB is preventing the koruna from appreciating further by intervening on the foreign exchange market, i.e. by selling koruna and buying euro. On the weaker side of the CZK 27/EUR level, the CNB is allowing the koruna exchange rate to float.

The remainder of this paper is organized as follows: Section 2 describes the related literature. Section 3 specifies the examined time series and macroeconomic news events. Section 4 presents the methodology. Section 5 reveals the results, which is followed by concluding remarks.

Related Literature

The significance of the effect of macroeconomic news releases on financial markets has been studied previously in the literature. Andersen et al. (2003) demonstrated that macroeconomic news announcements influence financial markets in developed countries. He found that surprise announcements (that is, divergences between expectations and realization of news) produce conditional mean jumps and that high-frequency exchange rate dynamics are thus linked to fundamentals. Evans and Lyons (2008) produced empirical evidence of the effects of macroeconomic news announcements on exchange rates, in particular. Fratzscher (2006) and Laakonen (2007) showed that macroeconomic news releases accounted for approximately 15% of the variations in exchange rates. However, most of this research has thus far focused

on developed countries, and little attention has been paid to developing and emerging countries.

Many authors suggest that news from the largest economies has significant effects on emerging markets assets. For example, Cakan et al. (2015) analyzed the impact of US macroeconomic surprise announcements regarding inflation (CPI) and unemployment rates on the volatility of twelve emerging stock markets and found that these announcements exerted significant effects on these markets. They concluded that positive US news decreases the volatility of emerging stock markets and contributes to the stability of many emerging stock markets.

Examining emerging markets, particularly the CEE-3 countries, Égert and Kočenda (2014) analyzed the impact of local macroeconomic news releases on CEE-3 currencies, including the EUR/CZK exchange rate. Specifically, they examined the impact of news announcements on conditional means rather than on volatility. Their results show that during the pre-crisis period, i.e., 2004–2007, announcements for the producer price index (PPI) and unemployment rate affected the value of the EUR/CZK exchange rate, whereas during the crisis period (2008–2009), only GDP announcements had impacts on the mean EUR/CZK rate. These authors also incorporated the impact of Eurozone macroeconomic data on the EUR/CZK exchange rate by including the EUR/USD exchange rate as an explanatory variable. Their results show that this variable significantly affects the mean equation during the crisis at conventional levels of significance. Fišer and Horváth (2010) showed that Czech macroeconomic news lower the EUR/CZK exchange rate volatility.

Only 3 papers have investigated the impact of foreign news on the Czech financial market, and only one has focused on the EUR/CZK exchange rate. Hanousek and Kočenda (2011) and Hanousek et al. (2009) investigated the impact of US and euro area macroeconomic news on the CEE-3 stock markets including Czech stock market (PX50). Büttner et al. (2012) investigated the effects of euro area and US macroeconomic news on CEE-3 financial markets (including exchange rates) in the Czech Republic, Hungary, and Poland from 1999 to 2006 and found that after the Copenhagen Summit, US news had a significant impact on only one of the CEE-3 financial markets – the Hungarian money market. Moreover, the article suggests the growing importance of EU news after the Copenhagen Deal for European Union Enlargement in comparison to US news. They concluded that euro area influence on CEE-3 financial markets was growing over time.

Many researchers investigated the characteristics of exchange rate volatility in the context of leverage effects, volatility clustering and persistence. For example, Friedman and Stoddard (1982), Meese and Rogoff (1983), Longmore and Robinson (2004), and Yoon and Lee (2008) found evidence of volatility clustering and persistence, which indicates that large and small log-returns tend to occur in clusters in financial time series. They also recognized asymmetric effects in exchange rate returns, which indicates that downward price movements are associated with higher volatility, whereas upward movements are associated with lower volatility. Therefore, defining the volatility characteristic of the EUR/CZK exchange rate is one of the objectives of this paper.

Data

The EUR/CZK exchange rate is measured as units of CZK per unit of EUR, which implies that an increase in the rate indicates CZK depreciation and EUR appreciation and vice versa. The daily exchange rate data are taken from MetaQuotes Software Corp. as the closing price at midnight CET for the period beginning on 1st January 2008 and ending on 31st December 2014. Thus, the sample includes 1,817 observations.

The scheduled German macroeconomic news announcements were obtained from Reuters. I examine four forward-looking German macroeconomic indicators: the ZEW index; the IFO index; the PMIs for the service and manufacturing sectors separately; and three traditional macroeconomic indicators, i.e., factory orders, GDP (Gross domestic product) and industrial production.[4] All announcements are made monthly except for GDP, which is measured quarterly. Reuters reports the macroeconomic news announcements used in this paper with a clearly defined calendar and timing of news releases, providing market participants not only with the actual indicator value but also with the market's expected value.[5] This paper examines the impact of news announcements on the exchange rate as the deviation of the news actual value from the previously expected value. In addition, news announcements are reported in different units. I follow Égert and Kočenda (2014) a standardize them to allow meaningful comparison.

The news surprise effect can be formulated as follows:

$$yn_{it} = \frac{(an_{it} - E_{t-1}[an_{it}])}{\partial_i}, \qquad (1)$$

where an_{it} stands for the value of a scheduled announcement i at time t; i ranges from 1 to 7
$E_{t-1}[an_{it}]$ is the value of the announcement for time t expected by the market at time t-1[6]
∂_i is the sample standard deviation of the announcement i
yn_{it} is excess impact news variable or surprise effect

Hence, the macroeconomic variables enter into the model as follows: a value of yn_{it} (non-zero) on an announcement day and a zero value on non-announcement days. If the macroeconomic news value an_{it} is higher than expected value $E_{t-1}[an_{it}]$, then yn_{it} is positive. Conversely, if the macroeconomic news value an_{it} is lower than expected value $E_{t-1}[an_{it}]$, then yn_{it} is negative. The standardization does not affect the properties of the coefficients' estimates as the sample standard deviation ∂_i is constant of any announcement indicator i.

The dependent variable is the daily change of the EUR/CZK exchange rate. This variable is modeled as the percentage daily exchange rate return, which is the first difference of the natural logarithm of the exchange rate and is given by the following equation:

$$r_t = \ln(\frac{s_t}{s_{t-1}})100, \qquad (2)$$

where r_t[7] is the daily percentage return to the exchange rate, and s_t and s_{t-1} denote the exchange rates on the current day t and previous day t-1, respectively.

The news announcements' effects on the exchange rate value are explored by examining the coefficients of the news variables in the conditional mean equations (3,7,11). The statistically significant coefficients affect the mean of the exchange rate on the dates of news announcements. Positive coefficients indicate that the exchange rate appreciated more than average rate of appreciation on the day of news announcements. Likewise, negative coefficients indicate that the exchange rate depreciated more than average rate of depreciation on the day of news announcements. The conditional variance equations (6,10,14) examine the effect of news variables on the conditional volatility of exchange rate returns. The volatility

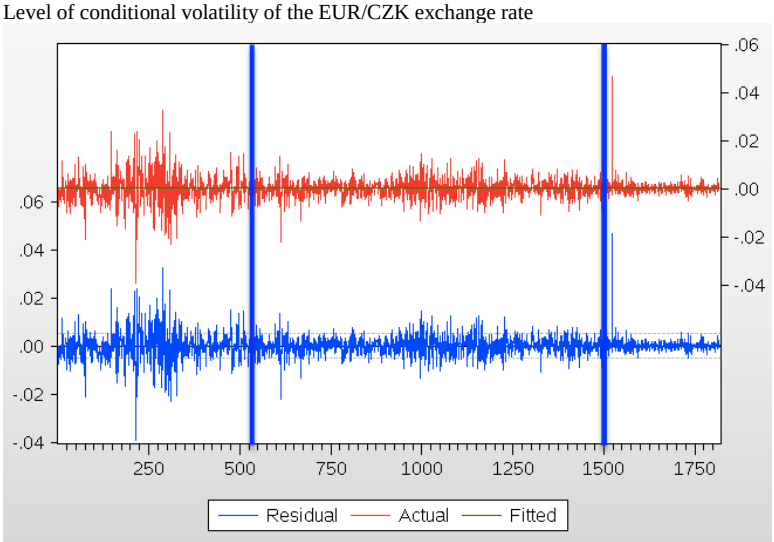
[4] The examined macroeconomic indicators are described in detail in the Final Notes.
[5] Market expectations are constructed using a survey of the world's best-rated institutional analysts and economists approximately one week before the information is released. This number represents the market consensus. It is not the news itself that matters but the difference between the actual and expected value (market consensus).
[6] Time t-1 means the time before the news announcement during which the estimations were collected.
[7] r_t is calculated only for days when the market is open. Saturdays, Sundays and holidays are excluded.

of the exchange rate can be either higher or lower on the day of the macroeconomic news announcement than the average rate.

S.-J. Kim (1998) claimed that the conditional volatility changes when market participants are caught by surprise by the announcement and must adjust their positions, thus leading to market price adjustment. Alternatively, new information may increase uncertainty in the markets due to a lack of market consensus regarding the effects of the particular announcement and the necessary course of monetary or fiscal action. In the other words, heterogeneity of market responses to news creates a higher conditional volatility of returns on the announcement day. However, reduced volatility should be the result of reduced uncertainty. Kim (1998) suggests that reduced volatility may be a sign of reduced uncertainties in the markets due to reductions of speculation tradings based on incorrect information. The conditional volatility is not affected when there is market consensus regarding the effect of a particular news announcement and so new equilibrium price is reached without affecting the conditional volatility. Finally, if the macro-economic variable is consistent with market expectations, then there is no adjustment needed, and both conditional mean and variance remain unchanged.

Graph 1 shows that the EUR/CZK exchange rate conditional volatility exhibits different patterns of volatility clustering during the examined 7-year period. For this reason, I divide it into 3 sub-periods in order to respect the different exchange rate's volatility characteristics. The first sub-period covers the years of the financial crisis, 2008–2009. Graph 1 depicts that this sub-period is characterized by the highest volatility. The second sub-period covers the years 2010–11/2013 (specifically up to the 6th of November 2013). Volatility diminished during these years. The third sub-period starts on the 7th November 2013 and covers the era of Czech national bank currency interventions. It lasts up to the 31st of December 2014.[8] The last period is characterized by the lowest volatility. The day that the currency interventions were launched is clearly visible on Graph 1. The volatility increased significantly that day, as shown by large residuals. The graphical depiction of the residuals suggests using generalized autoregressive conditional heteroscedastic (GARCH) models because they address volatility clustering.

Graph 1
Level of conditional volatility of the EUR/CZK exchange rate



Empirical Methodology

[8] The currency interventions are described in detail in the Methodology section.

The models in the GARCH class, which are used in this paper, capture two important characteristics of financial time series; excess kurtosis (i.e., fat tail behavior) and volatility clustering. Both these characteristics of the examined exchange rate can be observed in Table 1, which provides the descriptive statistics of the daily exchange rate returns. In the first column, the observed statistical properties of the entire examined time series (2008–2014) are provided; the third, fourth and fifth columns show the characteristics of the financial series divided into 3 separate periods, i.e., the first for 2008–2009 that covers the financial crisis (Égert and Kočenda, 2014), the second from 2010 to November 6, 2013 that tracks the post-crisis era, and the third that tracks central bank interventions dating from November 7, 2013 to December 31, 2014.[9] The last column shows the statistical properties of the exchange rate returns during the currency interventions, excluding the day of the intervention announcement.

One of the most important issues before applying the GARCH methodology is to first examine the residuals of the returns series of the exchange rates for evidence of heteroscedasticity. To test for this characteristic, I apply the Lagrange Multiplier (LM) test proposed by Engle (1982). The results in Table 1 show that the ARCH effect is significant in the entire observed time series (2008–2014), during the crisis (2008–2009), and after the crisis (2010–2013). However, the ARCH effect is not significant for the residuals of the returns of the exchange rate during the period of central bank currency interventions. This can be explained by small sample size. In summary, the daily returns of the EUR/CZK rate show leptokurtosis, skewness and volatility clustering (ARCH effect). Thus, a GARCH model and its variances should fit the data.

Table 1: Descriptive statistics of the daily returns for the EUR/CZK exchange rate [10]

	2008-2014	**2008-2014 without intervention announcement day**	**2008-2009 Financial Crisis**	**1.1.2010 – 6.11.2013 After the Crisis**	**7.11.2013 - 31.12.2014 Interventions**	**8.11.2013 – 31.12.2014 After 1st day of Interventions**
Observations	**1817**	**1816**	**521**	**1000**	**296**	**295**
Mean	0.0000	0.0000	0.0000	0.0000	0.0002	0.0001
Median	-0.0001	-0.0001	0.0002	-0.0001	-0.0003	-0.0002
Maximum	0.0464	0.0326	0.0326	0.0145	0.0462	0.0098
Minimum	-0.0391	-0.0391	-0.0392	-0.0222	-0.0055	-0.0047
Std. Dev.	0.01	0.00	0.01	0.00	0.00	0.00
Skewness	0.35	-0.09	-0.09	-0.03	9.59	0.97
Kurtosis	12.79	9.55	6.34	4.59	135.40	7.94
Jarque-Bera (Prob.)	7293.59 (0.0)	3250.32 (0.0)	242.87 (0.0)	105.55 (0.0)	220727.8 (0.0)	350.61 (0.0)
Residuals ARCH-LM test (Heteroscedasticity)	0.00	0.00	0.00	0.00	0.95	0.01

Data in Table 1 and Graph 1 suggest that characteristics of observed time series are varying during the examined time periods. It implies that one model may not fit properly to all

[9] The Czech National Bank decided to launch currency interventions on the 7th of November 2013. From this day forward, the bank was active in the foreign exchange market. The CNB commitment is asymmetric, that is, it would not allow the koruna to appreciate to a level close to CZK 27/EUR. On the weaker side of the CZK 27/EUR level, the CNB allowed the koruna exchange rate to float according to supply and demand on the foreign exchange market.

[10] The highest daily EUR/CZK exchange rate return (maximum) was reached on the day of the currency intervention announcement. The lowest daily exchange rate return (minimum) was observed during the financial crisis. The period with the highest daily volatility was the financial crisis (2008–2009), according to the standard deviation. The values of skewness and excess kurtosis indicate that the time series is not normally distributed. In a normally distributed series, skewness is 0 and kurtosis is 3. Likewise, the Jargue-Bera test for normality rejects the null hypothesis of normality for the daily returns. The ARCH LM test provides evidence of the ARCH effect in the residual series of the returns of the exchange rate during the entire examined period (2008–2014), particularly during the crisis years (2008–2009) and after the crisis (2009–11/2013). On the one hand, an ARCH effect was not evident during the period of central bank currency interventions, even if I eliminate the day of intervention announcement. Note the results in the last column of Table 1. The data show that the central bank's interventions changed the characteristics of the exchange rate returns. First, they shifted the skewness from negative to positive values and increased kurtosis. Second, the missing ARCH effect in the residuals suggests there is no volatility clustering or persistence.

examined time series. For this reason, I test three different models for each particular time horizon in order to identify the best one. The tested models are:

GARCH (1,1), EGARCH (1,1) and EGARCH (1,1) without an asymmetric component.[11]
The starting model for each time period is a GARCH (1,1) process for exchange rate returns, which can be observed as follows:

Examining the impact of macroeconomic news announcements on the conditional value of the EUR/CZK exchange rate:

Mean Equation: $\Delta s_t = \mu + \sum_{i=1}^{7} \alpha_i \ NEWS_{it} + \varepsilon_t$ (3)
Variance Equation: $\delta_t^2 = \gamma_1 + \gamma_2 \ \varepsilon_{t-1}^2 + \gamma_3 \ \sigma_{t-1}^2$ (4)

Examining the impact of macroeconomic news announcements on the conditional volatility of the EUR/CZK exchange rate:

Mean Equation: $\Delta s_t = \mu + \varepsilon_t$ (5)
Variance Equation: $\delta_t^2 = \gamma_1 + \gamma_2 \ \varepsilon_{t-1}^2 + \gamma_3 \ \sigma_{t-1}^2 + \theta_i \ \sum_{i=1}^{7} NEWS_{it}$ (6)

where s_t stands for the log of daily change return of EUR/CZK, the error term ε_t in the mean equations (3,5) is assumed to have conditional variance δ_t^2 specified in the equations (4,6 respectively), μ denotes average returns and news announcement effect is represented by $NEWS_{it}$. The variance equation (6) includes constant γ_1, ARCH term ε_{t-1}^2, GARCH term σ_{t-1}^2 and variables capturing the news announcement effect, $NEWS_{it}$. Symbol $NEWS_{it}$ represents 7 macroeconomic news variables (i) transformed into the daily variables by assigning the value of zero for days without the particular news announcement and magnitude of the news (Equation Nb. 1) for announcement days.

There is some evidence to suggest that GARCH models with normal error distribution cannot capture the full extent of excess kurtosis (Terasvirta, 1996). Additionally, Nelson (1991), Hamilton and Susmel (1994) use generalized error distributions (GED) and t-distributions to adjust the deviation of the tail. Hsieh (1989) shows that GARCH models with a standardized *t* distribution for the residuals are useful for modeling the time-varying nature of daily exchange rate returns. Following these studies, I apply five different error term distributions ε_t in the mean equations (3,5,7,9,11,13) for each of examined models to find the best date fitted model. Specifically, I employ Gaussian normal error distribution, Student's t distribution, generalized error distribution (GED), Student's t distribution with fixed degrees of freedom at 10, and generalized error distribution (GED) with fixed parameter at 1.5.

In the simple GARCH (1,1) approach, bad and good news, i.e., negative and positive shocks, have the same impact on the conditional variance. In other words, the conditional variance is a function only of the magnitudes of the past values and not their sign. To allow asymmetric volatility effects, Nelson (1991) introduced the exponential GARCH process (EGARCH). Assets' price movements are negatively correlated with volatility, i.e., volatility is higher after negative shocks than after positive shocks of the same magnitude. This feature is also called the leverage effect. Empirical studies conducted on daily data using EGARCH specifications for the conditional log-variance typically conclude that negative shocks have a more pronounced impact on volatility (Nelson, 1991). The key advantage of the EGARCH model is that it describes the logarithm of conditional variance process δ_t^2; the conditional variance itself will be positive. Therefore, no restrictions need be imposed on these equations for estimation. In addition to modeling the logarithm, the EGARCH model has additional leverage terms to capture asymmetry in volatility clustering. Gokcan (2000) compared the

[11] Higher order models failed to improve on the results obtained for the examined models.

performance on volatility forecasting of a GARCH (1,1) model and an EGARCH (1,1) model using the monthly stock market returns of seven emerging countries. All in all, the presence of the logarithm of conditional variance δ_t^2 ensures that the conditional variance is always positive. This model's characteristics may produce superior results than using an ordinary GARCH (1,1) model.

The EGARCH (1,1) is shown below:

Examining the impact of macroeconomic news announcements on the conditional value of the EUR/CZK exchange rate:

Mean Equation: $\Delta s_t = \mu + \sum_{i=1}^{7} \alpha_i \, NEWS_{it} + \varepsilon_t$ (7)

Variance Equation: $\ln(\sigma_t^2) = \gamma_1 + \gamma_2 \left(\frac{|\varepsilon_{t-1}|}{|\sigma_{t-1}|} - \sqrt{\frac{2}{\pi}} \right) + \gamma_3 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \gamma_4 \ln(\sigma_{t-1}^2)$ (8)

Examining the impact of macroeconomic news announcements on the conditional volatility of the EUR/CZK exchange rate:

Mean Equation: $\Delta s_t = \mu + \varepsilon_t$ (9)

Variance Equation:

$\ln(\sigma_t^2) = \gamma_1 + \gamma_2 \left(\frac{|\varepsilon_{t-1}|}{|\sigma_{t-1}|} - \sqrt{\frac{2}{\pi}} \right) + \gamma_3 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \gamma_4 \ln(\sigma_{t-1}^2) + \theta_i \sum_{i=1}^{7} NEWS_{it}$ (10)

The key benefit of the EGARCH (1,1) model is in capturing the asymmetry (leverage) effect. This model captures asymmetric responses of the time-varying variance to shocks and ensures that the variance is always positive. This model is asymmetric due to the $\frac{\varepsilon_{t-1}}{\sigma_{t-1}}$ component in variance equations (8,10). If the coefficient γ_3 is negative, positive shocks generate less volatility than negative return shocks, assuming other factors unchanged. The magnitude of the shock represents the ARCH term $\left(\frac{|\varepsilon_{t-1}|}{|\sigma_{t-1}|} - \sqrt{\frac{2}{\pi}} \right)$, and the significance of the conditional variance is represented by the GARCH term $\ln(\sigma_{t-1}^2)$.

The third model examined is the EGARCH (1,1) model without an asymmetric component. This model was chosen in the cases, when asymmetric component $\frac{\varepsilon_{t-1}}{\sigma_{t-1}}$ in variance equation (10) was not statistically significant. The purpose of this model is validation, whether I get better results after eliminating insignificant model's component.

The EGARCH (1,1) without asymmetry is shown below:

Examining the impact of macroeconomic news announcements on the conditional value of the EUR/CZK exchange rate:

Mean Equation: $\Delta s_t = \mu + \sum_{i=1}^{7} \alpha_i \, NEWS_{it} + \varepsilon_t$ (11)

Variance Equation: $\ln(\sigma_t^2) = \gamma_1 + \gamma_2 \left(\frac{|\varepsilon_{t-1}|}{|\sigma_{t-1}|} - \sqrt{\frac{2}{\pi}} \right) + \gamma_4 \ln(\sigma_{t-1}^2)$ (12)

Examining the impact of macroeconomic news announcements on the conditional volatility of the EUR/CZK exchange rate:

Mean Equation: $\Delta s_t = \mu + \varepsilon_t$ (13)

Variance Equation:

$$\ln(\sigma_t^2) = \gamma_1 + \gamma_2 \left(\frac{|\varepsilon_{t-1}|}{|\sigma_{t-1}|} - \sqrt{\frac{2}{\pi}} \right) + \gamma_4 \ln(\sigma_{t-1}^2) + \theta_i \sum_{i=1}^{7} NEWS_{it} \quad (14).$$

Empirical results

This paper first reports the results for the 7-year (2008–2014) total examined period. Second, individual sub-periods (financial crisis, post-crisis and currency intervention periods) are examined separately. The best model from the GARCH family is selected for each time period to identify which German macroeconomic variables influence both the value and volatility of the EUR/CZK exchange rate.

First, the GARCH (1,1) model is estimated for the entire 7-year period (2008–2014). Table 2 below reports the maximum likelihood estimation results for Equations (3,4,5,6).[12]

Table 2
Estimation results of GARCH (1,1) model; observed time period: 2008–2014

	GARCH (1,1)	Normal error distribution			Student's t distribution			GED distribution			Student's t distribution with 10 degrees of freedom			GED with parameter fixed at 1.5		
	Observations	1817														
	ARCH LM Test			0.9214			0.9331			0.9590			0.9383			0.9728
		Coefficient	Prob.		Coefficient	Prob.		Coefficient	Prob.		Coefficient	Prob.		Coefficient	Prob.	
Mean Equation	C	0.00003352	0.7112		-0.00002620	0.7054		-0.00004857	0.4543		-0.00001555	0.8282		-0.00003316	0.6671	
	ZEW	0.00024199	0.6079		0.00006990	0.8320		0.00007507	0.8152		0.00004106	0.9046		0.00004438	0.9050	
	IFO	-0.00013288	0.7584		-0.00022637	0.4920		-0.00071338	0.0303	**	-0.00017627	0.6103		-0.00044112	0.2388	
	PMI_PRODUCTION	-0.00035321	0.4312		-0.00034177	0.3297		-0.00019496	0.5702		-0.00027843	0.4385		-0.00025120	0.5175	
	PMI_SERVICES	-0.00041869	0.3794		-0.00029371	0.3716		-0.00045737	0.1494		-0.00032607	0.3513		-0.00028375	0.4493	
	GDP	0.00057563	0.5558		0.00069356	0.3461		0.00051421	0.3770		0.00064761	0.4000		0.00061343	0.4093	
	FACTORY_ORDERS	-0.00065544	0.1929		0.00005894	0.8816		-0.00004654	0.8948		0.00001951	0.9605		-0.00015113	0.7189	
	INDUSTRIAL_PRODUCTION	-0.00215087	0.0000	***	0.00010436	0.7730		-0.00033100	0.3384		0.00007816	0.8375		-0.00040847	0.2938	
Variance Equation	C	8.77E-07	0.0000	***	0.00000010	0.0454	**	0.00000013	0.0478	**	0.00000009	0.0217	**	0.00000018	0.0015	***
	RESID(-1)^2	0.174658926	0.0000	***	0.09737449	0.0000	***	0.09601811	0.0000	***	0.08771223	0.0000	***	0.08855782	0.0000	***
	GARCH(-1)	0.807451656	0.0000	***	0.90606344	0.0000	***	0.90735909	0.0000	***	0.90784879	0.0000	***	0.90642191	0.0000	***
	AIC Criterion	-8.06052201			-8.24594042			-8.22027163			-8.23706594			-8.19083252		
	SIC Criterion	-8.02719545			-8.20958417			-8.18391538			-8.20373938			-8.15750596		
Mean Equation	C	0.00007249	0.7530		0.00003449	0.8633		0.00007266	0.7557		0.00001000	0.9571		0.00001046	0.9533	
Variance Equation	C	0.00001631	0.0001	***	0.00001394	0.0002	***	0.00001633	0.0001	***	0.00001352	0.0004	***	0.00001470	0.0011	***
	RESID(-1)^2	0.14885075	0.0001	***	0.14884334	0.0004	***	0.14866521	0.0001	***	0.14905029	0.0011	***	0.14906898	0.0021	***
	GARCH(-1)	0.59410206	0.0000	***	0.59337615	0.0000	***	0.59317483	0.0000	***	0.59430657	0.0000	***	0.59467943	0.0000	***
	ZEW	-0.00000463	0.5907		-0.00000299	0.6943		-0.00000460	0.5937		-0.00000363	0.6219		-0.00000384	0.6617	
	IFO	-0.00000987	0.0077	***	-0.00000796	0.1969		-0.00000985	0.0079	***	-0.00000841	0.0145	**	-0.00000837	0.2062	
	PMI_PRODUCTION	-0.00000034	0.9700		0.00000004	0.9963		-0.00000035	0.9694		0.00000078	0.9237		-0.00000007	0.9941	
	PMI_SERVICES	-0.00000591	0.5045		-0.00000444	0.5747		-0.00000589	0.5059		-0.00000510	0.4973		-0.00000514	0.5674	
	GDP	-0.00001583	0.0000	***	-0.00001374	0.0000	***	-0.00001581	0.0000	***	-0.00001337	0.0000	***	-0.00001449	0.0000	***
	FACTORY_ORDERS	0.00000769	0.2067		0.00000323	0.6878		0.00000767	0.3228		0.00000105	0.8904		0.00000572	0.4136	
	INDUSTRIAL_PRODUCTION	-0.00000352	0.5257		0.00000140	0.8384		-0.00000352	0.6119		0.00000363	0.5625		-0.00000067	0.9165	
	AIC Criterion	-7.67242309			-7.798878534			-7.672163534			-7.85435556			-7.84037821		
	SIC Criterion	-7.63909653			-7.762522285			-7.635807285			-7.82102899			-7.80705165		
	ARCH LM Test			0.0284			0.1059			0.0282			0.1511			0.067

Note: * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

The estimation results show that selection of error distribution is important. Only the Student's t distribution with n degrees of freedom and the Student's t distribution with 10 degrees of freedom eliminate the ARCH effect in the residual series in Equation Nb. 5 at the 10 percent level of statistical significance. Both distributions imply that GDP announcements

[12] The estimations were conducted using the Student's version of EVIEWS software with default settings.

decrease exchange rate volatility on the day of announcement. In other words, they have calming effect on the Czech financial market. Specifically, volatility of the exchange rate is lower on the day of GDP announcement than average rate. More precisely, a one standard deviation in unanticipated change in the GDP lowers the conditional volatility by 0.001374 or 0.001337 percent (depending on the error distribution). Moreover, following Student's t distribution with 10 degrees of freedom, the announcements of IFO index reduce the exchange rate volatility too. These results are consistent with Fišer and Horváth (2010), who found that announcement of Czech macroeconomic news, has in general calming effect on the EUR/CZK exchange rate. With respect to the variance equations (Equations Nb. 4,6), the constants related to ARCH and GARCH terms are significant at the 1 percent level, which indicates that the model is well specified.

German macroeconomic news releases show no impact on conditional mean of daily exchange rate returns. The low responsiveness of the Czech crown's conditional mean to new macroeconomic information may result from the economic and political stability of the country. The results are consistent with Büttner and Hayo (2012), who found no evidence that Czech macroeconomic news affected the value of the EUR/CZK exchange rate.

GARCH (1,1) model shows that only the Student's t distribution can eliminate heteroscedasticity in the residual series in the mean Equation Nb. 5.[13] For this reason, I test EGARCH (1,1) model to see, how it copes with the heteroscedasticity in the residuals. The results in Table 7 in the appendix show, that it successfully eliminates the heteroscedasticity in the residual series using all error distributions. However, the asymmetry component $\frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}}}$, one of the key characteristics of EGARCH model, is not statistically significant in variance equations (Equations Nb. 8,10). This indicates that there is no leverage effect and contrasts with the usual expectations for the financial market reported by Nelson (1991). For this reason, I consider an EGARCH (1,1) model without an asymmetry component, which is obviously redundant. The results are shown below in Table 3. Overall, both EGARCH models were able to discharge heteroscedasticity in the residual series using all error distributions. Note that both EGARCH-type models find different statistically significant macroeconomic variables than does the GARCH (1,1).[14] Both EGARCH models (with/without asymmetry) component cope better with heteroscedasticity in the residual series in the mean equation than GARCH (1,1) model. However, their results' interpretation does not make any economic sense. For example, normal and GED distribution with fixed parameter at 1.5 of EGARCH (1,1) model without asymmetry component suggest that a one standard deviation in unanticipated change in the GDP and industrial production lowers the conditional volatility by enormous 21.5 and 32 percent depending on the error distribution. Furthermore, one standard deviation in unanticipated change in factory orders increases the volatility by 39.7 percent. The results imply the excessive effect comparing it with the median of daily returns.[15] Hence, I assume both EGARCH models inconvenient. As mentioned above the main advantage of EGARCH model is capturing the asymmetry (leverage) effect, which is not present in the data set.[16] In summary, the first model examined, a GARCH (1,1) with a Student's t distribution, provides the best data fit.

Table 3
Estimation results of EGARCH (1,1) model without asymmetry component; observed time period: 2008–2014

[13] See Table 2.
[14] Compare Table 2 with Tables 3,7.
[15] See Table 1.
[16] See Table 3 and 7.

	EGARCH (1,1)	Normal error distribution			Student's t distribution			GED distribution			Student's t distribution with 10 degrees of freedom			GED with parameter fixed at 1.5		
	Observations	**1817**														
	ARCH LM Test			**0.9178**			**0.9865**			**0.9908**			**0.9883**			**0.9889**
Mean Equation	C	0.00002961	0.7507		-0.00001702	0.8073		-0.00004415	0.5040		-0.00000712	0.9211		-0.00003423	0.6507	
	ZEW	-0.00013857	0.7543		0.00005665	0.8609		0.00005489	0.8620		0.00001763	0.9580		-0.00004136	0.9057	
	IFO	-0.00055860	0.2128		-0.00026516	0.4248		-0.00066362	0.0452	**	-0.00023013	0.5044		-0.00045535	0.2163	
	PMI_PRODUCTION	-0.00010291	0.8230		-0.00034471	0.3437		-0.00017240	0.6295		-0.00029464	0.4277		-0.00020966	0.5936	
	PMI_SERVICES	-0.00004760	0.9195		-0.00032644	0.3371		-0.00049693	0.1288		-0.00035182	0.3301		-0.00027487	0.4709	
	GDP	0.00055617	0.6002		0.00063849	0.3962		0.00045524	0.4610		0.00059983	0.4473		0.00057264	0.4569	
	FACTORY_ORDERS	0.00084319	0.0252	**	0.00001111	0.9773		-0.00025361	0.4813		-0.00005388	0.8870		-0.00041024	0.2816	
	INDUSTRIAL_PRODUCTION	-0.00071787	0.1323		0.00012267	0.7371		-0.00023641	0.4985		0.00011718	0.7600		-0.00022091	0.5787	
Variance Equation	C	-0.35978151	0.0000	***	-0.17695343	0.0000	***	-0.20618859	0.0002	***	-0.18324556	0.0000	***	-0.24176443	0.0000	***
	ARCH TERM	0.16496783	0.0000	***	0.14193677	0.0000	***	0.14736555	0.0000	***	0.13812495	0.0000	***	0.15035321	0.0000	***
	GARCH	0.97783352	0.0000	***	0.99368880	0.0000	***	0.99120770	0.0000	***	0.99322997	0.0000	***	0.98836274	0.0000	***
	AIC Criterion	-8.08453582			-8.25747722			8.23363927			-8.25032876			-8.21124386		
	SIC Criterion	-8.05120925			-8.22112097			-8.19728302			-8.21700220			-8.17791730		
Mean Equation	C	-0.00003626	0.6614		-0.00001639	0.8149		-0.00005073	0.4471		-0.00000360	0.9602		-0.00003279	0.6625	
Variance Equation	C	-0.38478890	0.0000	***	-0.16614442	0.0001	***	-0.19767310	0.000418	***	-0.17471715	0.0000	***	-0.23715030	0.0000	***
	ARCH TERM	0.20705381	0.0000	***	0.13300727	0.0000	***	0.14233487	0.0000	***	0.13151570	0.0000	***	0.15327031	0.0000	***
	GARCH	0.97860913	0.0000	***	0.99401519	0.0000	***	0.99159763	0.0000	***	0.99349361	0.0000	***	0.98894458	0.0000	***
	ZEW	0.01930842	0.7636		-0.02556038	0.6933		-0.00259417	0.9726		-0.01680748	0.7715		0.01178676	0.8582	
	IFO	-0.02470454	0.6535		0.02542494	0.6924		-0.00093230	0.9899		0.02659492	0.6402		-0.01186383	0.8490	
	PMI_PRODUCTION	-0.03783454	0.5435		-0.04475367	0.5488		-0.05006490	0.5646		-0.04314018	0.5195		-0.04621038	0.5285	
	PMI_SERVICES	-0.06600957	0.3076		-0.03705617	0.6203		-0.04485955	0.6007		-0.02163736	0.7437		-0.05390611	0.4565	
	GDP	**-0.21510487**	0.0991	*	-0.10509854	0.3693		-0.13210272	0.3619		-0.11241749	0.3033		-0.14999601	0.2489	
	FACTORY_ORDERS	**0.39723505**	0.0000	***	-0.06352025	0.3855		0.04266220	0.5909		-0.04525524	0.4691		0.13744864	0.0082	***
	INDUSTRIAL_PRODUCTION	**-0.32035603**	0.0000	***	0.06728290	0.3407		-0.00709759	0.9279		0.05249562	0.3926		-0.08572066	0.1482	
	AIC Criterion	-8.11676515			-8.25737341			-8.231760401			-8.25018807			-8.21260112		
	SIC Criterion	-8.08343859			-8.22101716			-8.195404152			-8.21686151			-8.17927455		
	ARCH LM Test			**0.9820**			**0.9962**			**0.9969**			**0.9965**			**0.9979**

Note: * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

Financial crisis 2008–2009

This sub-period is characterized by the highest volatility, as measured by the standard deviation.[17] The high volatility can be explained by high uncertainty related to the financial crisis. As discussed above, the years of financial crisis were characterized by high volatility, which might explain why none of the error distributions in the both EGARCH-type models (with/without asymmetry component) were able to eliminate heteroscedasticity in the residual series in the Equations Nb. 9 and 13 at 10 and 5 percent level of statistical significance (see the results of ARCH LM test in Table 8 and Table 9 in the appendix).

I follow the same process as before and examine GARCH (1,1) model. Only normal and GED distributions of the errors are able to eliminate heteroscedasticity in the residual series at least at the 10 percent level of significance in Equation Nb. 5. I prefer the GED distribution, where the ARCH term representing volatility persistence has higher statistical significance. Comprehensive results can be observed in Table 4 below.

Table 4
Estimation results of GARCH (1,1) model for the observed period: 2008–2009 (financial crisis)

[17] See Graph 1 and Table 1.

	GARCH (1,1)	Normal error distribution			Student's t distribution			GED distribution			Student's t distribution with 10 degrees of freedom			GED with parameter fixed at 1.5		
	Observations	521														
	ARCH LM Test			0.5312			0.4012			0.3957			0.3513			0.4266
Mean Equation	C	-0.00016121	0.4810		-0.00024263	0.3254		-0.00020496	0.3570		-0.00026866	0.2605		-0.00019906	0.3883	
	ZEW	0.00042509	0.7401		0.00061400	0.6199		0.00042290	0.7126		0.00066382	0.5731		0.00046192	0.7000	
	IFO	-0.00251870	0.1547		-0.00246490	0.1259		-0.00195450	0.1252		-0.00240710	0.1104		-0.00206626	0.1509	
	PMI_PRODUCTION	-0.00007550	0.9629		-0.00029714	0.8547		0.00040205	0.7918		-0.00045821	0.7737		0.00015569	0.9208	
	PMI_SERVICES	-0.00128705	0.4674		-0.00126327	0.4725		-0.00188929	0.2372		-0.00123435	0.4739		-0.00166679	0.3183	
	GDP	0.00109953	0.7991		0.00113383	0.7564		0.00109776	0.5305		0.00113893	0.7280		0.00108969	0.6368	
	FACTORY_ORDERS	0.00118530	0.3412		0.00133793	0.2251		0.00136408	0.1422		0.00139778	0.1670		0.00131135	0.1932	
	INDUSTRIAL_PRODUCTION	0.00005433	0.8151		0.00007546	0.7471		-0.00002289	0.9062		0.00007417	0.7419		0.00001557	0.9409	
Variance Equation	C	0.00000209	0.0067	***	0.00000154	0.0212	**	0.00000157	0.0714	*	0.00000134	0.0380	**	0.00000165	0.0392	**
	RESID(-1)^2	0.15411610	0.0000	***	0.12960961	0.0001	***	0.13654852	0.0016	***	0.12257430	0.0003	***	0.13782937	0.0004	***
	GARCH(-1)	0.80703434	0.0000	***	0.83529897	0.0000	***	0.83524038	0.0000	***	0.84751735	0.0000	***	0.82843398	0.0000	***
	AIC Criterion	-7.27970540			-7.30363477			-7.32356979			-7.32088292			-7.32267172		
	SIC Criterion	-7.18985271			-7.20561366			-7.22554867			-7.23103024			-7.23281904		
Mean Equation	C	0.0000	0.9959		0.00015665	0.7671		-0.00000310	0.9953		-0.00024540	0.2569		-0.00023409	0.2720	
Variance Equation	C	0.00002872	0.0034	***	0.00002920	0.0002	***	0.00002879	0.0012	***	0.00000163	0.0200	**	0.00000175	0.0209	**
	RESID(-1)^2	0.14767461	0.0534	*	0.14465259	0.0798	*	0.14730482	0.0312	**	0.10200529	0.0002	***	0.10224230	0.0002	***
	GARCH(-1)	0.58844409	0.0000	***	0.57877420	0.0000	***	0.58667125	0.0000	***	0.86185956	0.0000	***	0.86010414	0.0000	***
	ZEW	-0.00001855	0.3252		-0.00001288	0.5864		-0.00001945	0.2854		-0.00000077	0.8748		-0.00000250	0.5976	
	IFO	0.00002166	0.3892		0.00000605	0.8377		0.00004448	0.0000	***	0.00000672	0.3244		0.00000793	0.2856	
	PMI_PRODUCTION	-0.00004434	0.0615	*	-0.00001812	0.5458		-0.00004532	0.0420		0.00000061	0.9324		-0.00000163	0.8184	
	PMI_SERVICES	0.00001765	0.5488		-0.00000336	0.9201		0.00002098	0.3916		0.00000045	0.9351		0.00000128	0.8143	
	GDP	-0.00002817	0.0000	***	-0.00002719	0.0000	***	-0.00002812	0.0000	***	-0.00000726	0.0005	***	-0.00000742	0.0024	***
	FACTORY_ORDERS	-0.00003447	0.0008	***	-0.00003974	0.0000	***	-0.00003727	0.0000	***	-0.00000991	0.0001	***	-0.00001015	0.0003	***
	INDUSTRIAL_PRODUCTION	0.00000751	0.0000	***	0.00000573	0.0339	**	0.00000736	0.0000	***	-0.00000077	0.3209		-0.00000080	0.3453	
	AIC Criterion	-6.904938785			-7.026303137			-6.90640813			-7.32138347			-7.32436919		
	SIC Criterion	-6.815086097			-6.928282022			-6.80838701			-7.23153078			-7.23451650		
	ARCH LM Test			0.9796			0.0069			0.9842			0.0408			0.0441

Note: * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

As for macroeconomic news during the financial crisis (2008–2009), using an GARCH (1,1) model in which error distribution follows a GED distribution, none of the observed variables have the effect on the value of exchange rate returns. The low significance of macroeconomic data in explaining the value of the exchange rate can be advocated by the fact that financial markets reacted to other types of market information during financial crisis. In other words, the cause of financial crisis was the banking sector. The market suffered from a lack of liquidity, and thus, monetary policy was probably more important during that period. Égert and Kočenda (2014) revealed the significance of central bank communication on the value of EUR/CZK exchange rate during this period (2008–2009).

The conditional volatility is marginally calmed by the factory orders and GDP data announcements. A one standard deviation in unanticipated change in the GDP lowers the conditional volatility by 0.002812 percent. Similarly, one standard deviation in unanticipated change in the factory orders decreases the exchange rate volatility by 0.003727 percent on the day of announcement. On the other hand, the new information about German industrial production and IFO index marginally increase the exchange rate volatility on the day of announcement. The results are partially consistent with the results of 7-year total examined time period, where announcements of GDP data calm the Czech financial market too. Nonetheless, the IFO index had a calming effect on the exchange rate volatility examining the years 2008-2014. These dissimilarities can be explained by the fact that both positive and negative effects are close to zero, i.e., the values oscillate around zero. Therefore, the movement from positive to negative territory can be explained by examining different number of observations.

After the crisis (2010–11/2013)

Examining Graph 1, the volatility of the daily exchange rate returns decreased after the financial crisis, which might be explained by less uncertainty in financial markets as the crisis waned. Examination of the time series again begins with a GARCH (1,1) model and testing five different error distributions ε_t.

Table 5

Estimation results of GARCH (1,1) model for the observed period: 2010–11/2013 (after the financial crisis)

	GARCH (1,1)	Normal error distribution			Student's t distribution			GED distribution			Student's t distribution with 10 degrees of freedom			GED with parameter fixed at 1.5		
	Observations			1000												
	ARCH LM Test			0.1603			0.2157			0.1676			0.2165			0.1667
Mean Equation	C	-0.00005015	0.6451		-0.00004095	0.7040		-0.00005875	0.5800		-0.00004047	0.7076		-0.00005954	0.5729	
	ZEW	0.00061730	0.2539		0.00049934	0.3453		0.00056515	0.2821		0.00050520	0.3411		0.00056618	0.2793	
	IFO	0.00097397	0.0043	***	0.00090368	0.0181	**	0.00093340	0.0146	**	0.00090051	0.0178	**	0.00093084	0.0150	**
	PMI_PRODUCTION	-0.00049206	0.3662		-0.00062277	0.2117		-0.00051237	0.2967		-0.00061332	0.2217		-0.00050915	0.2964	
	PMI_SERVICES	-0.00081817	0.1480		-0.00063998	0.2125		-0.00059955	0.2378		-0.00065448	0.2057		-0.00058767	0.2446	
	GDP	0.00033620	0.7039		0.00038511	0.6489		0.00038948	0.6387		0.00037834	0.6553		0.00039214	0.6345	
	FACTORY_ORDERS	0.00017525	0.8379		0.00019681	0.7930		0.00021723	0.7618		0.00019453	0.7974		0.00021754	0.7591	
	INDUSTRIAL_PRODUCTION	-0.00006427	0.5592		-0.00003355	0.7550		-0.00006268	0.5668		-0.00003466	0.7464		-0.00006341	0.5603	
Variance Equation	C	0.00000054	0.0032	***	0.00000037	0.0534	*	0.00000047	0.0370	**	0.00000038	0.0419	**	0.00000047	0.0342	**
	RESID(-1)^2	0.07975632	0.0000	***	0.07262811	0.0001	***	0.07849238	0.0001	***	0.07207529	0.0001	***	0.07878683	0.0001	***
	GARCH(-1)	0.88419430	0.0000	***	0.90363148	0.0000	***	0.89079382	0.0000	***	0.90310188	0.0000	***	0.89081891	0.0000	***
	AIC Criterion	-8.32815152			-8.34343026			-8.34439073			-8.34532140			-8.34634818		
	SIC Criterion	-8.27416622			-8.28453720			-8.28549767			-8.29133609			-8.29236287		
Mean Equation	C	0.00000803	0.9558		0.00001387	0.9210		0.00000526	0.9741		0.00000342	0.9726		-0.00002987	0.8250	
Variance Equation	C	0.00000625	0.0006	***	0.00000601	0.0012	***	0.00000626	0.0004	***	0.00000558	0.0030	***	0.00000560	0.0030	***
	RESID(-1)^2	0.14927782	0.0047	***	0.14906930	0.0069	***	0.14915409	0.0048	***	0.14914713	0.0096	***	0.14923210	0.0108	**
	GARCH(-1)	0.59803037	0.0000	***	0.59752681	0.0000	***	0.59769431	0.0000	***	0.59775291	0.0000	***	0.59794969	0.0000	***
	ZEW	-0.00000499	0.0175	**	-0.00000501	0.0133	**	-0.00000497	0.0203	**	-0.00000477	0.0186	**	-0.00000437	0.0479	**
	IFO	-0.00000330	0.2485		-0.00000308	0.3135		-0.00000239	0.5119		-0.00000173	0.6503		-0.00000170	0.6674	
	PMI_PRODUCTION	0.00000047	0.9113		0.00000068	0.8696		0.00000044	0.9143		0.00000058	0.8790		0.00000040	0.9217	
	PMI_SERVICES	-0.00000526	0.1625		-0.00000519	0.1597		-0.00000661	0.0567	*	-0.00000570	0.1067		-0.00000610	0.0754	*
	GDP	-0.00000758	0.0000	***	-0.00000738	0.0000	***	-0.00000758	0.0000	***	-0.00000706	0.0000	***	-0.00000705	0.0000	***
	FACTORY_ORDERS	0.00000456	0.2657		0.00000426	0.3114		0.00000464	0.2558		0.00000476	0.2131		0.00000363	0.4227	
	INDUSTRIAL_PRODUCTION	0.00000039	0.4412		0.00000026	0.6840		0.00000037	0.4831		0.00000005	0.9478		0.00000032	0.6124	
	AIC Criterion	-8.23261741			-8.254356999			-8.231842007			-8.27752092			-8.28555314		
	SIC Criterion	-8.17863211			-8.195463936			-8.172948944			-8.22353562			-8.23156784		
	ARCH LM Test			**0.1857**			**0.1577**			**0.1856**			**0.1447**			**0.1291**

Note: * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

Table 5 shows that all error distributions are able to eliminate heteroscedasticity in the residual series in the mean equation (Equation Nb. 5) at 10 percent level of statistical significance. Moreover, all produce the same results with the same statistically significant variables.[18]

In other words, the ZEW index and GDP are significant at the 5 and 1 percent levels respectively in explaining the conditional variance. The release of both the ZEW index and GDP data decrease exchange rate volatility on the day of the news announcement. In other words, volatility of the EUR/CZK exchange rate is lower on the day of announcements of these macroeconomic indicators than average rate of volatility. A surprise effect of one standard deviation from the expected values of GDP reduces volatility by approximately 0.0007 percent (depending on the particular error distribution). The same logic applies to the ZEW indicator. A one standard deviation from the expected value of factory orders decreases volatility by 0.0004 – 0.0005 percent. To sum it up, the GDP showed calming effect on the conditional exchange rate volatility in two examining time periods, i.e., the 7-year total examined time series and in post-crisis era.

The announcement of a higher than expected IFO index causes EUR/CZK exchange rate appreciate more than average rate of appreciation (CZK depreciation). A one standard deviation increase in the IFO index surprise[19] implies almost 0.10 percent increase in the exchange rate return on the day of the index announcement. This is 10times bigger change in daily returns in absolute value than the value of median[20] of daily returns of exchange rate during the same examined period. This result is consistent with Büttner et al. (2012), who found that the IFO index had a significant impact on the Czech stock market (PX50) as well as the value of EUR/CZK and USD/CZK exchange rates.

The EGARCH (1,1) model was able to eliminate heteroscedasticity in the residual series in the mean equation using all five error distributions too. The asymmetry component is statistically significant at 5 percent level only using normal error distribution. Results in the appendix in Table 10 suggest that leverage effect is not present in the examined time series. I continue examining the EGARCH model (1,1) without asymmetry component. Table 11 in

[18] Solely GED distribution shows PMI index for Services sector significant in explaining exchange rate volatility as far as 10 percent level of significance.
[19] Following Equation 1.
[20] See Table 1.

the appendix shows the results. All error distributions consider the IFO index statistically significant explanatory variable for the conditional mean of the exchange rate return's value as did GARCH (1,1) model. However, the results of variance equation once again miss economic interpretation, because they suggest that surprise effect of one standard deviation from the expected values of IFO index increases volatility by approximately 17 percent. This number makes no sense comparing it with standard deviation of daily returns in this time period.[21]

Overall, the GARCH (1,1) model fits best the data. As in previous time series the missing leverage effect suggests that using EGARCH-type model is inconvenient.

Central bank interventions (11/2013–2014)

Table 1 shows no evidence of heteroscedasticity in the residuals of the returns series of exchange rate. This result indicates that using generalized autoregressive conditional heteroscedasticity (GARCH) models is not convenient. Additionally, Table 6 indicates that the ARCH term in the GARCH (1,1) model is not statistically significant at 1 percent level using any error distribution. The most favorable results show normal error distribution with ARCH term significant at least at 5 percent level. This distribution shows that the announcement of PMI index form production sector and GDP increase exchange rate volatility on the day of announcement at 5 and 10 percent levels respectively. The announcement of factory orders appreciates CZK. Overall, the sample size is small; thus, the results should not be overemphasized.

Table 6
Estimation results of GARCH (1,1) model for the observed period: 11/2013-2014 (currency interventions)

	GARCH (1,1)	Normal error distribution			Student's t distribution			GED distribution			Student's t distribution with 10 degrees of freedom			GED with parameter fixed at 1.5		
	Observations			296												
	ARCH LM Test			**0.8553**			**0.936893**			**0.952971127**			**0.924908**			**0.9213**
Mean Equation	C	0.00008744	0.3981		0.00005216	0.6002		0.00003376	0.7208		0.00005830	0.5595		0.00004705	0.6328	
	ZEW	-0.00053231	0.3109		-0.00061433	0.1872		-0.00082222	0.0887	*	-0.00059269	0.2124		-0.00069490	0.1552	
	IFO	-0.00084449	0.2477		-0.00082699	0.1633		-0.00107430	0.0661	*	-0.00082547	0.1798		-0.00096594	0.1132	
	PMI_PRODUCTION	0.00070660	0.3051		0.00070966	0.2498		0.00077800	0.2272		0.00070797	0.2581		0.00074297	0.2571	
	PMI_SERVICES	0.00038033	0.6197		0.00032656	0.6041		0.00022233	0.7145		0.00033671	0.6063		0.00027397	0.6745	
	GDP	0.00209779	0.4687		0.00063257	0.8433		-0.00059186	0.8383		0.00090093	0.8075		0.00031751	0.9159	
	FACTORY_ORDERS	-0.00085110	0.0213	**	-0.00069425	0.1450		-0.00065241	0.1684		-0.00072578	0.1075		-0.00073765	0.1005	
	INDUSTRIAL_PRODUCTION	0.00004079	0.8072		0.00003768	0.7643		0.00008084	0.4764		0.00003825	0.7734		0.00006677	0.5921	
Variance Equation	C	0.00000072	0.0000	***	0.00000090	0.0001	***	0.00000090	0.0001	***	0.00000084	0.0000	***	0.00000083	0.0000	***
	RESID(-1)^2	0.11691760	0.0212	**	0.11408502	0.0890	*	0.10987331	0.1261		0.11315535	0.0607		0.11073294	0.0826	*
	GARCH(-1)	0.64820556	0.0000	***	0.60533528	0.0000	***	0.60739803	0.0000	***	0.61360079	0.0000	***	0.61785402	0.0000	***
	AIC Criterion	-9.64100928			-9.65464226			-9.66425049			-9.66047311			-9.66832724		
	SIC Criterion	-9.50386755			-9.50503309			-9.51464132			-9.52333137			-9.53118550		
Mean Equation	C	0.00002219	0.8179		0.00001293	0.8959		-0.00000331	0.9724		0.00000507	0.9578		-0.00000811	0.9310	
Variance Equation	C	0.00000058	0.0000	***	0.00000068	0.0001	***	0.00000068	0.0002	***	0.00000075	0.0001	***	0.00000070	0.0003	***
	RESID(-1)^2	0.09574300	0.0238	**	0.09567584	0.0569	*	0.08963105	0.0975	*	0.09182424	0.1025		0.09261462	0.1092	
	GARCH(-1)	0.71057994	0.0000	***	0.67998654	0.0000	***	0.68954096	0.0000	***	0.66963337	0.0000	***	0.68165501	0.0000	***
	ZEW	-0.00000142	0.3483		-0.00000138	0.4201		-0.00000134	0.4807		-0.00000138	0.4587		-0.00000133	0.5028	
	IFO	-0.00000025	0.8396		-0.00000030	0.8383		-0.00000026	0.8772		-0.00000030	0.8558		-0.00000026	0.8860	
	PMI_PRODUCTION	0.00000275	0.0334	**	0.00000262	0.0841	*	0.00000263	0.1206		0.00000259	0.1244		0.00000263	0.1412	
	PMI_SERVICES	-0.00000097	0.4297		-0.00000098	0.5381		-0.00000086	0.5885		-0.00000085	0.5888		-0.00000085	0.6133	
	GDP	0.00000675	0.0920	*	0.00000649	0.1506		0.00000658	0.1999		0.00000646	0.2070		0.00000663	0.2146	
	FACTORY_ORDERS	-0.00000177	0.1359		-0.00000163	0.2206		-0.00000154	0.2923		-0.00000145	0.3170		-0.00000151	0.3217	
	INDUSTRIAL_PRODUCTION	0.00000026	0.1998		0.00000025	0.2684		0.00000025	0.3344		0.00000025	0.3287		0.00000025	0.3723	
	AIC Criterion	-9.66680998			-9.66557839			-9.671031163			-9.67279512			-9.67748388		
	SIC Criterion	-9.52966824			-9.515969223			-9.521421996			-9.53565338			-9.54034215		
	ARCH LM Test			**0.9581**			**0.9239**			**0.8754**			**0.8723**			**0.8980**

Note: * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

Conclusion

This paper has examined the announcement effects of German macroeconomic news on the conditional mean and conditional variance of daily returns of the EUR/CZK exchange rate. The second object of this paper has been to analyze the volatility characteristics of the exchange rate returns. The 7-year (2008–2014) total examined period; and individual sub-

[21] See Table 1 for the values..

periods (financial crisis, post-crisis and currency intervention periods) are examined separately in order to find the best data fitted model. Therefore, this paper applies both symmetric and asymmetric generalized autoregressive conditional heteroscedasticity models (GARCH) that capture the most stylized features of financial time series. The macroeconomic news announcements considered are forward-looking indicators (the ZEW index, IFO index, PMIs for the service and production sectors) and traditional macroeconomic indicators (GDP, industrial production and factory orders). The data span from the 1st of January 2008 to the 31st of December 2014.

The empirical results show that there is no leverage effect presented in the examined financial time series. Hence, the applied EGARCH (1,1) model does not fit the data set properly and produces irrational results. The outcome projects the GARCH (1,1) model as the most convenient one. Paper shows that GARCH (1,1) model finds different macroeconomic news announcement statistically significant than EGARCH models. In other words, different models may yield varying statistically significant news variables. This paper concludes that the model selection is important in examining the impact of macroeconomic news announcements on the financial market. However, using different error distribution within one model produces the same statistically significant variables. In addition, changing the error distributions may help to eliminate heteroscedasticity from the residual series in the mean equation. Finally, the CNB's currency interventions changed the previous character of exchange rate volatility, particularly vanished volatility clustering. Thus, applying models from GARCH family may not be appropriate for this individual sub-period.

Finally, the paper concludes that announcement of German GDP data is the most significant variable in explaining the exchange rate conditional volatility. The results suggest that this macroeconomic variable is statistically significant in all examined time periods. The announcement of German GDP data has calming effect on the EUR/CZK exchange rate conditional volatility at 1 percent level in 3 out of 4 examined time periods, i.e., the 7-year (2008–2014) total examined period, financial crisis and in post-crisis data set.

The results for individual sub-periods are following. The announcements of GDP, IFO index, factory orders and industrial production have explained the conditional variance during the financial crisis. Moreover, this time period is characterized by both the highest volatility and the biggest number of statistically significant macroeconomic variables in explaining exchange rate conditional variance. Furthermore, the announcements of GDP and ZEW index decrease the exchange rate conditional volatility after the financial crisis. What is more, the exchange rate appreciates more than average rate of appreciation on the day of IFO index announcement. Specifically, the effect of German news announcement on the exchange rate value is presented only in post-crisis the dataset. Finally, the announcements of GDP and PMI index from production sector increase the exchange rate volatility on the day of announcement during the central bank's currency interventions. Besides that, the PMI indices have showed the least significance in influencing conditional volatility.

All in all, German macroeconomic news releases show little impact on conditional mean of daily exchange rate returns. The impact on conditional volatility of the EUR/CZK exchange rate is more significant.

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Data appendix

Additional results for the remaining GARCH family models

7-year examined period (2008–2014)

Table 7
Estimation results of EGARCH (1,1) model for the observed period: 2008–2014

	EGARCH (1,1)	Normal error distribution			Student's t distribution			GED distribution			Student's t distribution with 10 degrees of freedom			GED with parameter fixed at 1.5		
	Observations	**1817**														
	ARCH LM Test			**0.9201**			**0.9961**			**0.9830**			**0.9950**			**0.9963**
Mean Equation	C	0.00003491	0.7198		-0.00003132	0.6542		-0.00005647	0.3946		-0.00001902	0.7934		-0.00003736	0.6262	
	ZEW	-0.00013049	0.7671		0.00007151	0.8253		0.00004106	0.8963		0.00002541	0.9397		-0.00003181	0.9276	
	IFO	-0.00055444	0.2163		-0.00026195	0.4308		-0.00067654	0.0411	**	-0.00022459	0.5148		-0.00045905	0.2118	
	PMI_PRODUCTION	-0.00010261	0.8236		-0.00034150	0.3502		-0.00016149	0.6510		-0.00029160	0.4343		-0.00020353	0.6046	
	PMI_SERVICES	-0.00005018	0.9147		-0.00032067	0.3459		-0.00049357	0.1306		-0.00034639	0.3394		-0.00027615	0.4687	
	GDP	0.00055867	0.5973		0.00064192	0.3951		0.00044013	0.4766		0.00060227	0.4470		0.00056897	0.4600	
	FACTORY_ORDERS	0.00085281	0.0220	**	0.00002078	0.9577		-0.00025331	0.4792		-0.00004660	0.9023		-0.00039649	0.2977	
	INDUSTRIAL_PRODUCTION	-0.00070798	0.1366		0.00014102	0.7014		-0.00022697	0.5161		0.00013114	0.7338		-0.00022065	0.5779	
Variance Equation	C	-0.36302339	0.0000	****	-0.18585380	0.0000	***	-0.21474069	0.0003	***	-0.18953911	0.0000	***	-0.24450321	0.0000	***
	ARCH TERM	0.16692126	0.0000	****	0.14901283	0.0000	***	0.15316172	0.0000	***	0.14277031	0.0000	***	0.15271457	0.0000	***
	ASYMETRIC	-0.00134591	0.8880		-0.01906874	0.1930		-0.01431366	0.3646		-0.01347909	0.2596		-0.00682703	0.5633	
	GARCH	0.97769121	0.0000	****	0.99333062	0.0000	***	0.99078647	0.0000	***	0.99297749	0.0000	***	0.98827357	0.0000	***
	AIC Criterion	-8.08349723			-8.25730563			-8.23299044			-8.24980902			-8.21028677		
	SIC Criterion	-8.04714098			-8.21791970			-8.19360450			-8.21345278			-8.17393052		
Mean Equation	C	-0.00002039	0.8141		-0.00003600	0.6076		-0.00006401	0.3398		-0.00002136	0.7698		-0.00003611	0.6382	
Variance Equation	C	-0.36268946	0.0000	****	-0.18006734	0.0001	***	-0.20478513	0.0006	***	-0.18464563	0.0000	***	-0.23919986	0.0000	***
	ARCH TERM	0.19974433	0.0000	****	0.14073289	0.0000	***	0.14587904	0.0000	***	0.13666720	0.0000	***	0.15419909	0.0000	***
	ASYMETRIC	0.01665107	0.1322		-0.02529134	0.0956	*	-0.01561754	0.3386		-0.01922068	0.1254		-0.00415464	0.7444	
	GARCH	0.98019257	0.0000	****	0.99323950	0.0000	***	0.99114712	0.0000	***	0.99294488	0.0000	***	0.98881115	0.0000	***
	ZEW	0.01103106	0.8660		-0.02115112	0.7562		0.00266142	0.9734		-0.01214686	0.8415		0.01394330	0.8414	
	IFO	-0.01606831	0.7674		0.02516368	0.7056		-0.00316960	0.9667		0.02579631	0.6588		-0.01360534	0.8302	
	PMI_PRODUCTION	-0.02980643	0.6411		-0.04666738	0.5448		-0.05285233	0.5477		-0.04592695	0.5015		-0.04731640	0.5236	
	PMI_SERVICES	-0.07195216	0.2645		-0.03170224	0.6807		-0.04148971	0.6326		-0.01645592	0.8073		-0.05338741	0.4638	
	GDP	-0.20502050	0.1131		-0.12517350	0.2969		-0.14471007	0.3252		-0.12911608	0.2457		-0.15322866	0.2433	
	FACTORY_ORDERS	**0.38273676**	0.0000	****	-0.10057388	0.1970		0.02450676	0.7632		-0.07266969	0.2634		0.13637679	0.0088	***
	INDUSTRIAL_PRODUCTION	**-0.31871647**	0.0000	****	0.08834005	0.2393		0.00859585	0.9173		0.07154399	0.2717		-0.08319638	0.1761	
	AIC Criterion	-8.11638139			-8.25789310			-8.231200209			-8.25023724			-8.21154913		
	SIC Criterion	-8.080025 14			-8.21850716			-8.191814272			-8.21388099			-8.175192 88		
	ARCH LM Test			**0.9894**			**0.9789**			**0.9928**			**0.9836**			**0.9992**

Note: * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

Financial crisis (2008–2009)

Table 8
Estimation results of EGARCH (1,1) model for the observed period: 2008–2009 (Financial crisis)

	EGARCH (1,1)	Normal error distribution			Student's t distribution			GED distribution			Student's t distribution with 10 degrees of freedom			GED with parameter fixed at 1.5		
	Observations			**521**												
	ARCH LM Test			**0.2994**			**0.2314**			**0.2609**			**0.2257**			**0.2500**
Mean Equation	C	-0.00009788	0.6862		-0.00023440	0.3082		-0.00015429	0.4867		-0.00021349	0.3662		-0.00015052	0.5167	
	ZEW	0.00028119	0.8207		0.00048135	0.6716		0.00031429	0.7832		0.00048288	0.6762		0.00031440	0.7904	
	IFO	-0.00255921	0.1335		-0.00244813	0.0663	*	-0.00194037	0.1224		-0.00251343	0.0800	*	-0.00215315	0.1201	
	PMI_PRODUCTION	0.00011482	0.9405		-0.00046047	0.7718		0.00033954	0.8232		-0.00044482	0.7806		0.00015448	0.9208	
	PMI_SERVICES	-0.00144488	0.3839		-0.00132345	0.4398		-0.00185522	0.2393		-0.00121291	0.4688		-0.00167160	0.3026	
	GDP	0.00128464	0.7265		0.00115640	0.6712		0.00115199	0.5290		0.00117375	0.6919		0.00115698	0.6168	
	FACTORY_ORDERS	0.00153111	0.1926		0.00168531	0.0590	*	0.00166161	0.0707	*	0.00169318	0.0791	*	0.00163514	0.0947	*
	INDUSTRIAL_PRODUCTION	0.00005905	0.8077		0.00005867	0.7867		-0.00001604	0.9353		0.00006657	0.7701		0.00001740	0.9351	
Variance Equation	C	-0.66196141	0.0006	***	-0.47507350	0.0157	**	-0.57722324	0.0175	**	-0.48715758	0.0075	***	-0.55898702	0.0086	***
	ARCH TERM	0.27161954	0.0000	***	0.23823398	0.0002	***	0.25775269	0.0002	***	0.23133967	0.0000	***	0.25089846	0.0000	***
	ASYMETRIC	-0.00008109	0.9972		0.00753687	0.8214		0.00437572	0.8955		0.00758849	0.7897		0.00348417	0.9026	
	GARCH	0.95492252	0.0000	***	0.97068934	0.0000	***	0.96221702	0.0000	***	0.96959713	0.0000	***	0.96377124	0.0000	***
	AIC Criterion	-7.28098079			-7.31990662			-7.32169229			-7.31894530			-7.32160342		
	SIC Criterion	-7.18295967			-7.21371708			-7.21550275			-7.22092418			-7.22358231		
Mean Equation	C	-0.00007130	0.7649		-0.00018678	0.4214		-0.00010085	0.6527		-0.00016702	0.4772		-0.00010708	0.6405	
Variance Equation	C	-0.80596025	0.0006	***	-0.77004637	0.0049	***	-0.81627570	0.0085	***	-0.77086978	0.0028	***	-0.81097202	0.0050	***
	ARCH TERM	0.23479308	0.0000	***	0.23036835	0.0003	***	0.23516401	0.0005	***	0.22627756	0.0001	***	0.23302095	0.0002	***
	ASYMETRIC	-0.00153523	0.9531		0.00030246	0.9936		0.00064041	0.9863		0.00119203	0.9717		-0.00000366	0.9999	
	GARCH	0.93820342	0.0000	***	0.94134266	0.0000	***	0.93731931	0.0000	***	0.94142828	0.0000	***	0.93784984	0.0000	***
	ZEW	-0.10455198	0.4986		0.03396527	0.8632		-0.02521307	0.9068		0.00171506	0.9924		-0.04061380	0.8349	
	IFO	0.22691036	0.2175		0.18904996	0.3629		0.21548900	0.3585		0.19274488	0.3293		0.21605844	0.3276	
	PMI_PRODUCTION	-0.28306667	0.0568	*	-0.25197935	0.2415		-0.30433416	0.1663		-0.25087455	0.1928		-0.29520894	0.1405	
	PMI_SERVICES	0.19550815	0.2185		0.15120401	0.4669		0.18680724	0.3999		0.16043733	0.4024		0.18706513	0.3620	
	GDP	-0.50634528	0.0819	*	-0.38769765	0.2253		-0.43171541	0.2404		-0.41313135	0.1761		-0.44643145	0.1948	
	FACTORY_ORDERS	-0.34130174	0.0944	*	-0.36344324	0.0980	*	-0.36476861	0.1480		-0.35416947	0.0953	*	-0.35924200	0.1321	
	INDUSTRIAL_PRODUCTION	0.00452372	0.8733		0.0191735 07	0.5767		0.01579152	0.6723		0.01522257	0.6375		0.01343082	0.7012	
	AIC Criterion	-7.286285502			-7.310823758			-7.316163258			-7.31230432			-7.31827614		
	SIC Criterion	-7.188264387			-7.204634218			-7.209973718			-7.21428321			-7.22025503		
	ARCH LM Test			**0.0347**			**0.0285**			**0.0405**			**0.0291**			**0.0379**

Note: * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

Table 9
Estimation results of EGARCH (1,1) model without asymmetry for the observed period: 2008–2009 (Financial crisis)

	EGARCH (1,1)	Normal error distribution			Student's t distribution			GED distribution			Student's t distribution with 10 degrees of freedom			GED with parameter fixed at 1.5		
	Observations			**521**												
	ARCH LM Test			**0.3110**			**0.2008**			**0.2390**			**0.2181**			**0.2374**
Mean Equation	C	-0.00009788	0.6862		-0.00023440	0.3082		-0.00015429	0.4867		-0.00021349	0.3662		-0.00015052	0.5167	
	ZEW	0.00028119	0.8207		0.00048135	0.6716		0.00031429	0.7832		0.00048288	0.6762		0.00031440	0.7904	
	IFO	-0.00255921	0.1335		-0.00244813	0.0663	*	-0.00194037	0.1224		-0.00251343	0.0800	*	-0.00215315	0.1201	
	PMI_PRODUCTION	0.00011482	0.9405		-0.00046047	0.7718		0.00033954	0.8232		-0.00044482	0.7806		0.00015448	0.9208	
	PMI_SERVICES	-0.00144488	0.3839		-0.00132345	0.4398		-0.00185522	0.2393		-0.00121291	0.4688		-0.00167160	0.3026	
	GDP	0.00128464	0.7265		0.00115640	0.6712		0.00115199	0.5290		0.00117375	0.6919		0.00115698	0.6168	
	FACTORY_ORDERS	0.00153111	0.1926		0.00168531	0.0590	*	0.00166161	0.0707	*	0.00169318	0.0791	*	0.00163514	0.0947	
	INDUSTRIAL_PRODUCTION	0.00005905	0.8077		0.00005867	0.7867		-0.00001604	0.9353		0.00006657	0.7701		0.00001740	0.9351	
Variance Equation	C	-0.66761417	0.0006	***	-0.46833928	0.0159	**	-0.57018643	0.0180	**	-0.52484335	0.0066	***	-0.57849855	0.0081	***
	ARCH TERM	0.27371666	0.0000	***	0.23930788	0.0001	***	0.25794970	0.0002	***	0.24040450	0.0000	***	0.25341251	0.0000	***
	GARCH	0.95452559	0.0000	***	0.97141467	0.0000	***	0.96291606	0.0000	***	0.96657337	0.0000	***	0.96204800	0.0000	***
	AIC Criterion	-7.28478970			-7.32365682			-7.32548790			-7.32259014			-7.32536300		
	SIC Criterion	-7.19493702			-7.22563570			-7.22746679			-7.23273745			-7.23551031		
Mean Equation	C	-0.00006941	0.7595		-0.00018705	0.4153		-0.00010148	0.6460		-0.00016817	0.4663		-0.00010708	0.6328	
Variance Equation	C	-0.80294291	0.0006	***	-0.77034176	0.0049	***	-0.81723559	0.0084		-0.77228998	0.0028	***	-0.81096604	0.0050	***
	ARCH TERM	0.23378696	0.0000	***	0.23049708	0.0002	***	0.23551594	0.0004		0.22684660	0.0001	***	0.23301883	0.0002	***
	GARCH	0.93842243	0.0000	***	0.94132292	0.0000	***	0.93725198	0.0000		0.94133139	0.0000	***	0.93785026	0.0000	***
	ZEW	-0.10654188	0.4744		0.03428360	0.8613		-0.02444613	0.9086		0.00299921	0.9867		-0.04061832	0.8316	
	IFO	0.22724758	0.2161		0.18887559	0.3631		0.21522860	0.3592		0.19219424	0.3308		0.21605980	0.3275	
	PMI_PRODUCTION	-0.28189004	0.0528	*	-0.25194773	0.2333		-0.30460204	0.1566		-0.25107364	0.1829		-0.29520697	0.1322	
	PMI_SERVICES	0.19368990	0.2149		0.15134259	0.4606		0.18738905	0.3911		0.16124831	0.3933		0.18706148	0.3542	
	GDP	-0.50552128	0.0820	*	-0.38783649	0.2249		-0.43202001	0.2399		-0.41362894	0.1756		-0.44642941	0.1946	
	FACTORY_ORDERS	-0.34036014	0.0929	*	-0.36358546	0.0969	*	-0.36512369	0.1464		-0.35472572	0.0940	*	-0.35923982	0.1308	
	INDUSTRIAL_PRODUCTION	0.00413000	0.8801		0.01923571	0.5650		0.01593962	0.6606		0.01548095	0.6216		0.01342994	0.6922	
	AIC Criterion	-7.290120055			-7.314662417			-7.320001524			-7.31614108			-7.32211492		
	SIC Criterion	-7.200267367			-7.216641303			-7.22198041			-7.22628840			-7.23226223		
	ARCH LM Test			**0.0350**			**0.0284**			**0.0403**			**0.0287**			**0.0379**

Note: * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

After the crisis (2009–6.11.2013)

Table 10

Estimation results of EGARCH (1,1) model for the observed period: 2010–11/2013 (after the Financial crisis)

	EGARCH (1,1)	Normal error distribution			Student's t distribution			GED distribution			Student's t distribution with 10 degrees of freedom			GED with parameter fixed at 1.5		
	Observations			**1000**												
	ARCH LM Test			**0.3354**			**0.3482**			**0.3011**			**0.3530**			**0.2981**
Mean Equation	C	0.00004346	0.6936		0.00001114	0.9178		-0.00000365	0.9727		0.00001237	0.9090		-0.00000694	0.9478	
	ZEW	0.00051262	0.3082		0.00047024	0.3569		0.00051149	0.3083		0.00047180	0.3560		0.00051524	0.3030	
	IFO	0.00077052	0.0503	*	0.00082457	0.0362	**	0.00081231	0.0430	**	0.00081772	0.0377	**	0.00081256	0.0430	**
	PMI_PRODUCTION	-0.00055202	0.3012		-0.00068340	0.1711		-0.00059845	0.2240		-0.00067589	0.1777		-0.00059671	0.2211	
	PMI_SERVICES	-0.00086956	0.1087		-0.00064730	0.2040		-0.00064520	0.1992		-0.00066103	0.1965		-0.00062613	0.2093	
	GDP	0.00025990	0.7838		0.00030400	0.7221		0.00032456	0.7038		0.00029761	0.7288		0.00032987	0.6963	
	FACTORY_ORDERS	-0.00000393	0.9962		0.00009798	0.8923		0.00015961	0.8192		0.00009936	0.8917		0.00016912	0.8060	
	INDUSTRIAL_PRODUCTION	-0.00006159	0.5795		-0.00003209	0.7657		-0.00005663	0.6072		-0.00003350	0.7549		-0.00005764	0.5986	
Variance Equation	C	-0.45395328	0.0005	***	-0.35725283	0.0146	**	-0.42737605	0.0110	**	-0.35899259	0.0097	***	-0.42671656	0.0092	***
	ARCH TERM	0.14220145	0.0000	***	0.13969175	0.0000	***	0.14621941	0.0000	***	0.13851298	0.0000	***	0.14697562	0.0000	***
	ASYMETRIC	0.03548431	0.0160	**	0.02150944	0.3214		0.02612604	0.2055		0.02217284	0.2880		0.02548856	0.2249	
	GARCH	0.96923786	0.0000	***	0.97770858	0.0000	***	0.97192357	0.0000	***	0.97750670	0.0000	***	0.97201326	0.0000	***
	AIC Criterion	-8.32927850			-8.34437171			-8.34446663			-8.34630227			-8.34636719		
	SIC Criterion	-8.27038544			-8.28057089			-8.28066581			-8.28740921			-8.28747413		
Mean Equation	C	0.00007367	0.51		0.00002190	0.84		0.00000661	0.95		0.00002310	0.83		-0.00000185	0.99	**
Variance Equation	C	-0.34827801	0.0027	***	-0.28889445	0.0236	**	-0.34419120	0.0188	**	-0.28947236	0.0188	**	-0.34485234	0.0197	**
	ARCH TERM	0.12011382	0.0000	***	0.12170272	0.0001	***	0.12653753	0.0001	***	0.12126092	0.0001	***	0.12796077	0.0001	***
	ASYMETRIC	0.03238037	0.0500	**	0.01976670	0.3568		0.02324038	0.2838		0.02007871	0.3404		0.02201804	0.3269	
	GARCH	0.97725496	0.0000	***	0.98267943	0.0000	***	0.97811132	0.0000	***	0.98260886	0.0000	***	0.97812335	0.0000	***
	ZEW	-0.01043989	0.8837		-0.03798693	0.6633		-0.02587290	0.7801		-0.03724775	0.6650		-0.02805766	0.7687	
	IFO	0.16387432	0.0133	**	0.15322969	0.0772	*	0.16404746	0.0610	*	0.15312846	0.0740	*	0.16438626	0.0701	*
	PMI_PRODUCTION	-0.10940549	0.2387		-0.12689417	0.2284		-0.12409630	0.2744		-0.12649463	0.2273		-0.12585747	0.2807	
	PMI_SERVICES	0.01318220	0.8731		-0.03139549	0.7606		-0.00367394	0.9725		-0.03035907	0.7642		-0.00586854	0.9572	
	GDP	-0.24163429	0.1238		-0.22490883	0.1818		-0.23681701	0.2039		-0.22519771	0.1790		-0.23646670	0.2146	
	FACTORY_ORDERS	0.09512977	0.3285		0.02461984	0.8300		0.04641116	0.7023		0.02652618	0.8147		0.03998618	0.7484	
	INDUSTRIAL_PRODUCTION	0.01650210	0.3360		0.018578114	0.3639		0.01979703	0.3607		0.01846698	0.3632		0.020266681	0.3645	
	AIC Criterion	-8.330104046			-8.342192935			-8.342850223			-8.34418099			-8.34458487		
	SIC Criterion	-8.271210983			-8.278392117			-8.279049405			-8.28528793			-8.28569181		
	ARCH LM Test			**0.3166**			**0.3571**			**0.2808**			**0.3572**			**0.2760**

Note: * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

Table 11
Estimation results of EGARCH (1,1) model without asymmetry for the observed period: 2010–11/2013 (after the Financial crisis)

	EGARCH (1,1)	Normal error distribution			Student's t distribution			GED distribution			Student's t distribution with 10 degrees of freedom			GED with parameter fixed at 1.5		
	Observations			1000												
	ARCH LM Test			0.2395			0.3102			0.2501			0.3135			0.2509
Mean Equation	C	0.00000019	0.9986		-0.00000778	0.9413		-0.00002451	0.8147		-0.00000596	0.9552		-0.00002577	0.8048	
	ZEW	0.00051322	0.3173		0.00047036	0.3585		0.00051531	0.3079		0.00047256	0.3575		0.00051690	0.3054	
	IFO	0.00083417	0.0340	**	0.00084256	0.0332	**	0.00083920	0.0377	**	0.00083509	0.0349	**	0.00083816	0.0379	**
	PMI_PRODUCTION	-0.00058384	0.2891		-0.00068973	0.1694		-0.00060574	0.2203		-0.00068013	0.1794		-0.00060414	0.2191	
	PMI_SERVICES	-0.00079706	0.1636		-0.00062820	0.2194		-0.00060287	0.2352		-0.00064581	0.2111		-0.00059420	0.2398	
	GDP	0.00028713	0.7586		0.00032461	0.7022		0.00035077	0.6783		0.00031603	0.7113		0.00035277	0.6750	
	FACTORY_ORDERS	0.00006054	0.9414		0.00013113	0.8565		0.00018736	0.7892		0.00012877	0.8607		0.00019480	0.7795	
	INDUSTRIAL_PRODUCTION	-0.00004980	0.6591		-0.00001806	0.8674		-0.00005423	0.6253		-0.00001933	0.8576		-0.00005504	0.6178	
Variance Equation	C	-0.52891185	0.0001	***	-0.38475317	0.0136	***	-0.47666309	0.0078	***	-0.38946590	0.0071	***	-0.47436806	0.0050	***
	ARCH TERM	0.15950720	0.0000	***	0.14759422	0.0000	***	0.15784915	0.0000	***	0.14627581	0.0000	***	0.15789195	0.0000	***
	GARCH	0.96376263	0.0000	***	0.97579511	0.0000	***	0.96831494	0.0000	***	0.97534381	0.0000	***	0.96850933	0.0000	***
	AIC Criterion	-8.32808829			-8.34549088			-8.34517236			-8.34732363			-8.34714494		
	SIC Criterion	-8.27410298			-8.28659781			-8.28627930			-8.29333832			-8.29315963		
Mean Equation	C	0.00003141	0.7752		0.00000408	0.9695		-0.00001426	0.8934		0.00000593	0.9559		-0.00001910	0.8566	
Variance Equation	C	-0.43325034	0.0009	***	-0.32856628	0.0181	**	-0.40178989	0.0118	**	-0.33210271	0.0114	**	-0.39969179	0.0108	**
	ARCH TERM	0.13727556	0.0000	***	0.13178059	0.0000	***	0.13884221	0.0000	***	0.13118855	0.0000	***	0.13936541	0.0000	***
	GARCH	0.97091133	0.0000	***	0.97983841	0.0000	***	0.97382277	0.0000	***	0.97951437	0.0000	***	0.97402018	0.0000	***
	ZEW	-0.02380187	0.7724		-0.04882275	0.6044		-0.03821730	0.7089		-0.04749700	0.6077		-0.03943028	0.7042	
	IFO	0.16952906	0.0193	**	0.15494519	0.0892	*	0.16772858	0.0735	*	0.15486814	0.0835	*	0.16779380	0.0799	*
	PMI_PRODUCTION	-0.14851144	0.1284		-0.14701427	0.1750		-0.14938998	0.2050		-0.14712981	0.1712		-0.14943939	0.2130	
	PMI_SERVICES	0.04456809	0.5996		-0.01761378	0.8673		0.01448220	0.8945		-0.01433630	0.8883		0.01185871	0.9145	
	GDP	-0.24805336	0.1385		-0.22482892	0.1962		-0.23770266	0.2225		-0.22570945	0.1905		-0.23720519	0.2289	
	FACTORY_ORDERS	0.07238937	0.4930		0.00430361	0.9709		0.02760463	0.8290		0.00800331	0.9451		0.02369015	0.8551	
	INDUSTRIAL_PRODUCTION	0.02304976	0.1773		0.02142670	0.2942		0.02391392	0.2623		0.02132001	0.2869		0.02403651	0.2681	
	AIC Criterion	-8.32939574			-8.34342544			-8.34381092			-8.34536023			-8.34567136		
	SIC Criterion	-8.27541044			-8.28453237			-8.28491786			-8.29137492			-8.29168605		
	ARCH LM Test			**0.2107**			**0.3091**			**0.2200**			**0.3058**			**0.2206**

Note: * denotes significance at the 10% level, ** denotes significance at the 5% level, *** denotes significance at the 1% level.

Table 12
Statistical properties of German macroeconomic news announcements

	ZEW	IFO	PMI PRODUCTION	PMI SERVICES	FACTORY ORDERS	GDP	INDUSTRIAL PRODUCTION
Mean	8.44	102.06	50.50	52.48	-0.17%	0.23%	-0.12%
Median	12.25	105.40	51.15	52.55	-0.15%	0.30%	0.00%
Maximum	62.00	114.50	62.60	60.10	5.20%	2.20%	4.00%
Minimum	-63.90	45.60	32.00	41.60	-8.00%	-2.10%	-7.50%
Std. Dev.	36.70	10.37	6.86	4.00	3.10%	0.82%	2.01%
Skewness	-0.36	-2.40	-0.80	-0.54	-0.33	-0.34%	-0.49
Kurtosis	1.91	11.93	3.84	3.38	2.51	4.77	4.11
Jarque-Bera (Prob.)	6 (0.05)	359.58 (0.00)	11.06 (0.00)	4.15 (0.13)	2.31 (0.32)	4.20 (0.12)	7.74 (0.02)
Observations	84	84	82	76	84	28	84.00

Note: GDP has lower number of observations as it is measured quarterly; PMI indexes were firstly published during the year 2008.

Final Notes

Description of examined German macroeconomic news announcements

ZEW index – released monthly on second or third Thursday of the current month. It is a survey of approximately 275 German institutional investors and analysts who are asked to rate the relative 6-month economic outlook for Germany. Investors and analysts are highly informed by virtue of their jobs; therefore, changes in their sentiments can provide early signals of future economic activity and is a leading indicator of economic health.

IFO index - released monthly, approximately 3 weeks into the current month. It is based on surveyed of 7,000 manufacturers, builders, wholesalers and retailers. It asks respondents to rate the relative level of current business conditions and expectations for the next 6 months. Businesses react quickly to market conditions, and changes in their sentiments can provide early signals of future economic activity, such as spending, hiring, and investment, which is a leading indicator of economic health.

Purchasing manager's index (PMI) for the manufacturing sector - released monthly, approximately 3 weeks into the current month. There are 2 versions of this index – flash and final. The flash index release provides the market with new information sooner than the final version. Thus, the market reaction to the flash PMI index is more significant. For this reason, we examine the impact of flash data. The flash PMI index was first released in March 2008, so values are zero for January and February 2008. This indicator consists of a survey of approximately 500 purchasing managers who are asked to rate the relative level of business conditions, including employment, production, new orders, prices, supplier deliveries, and inventories. Businesses react quickly to market conditions, and their purchasing managers hold perhaps the most current and relevant insights into the company's view of the economy, which is a leading indicator of economic health.

Purchasing manager's index (PMI) for the service sector - released monthly, approximately 3 weeks into the current month. The flash index was firstly released in March 2008; therefore, the values are zero for January and February 2008. This paper examines flash data rather than final data for the same reason described above for the PMI for the manufacturing sector. The index is identical to the PMI index from manufacturing sector with but surveys managers (500) who work in the service sector.

Factory orders - released monthly, approximately 35 days after the month ends. Increasing purchase orders signal that manufacturers will increase activity as they work to fill the orders. It shows the change in the total value of new purchase orders placed with manufacturers. It is a leading indicator of production.

Industrial production - released monthly, approximately 40 days after the month ends. This indicator shows changes in the total inflation-adjusted value of the output produced by manufacturers, mines, and utilities.

GDP (Gross domestic product) - released quarterly, approximately 45 days after the quarter ends. This indicator shows the change in the inflation-adjusted value of all goods and services produced by the economy. There are 2 versions of GDP released approximately 10 days apart – preliminary and final. The preliminary release is the earliest and thus tends to have a larger impact. We examine data for the preliminary GDP release.

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