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Multivariate GARCH estimations of volatility spillover amongst oil prices, exchange rates and news-based uncertainty in the CEE - 3 countries

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Abstract

This study empirically examined the comparative difference in the outcomes of multivariate GARCH estimations in the volatility transmission amongst oil prices, new-based policy uncertainty and exchange rates of the CEE-3 countries. The methodological scope is restricted to BEKK-GARCH, Constant CCC-GARCH and VEC-GARCH. The results of this research indicate significant transfer of volatility from the HUF/EUR, PLN/EUR, and CZK/EUR exchange rates to the price of Brent oil. The BEKK-GARCH results uphold the co-volatility with relation to exchange rates and oil prices in the CEE-3 countries and this was found as highly reciprocating and interdependent. The research also established a reciprocating transmission of volatility between the fluctuating price of oil and news based economic policy uncertainties in Hungary and Czech. The CCC-GARCH model sufficiently estimated oil price volatility spillover on currency rate and its volatility spillover on oil price fluctuation in Czech while VEC-GARCH model estimations sufficiently estimated oil price volatility transmission to exchange rates. The Polish and Czech news-based policy uncertainties were significant in influencing the PLN/EUR and CZK/EUR exchange rates respectively. The BEKK-GARCH and VECH-GARCH model estimations are efficient and hence highly recommended for ascertaining the volatility transmission within the financial markets in the CEE-3 countries.

Keywords: BEKK-GARCH model, CCC-GARCH model, CZK/EUR exchange rate, High-Income countries, HUF/EUR exchange rate, NEWS-based uncertainty, Oil price variation, PLN/EUR exchange rate, VEC-GARCH model, Volatility transmission.

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Contribution of this paper to the literature

The study advances our understanding of the modeling volatility spread amongst news-based uncertainty, exchange rate returns, and shocks to the price of oil of the CEE-3 countries. The discovery of a reciprocal distribution of volatility between news-based economic policy uncertainty and fluctuating oil prices in Hungary and the Czech Republic adds to the body of empirical research. For future financial economics scientists who could be intrigued by the fields of market volatility modeling, this could serve as a resource.

1. Introduction

The three nations that make up Central and Eastern Europe (CEE) are the subject of this study is Hungary, the Czech Republic, and Poland. The prolonged instability brought on by Russia's war has exposed the CEE region to longer-term vulnerabilities, including high inflation and an economic downturn. Along with increased uncertainty, pandemics, and shocks to energy prices, these economies have also seen slower short-term growth and long-term macroeconomic prospects that are affected. Significant disruptions have been transmitted to Poland, Hungary, and the Czech Republic by the combined effect of all these variables. In July 2024, the positive trade balance with EU Member States increased by CZK 5.8 billion, year over year, according to the (Ikwuagwu & Yagboyaju, 2023). The amount of the trade imbalance with non-EU nations rose by CZK 3.4 billion. The primary cause of the negative impact on the overall trade balance was a greater trade deficit of CZK 3.7 billion in basic metals and CZK 1.9 billion in "refined petroleum products," among other items. The Hungarian economy is extremely susceptible to shocks from without. The threats are defined by poor macroeconomic growth and significant uncertainty about the strength of the macroeconomy. The selection of these countries stems from the fact that, in terms of economic growth and development, they are transition economies, becoming market economies. These nations also use the same currency.

The vulnerabilities are typified by large budget deficit expenditure, poor macroeconomic activity, and significant concerns about the health of the macroeconomy. For instance, the GDP growth rate in 2022 was 4.6%, but in 2023 it fell by 0.9%. Capital inflows that generate debt are used to finance the external deficit. In July 2024, the USD to HUF exchange rate saw a 90-day high of 371.5440 and a 90-day low of 351.6660. This suggests that the USD/HUF changed by -3.92 and the 90-day average was 359.5148. Poland is home to a thriving market that is situated in the center of Central Europe. In 2022, the GDP expanded by 4.9% after declining by 2.7% in 2020. Nonetheless, there has been a noticeable decline in economic activities of Poland as a result of Russia's invasion of Ukraine. The exchange rate between the euro and Polish zloty on September 19, 2024, was 4.27. In June 2023, Poland's exchange rate versus the US dollar averaged 4.1 (USD/PLN). In comparison to April 2024, the daily average foreign exchange market turnover grew by 276 million USD (3.1%) to USD 9,145 million, according to the (Nabila, Usman, Indryani, & Kurniasari, 2021).

The CEE countries are major consumers of oil, rather than producers. When oil prices rise, these countries experience higher import costs, leading to inflation and a weaker currency (Abiad & Qureshi, 2023). Conversely, when oil prices fall, their economies benefit from lower fuel costs, leading to decreased inflation and a stronger currency. Aside oil price shocks, news-based uncertainty is another crucial factor that may also play significant role in the dynamics of financial markets in Africa and Europe (Adeosun, Adeosun, Tabash, & Anagreh, 2023). In recent years, the rise of globalization has interconnected economies and financial systems across the globe, making news events and uncertainty in one region affect foreign exchange rates in another. Hence, news events such as political unsteadiness, economic downturns, natural disasters, or geopolitical tensions in one region can have ripple effects on foreign exchange rates in other regions (Bush & Noria, 2021). Investors and traders closely monitor news events to assess risks and make informed decisions on foreign exchange trading.

In Europe, news-based uncertainty can impact foreign exchange rates, especially during times of economic instability or political turmoil (Olasehinde-Williams & Olanipekun, 2022). The Eurozone, which comprises 19 nations that use the euro as their currency, is particularly sensitive to news events that can impact the stability of the euro. For instance, news of a potential breakup of the Eurozone or a major economic crisis in one of its member countries can lead to fluctuations in foreign exchange rates across the region. Moreover, news-based uncertainty in Europe can also be driven by external factors such as global economic trends, trade policies, or changes in interest rates by central banks. For example, news of a trade war between major economies like the US and China can impact foreign exchange rates in Europe as investors and traders adjust their positions based on the potential risks and opportunities arising from such news events (Aftab, Naeem, Tahir, & Ismail, 2024).

In Europe, the oil price uncertainty and exchange rate problems also pose significant challenges to the economy. This is because high income nations in Europe is highly dependent on oil imports to meet its energy needs, and fluctuations in oil prices can lead to increased costs for consumers and businesses. This can impact inflation rates, consumer spending, and overall economic growth in the region. Additionally, exchange rate problems resulting from oil price uncertainty can create instability in the financial markets, leading to fluctuations in stock prices, currency values, and investment decisions (Olasehinde-Williams & Olanipekun, 2022). Despite the fact that some studies have been carried out for the BRICS nations (Umoru et al., 2023; Wang, Cheng, & Cao, 2022) no recent study utilized a combination of multivariate GARCH estimation methods like BEKK-GARCH, CCC-GARCH and VEC-GARCH from 2019Q1 to 2023Q4. This study sought to fill this research gap. Accordingly, the study aims at ascertaining whether or not there is a significant difference in the outcomes of volatility spillover amongst oil prices, exchange rates and uncertainty basing analysis on Multivariate GARCH Estimations in High Income Countries. The findings of the study contribute to knowledge and add up to empirical literature on oil price shocks, news-based uncertainty and exchange rate returns modeling. This could become a reference point for prospective researchers in financial economics who may be interested in the areas of market volatility modeling. The following section provides a synopsis of related studies. The study's methodology, results, and discussions come next. The final section of the paper is the concluding remarks.

2. Earlier Scientific Findings

The dynamic volatility spillover between the BRICS nations' gold, exchange, and oil prices was examined by Oladeji and Musa (2022). The analysis discovered a relationship between China's exchange rate and oil prices, but not between Brazil and India's volatility spillover toward gold. Yusufu, Yusufu, and Abdullahi (2022) worked on the association that exists between foreign direct investment and volatility in rates of exchange in Turkey. Expected gain from FDI is at risk as the oscillations in the rate of exchange express or show instability. Nevertheless, FDI has crucially influenced how many investments take place. We examine the relationship between the volatility of the exchange rate and foreign direct investment (FDI) in Turkey from the fourth quarter of 2005 to the first quarter of 2018. With the use of the Toda-Yamamoto causality test, the oscillations in the rate of exchange were ascertained.

Using copulas, Wang et al. (2022) investigated the potential of oil price shocks to predict the CNY/USD exchange rate. The bivariate copula outperformed the univariate in terms of predicting abilities, according to the results. The influence of both domestic and international oil prices on the Chinese currency rate was shown to be considerable by Kutu, Alorı, and Ngalawa (2021). Chang and Tan (2008) investigated how the dollar's value fluctuated in relation to the exchange rates of OPEC nations. The dynamic factor technique was used by Camanho, Hau, and Rey (2022) to assess the degree of uncertainty in the Colombian economy. The market rate of the peso and the prices of gas and oil were utilized by the author. The created index demonstrates the rise in unpredictability that coincided with the 2008 global and COVID-19 crises.

In a study by Abdullahi, Abubarkar, Fakunmoju, and Giwa (2016) which analyzed the causes of instability in rates of exchange, it was pointed out that change in foreign reserves adversely caused fluctuations in currency rates in Bangladesh, Malaysia, and China, while India's exchange rate fluctuated wildly. Nonetheless, changes in government spending had a positive and significant impact on currency rate fluctuations in China, Malaysia, Pakistan, Indonesia, and Bangladesh. The fluctuation in terms of trade required a significant reduction in the rate of exchange fluctuations in Bangladesh and Pakistan. But in China, Malaysia, Pakistan, Indonesia, and India, it causes an increase in that. On its own side, variations in gold price added advantageously and in a momentous way to the rate of exchange volatility in Indonesia, Bangladesh, and Malaysia.' The precariousness in the rate of exchange of Pakistan and Indonesia was majorly influenced by production.

By using the wavelet analysis approach, Engle (2002) highlighted the time-frequency connection between oil prices, stock market returns, and currency rates. The results demonstrate a strong relationship between foreign exchange rates and oil prices, that is, the Indian stock market. The association between the Indian market's exposure to developed markets' volatility and a few macroeconomic events was identified by the author. Seguino (2020) examines the link between the G10 exchange rate and the OPEC newspaper count index using a Bayesian inference approach and multiple vector autoregressive models.

Salimi, Saeedi, Heidarzadeh, and Emamverdi (2023) investigated the influence the instruments of monetary policy had on the volatility of the rate of exchange from 1997 to 2017 in Sudan. To ascertain the influence in the short-term period, they made use of co-integration analysis. Proceeding from this, they established that the variables were stable at their first difference. To analyze the long-term link, VECM was estimated. The findings showed that there has been instability in the currency rate of Sudan throughout the time frame under investigation. The variations in the money supply and variables of the rate of profit margin that experienced involvement of the Central Bank of Sudan from time to time explained the volatility in the short term.

3. Econometric Methodology

The research evaluates transmission of volatility amongst the CEE-3 countries' exchange rates. The CEE- 3 countries considered in this research are Hungary, Poland and Czech Republic. Accordingly, the HUF/EUR, PLN/EUR and CZK/EUR serve as the CEE-3's currency exchange rates, respectively. Each of the CEE-3's monthly currency exchange rate returns was utilized. Also, monthly volatility in Brent crude oil prices was utilized for estimation. The news-based economic policy uncertainty index uncertainty was constructed by evaluating the frequency of words associated with news, policy, and uncertainty appearing together in the English-language main newspapers of Hungary, Poland, and the Czech Republic. This methodology of obtaining economic country-specific uncertainty was pioneered by Baker, Bloom, and Davis (2016). It has also been adopted by Kilic and Balli (2024).

The econometrics estimations covered the sample period of January 2009 to June 2024. The choice of these CEE- 3 countries stems from the fact that they are transition economies. These countries are on transition to market economies as against being communist nations. The econometric methodological scope is restricted to three (3) multivariate-GARCH estimation techniques. These include: BEKK-GARCH, CCC-GARCH and VECH-GARCH. The E-views 13 econometric software was utilized in the estimation process. The output of each was compared to determine the best fit for volatility spillover estimation for developing and developed countries. We measure the reliability of news-based uncertainty by examining their track record of accuracy. This was done by looking at the history of the news outlet and checking for any past instances of false reporting or bias. Additionally, analyzing the sources of the news outlet provided insight into the credibility of news outlets. According to Bush and Noria (2021) when a news source consistently relies on reputable sources and fact-checks their information, it is likely to be more reliable.

The BEKK-GARCH, CCC-GARCH and VEC-GARCH models were estimated. The justification for estimating these set of equations is rooted on the fact that BEKK-GARCH equation is a potent tool for measuring volatility in financial markets. Its capacity to measure cross-correlations between variables as well as time-varying volatility makes it a useful model for risk control and portfolio enhancement (Rastogi & Kanoujiya, 2024). Similarly, the CCC-GARCH equation has become a valuable tool for financial analysts and researchers in modeling and forecasting asset or rate returns in volatile markets (Xiao, Xu, Liu, & Liu, 2020). By incorporating both the CCC assumption and the GARCH process, this equation provides a more comprehensive and flexible framework for capturing the dynamics of volatility (Salimi et al., 2023). As financial markets continue to evolve and become more complex, the CCC-GARCH equation remains a key tool for understanding and managing risk in portfolios. In line

with the preceding, the BEKK-GARCH model was effectively applied in this research to the analysis of financial data to show interdependencies. The mean and variance equations listed below define the model:

$$HUF/EUR_{it} = \delta_i + \sum_{i=1}^{p} \gamma_{ik} HUF/EUR_{t-j} + \sum_{j=1}^{q} \beta e_{t-j,i}$$

$$\sigma^2_{HUF/EUR_{it}} = B_0 B_0^{'} \delta_i + \sum_{i=1}^{p} G_{i_k} e_{t-i} e_{t-i}^{'} G_i^{'} + \sum_{j=1}^{q} C_i \sigma^2_{HUF/EUR_{it}t-i} C_i^{'} \quad (1)$$

$$PLN/EUR_{it} = \varphi_i + \sum_{i=1}^{p} \alpha_{ik} PLN/EUR_{t-j} + \sum_{j=1}^{q} \rho e_{t-j,i}$$

$$\sigma^2_{PLN/EUR_{it}} = B_0 B_0^{'} + \sum_{i=1}^{p} G_{i_k} e_{t-i} e_{t-i}^{'} G_i^{'} + \sum_{j=1}^{q} C \sigma^2_{PLN/EUR_{it}t-i} C_i^{'} \quad (2)$$

$$CZK/EUR_{it} = \tau_i + \sum_{i=1}^{p} \varpi_{ik} CZK/EUR_{t-j} + \sum_{j=1}^{q} \mu e_{t-j,i}$$

$$\sigma^2_{CZK/EUR_{it}} = B_0 B_0^{'} + \sum_{i=1}^{p} G_{i_k} e_{t-i} e_{t-i}^{'} G_i^{'} + \sum_{j=1}^{q} C \sigma^2_{CZK/EUR_{it}t-i} C_i^{'} \quad (3)$$

where: $\delta_i \varphi_i \tau_i$ are the mean of HUF/EUR, PLN/EUR and CZK/EUR exchange rates; γ and β; α and ρ; and ϖ and $\mu$are the autoregressive and moving average coefficients of the aforementioned exchange rates respectively; $\sigma^2_{HUF/EUR_{it}}$, $\sigma^2_{PLN/EUR_{it}}$ and $\sigma^2_{CZK/EUR_{it}}$ are the conditional covariance matrices of HUF/EUR, PLN/EUR and CZK/EUR at time t; B_0 is a matrix of constants; G_{i_k} and C_i are coefficient matrices; e_t is an array of standardized regression errors; p and q are the lag orders. The breaking down of the conditional covariance matrix into conditional correlation is the methodological applicability of the CCC-GARCH model. Therefore, a considering serially uncorrelated vectors of zero-mean, the variables are modeled using the following Equation 4.

$$e_t = X_t - \mu \quad (4)$$

The covariance of the study's variables was used to express the contemporaneous correlation, so that:

$$\sum_t E_{t-1}[(X_t - \mu)(X_t - \mu)'] \quad (5)$$

To correct for conditional heteroskedasticity, we estimated for each variable, the conditional volatility σ_t^{2i} using a GARCH model and the standardized residuals are given by:

$$\upsilon_t = C_t^{-1}(X_t - \mu), \quad (6)$$

$$\begin{cases} C_t^{i,i} = \sigma_t^i \forall i = j \\ C_t^{i,i} = 0 \forall i \neq j \end{cases} \quad (7)$$

where C_t represents conditional fluctuations contained in a diagonal matrix as expressed in Equation 7, so that the CCC estimator matrix of (Bollerslev, 1990) becomes:

$$\overline{r} = 1/T \sum_{t=1}^{T} [C_t^{-1}(X_t - \mu)] [C_t^{-1}(X_t - \mu)]_t^{'} \quad (8)$$

The dynamic conditional correlations (DCC) were estimated based on Equation 9.

$$\rho_{CCC} = \overline{r} + \varphi[\upsilon_{t-1}\upsilon_{t-1}^{'} - \overline{r}] + \eta[\rho_{t-1} - \overline{r}] \quad (9)$$

$$\rho_{CCC} = \overline{r} + \varphi \frac{1}{C_{t-1}} \left([(X_{t-1} - \mu)][(X_{t-1} - \mu)]_t^{'} - \overline{r} \right) + \eta[\rho_{t-1} - \overline{r}] \quad (10)$$

The GARCH representation of the DCC-GARCH model is given correspondingly in Equation 11:

$$\rho_{CCC} = \Phi + \varphi \upsilon_{t-1} \upsilon_{t-1}' + \eta \rho_{t-1} \quad (11)$$

$$\rho_{CCC} = \overline{r} + \sum_{i=1}^{p} \varphi_i [\upsilon_{t-1}\upsilon_{t-1}^{'} - \overline{r}] + \sum_{j=1}^{q} \eta_j [\rho_{t-1} - \overline{r}] \quad (12)$$

Where Φ is a matrix with $2 + n(n+1/2)$ parameters. In effect, the unconditional relationship represented by the DCC-GARCH model according to Engle (2002) and becomes Equation 13 accordingly:

$$\overline{r} = \Phi / 1 - \varphi - \eta \quad (13)$$

Therefore, while estimating time-varying covariance and correlations between variables, the DCC-GARCH methodology targets variance. We used the quasi-maximum likelihood estimation (QMLE) approach to estimate the BEKK-GARCH model having assumed that the regression residuals obey a standardized distribution that is normally distributed. The QMLE was adopted because, even in cases when the error distribution deviates from normality, the method yields consistent and asymptotically Gaussian regression estimates (Bollerslev, 1990). The main source that provides data for the study was the IMF dataset.

4. Results and Discussions

The pooled data for the CEE-3 countries of Europe are descriptively presented in Table 1. Table 1 show that mean oil price is 1.6. The standard deviation of news-based policy uncertainty in the CEE -3 countries are 0.637554, 1.3267, and 1.32038 are moderately low. The HUF/EUR, PLN/EUR, and CZK/EUR currency exchange rates had standard deviation values given by 153.1, 67.4 and 112.5 respectively. These values signify instability in the exchanger rates of the CEE-3 countries. The series are not normal in distribution, according to the Jarque-Bera test ($p<0.05$).

Table 1. Preliminary results.

Statistics	OILP	HUNNEWS	POLNEWS	CZENEWS	HUF/EUR	PLN/EUR	CZK/EUR
Mean	1.600	3.209	1.293	1.288	17.081	19.386	187.349
Median	1.592	3.087	3.871	1.568	10.913	184.267	148.487
Maximum	2.530	5.100	0.187	1.289	372.596	426.481	790.374
Minimum	0.590	2.000	1.139	2.489	0.501	32.489	134.086
Std. dev.	0.271	0.638	1.327	1.320	153.182	167.389	112.549
Skewness	-0.152	0.521	1.732	1.371	4.294	13.489	18.487
Kurtosis	3.923	2.716	1.389	1.380	22.159	19.743	18.034
Jarque-Bera	37.086	21.062	79.560	1.230	13.546	14.571	123.809
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Source: Authors' Eviews 13 results (2024).

From Figures 1 and 2 the trend behavior of oil price, NEWS-based uncertainty and they exchange rates of the CEE-3 countries of Europe showed high volatility clustering. This is evident as high rise shocks are followed with higher rise values while low drops are followed with further drops.

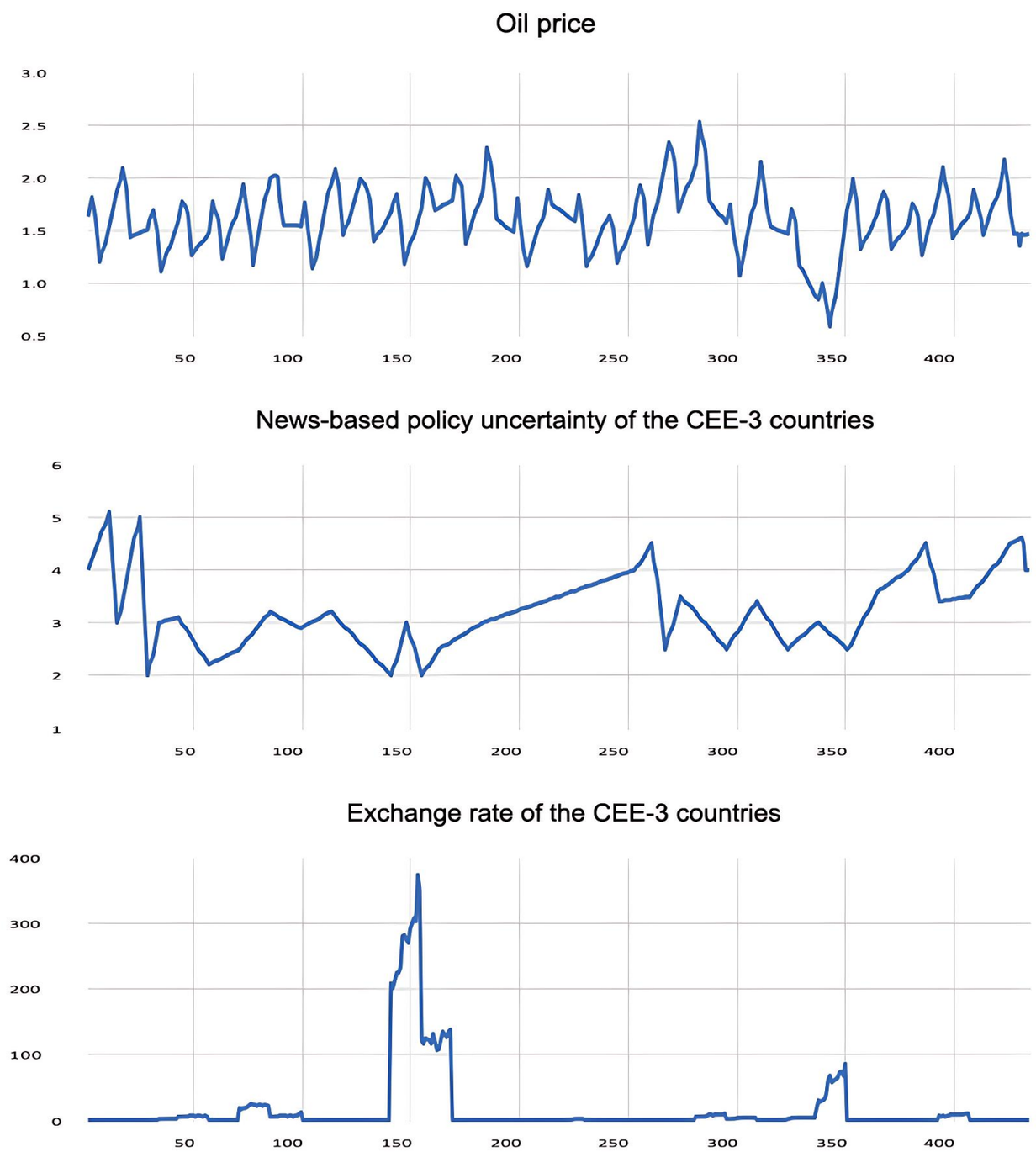

Figure 1. Oil price, news-based policy uncertainty and exchange rates of the CEE-3 countries.

Source: Authors' plot (2024) with Eviews 13 results.

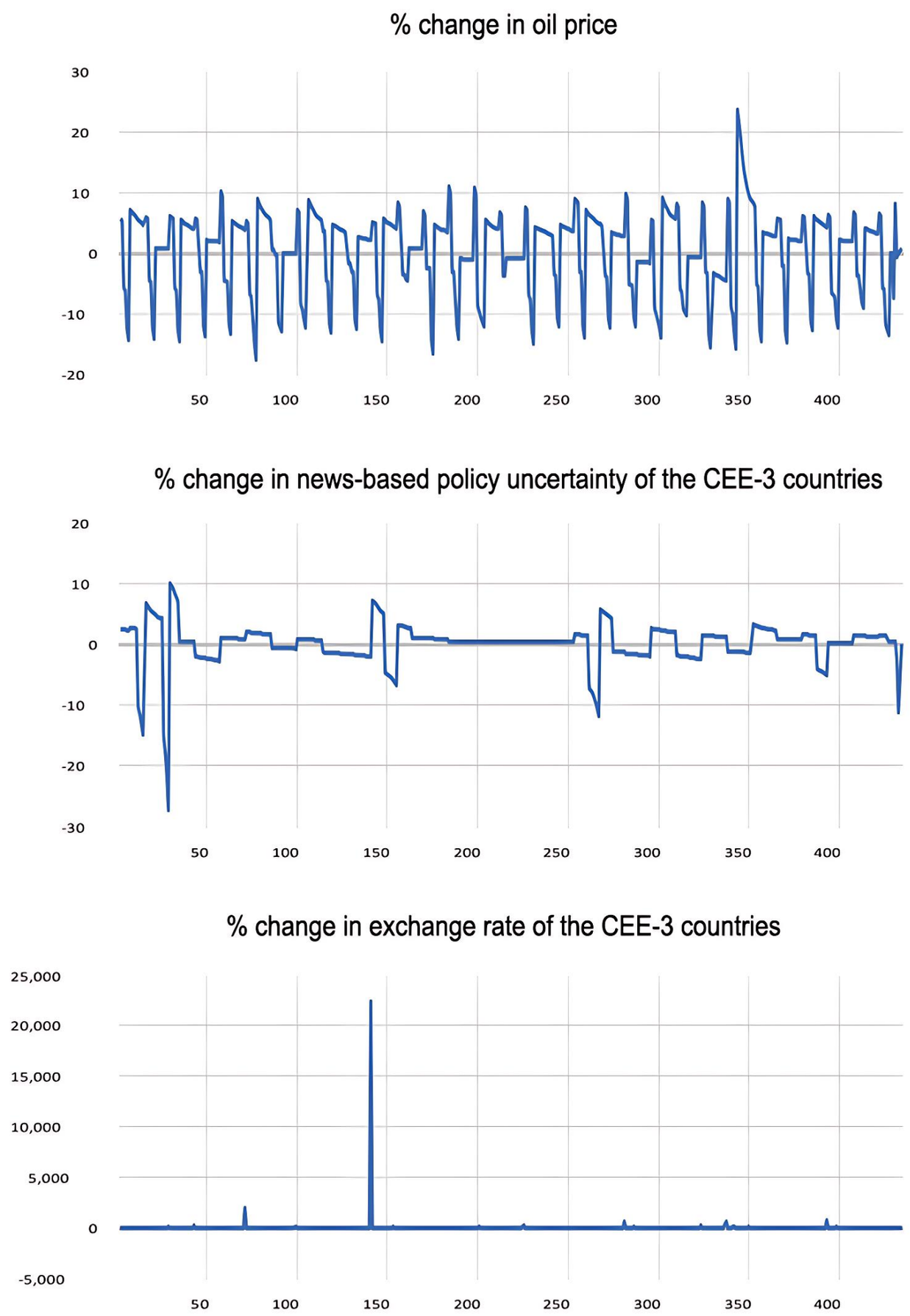

Figure 2. % change in oil price, news-based policy uncertainty and exchange rates of the CEE-3 countries.
Source: Authors' plot (2024) with Eviews 13 results.

This section analyzes the results of estimations of the three (3) multivariate-GARCH (M-GARCH) models. Tables 2, 3, and 4 are the BEKK-GARCH estimates for Hungary, Poland and Czech. According to Tables 2, 3 and 4 the mean equations of the BEKK-GARCH for Hungary, Poland and Czech Republic shows that oil price volatility spillover on HUF/EUR was significant (p=0.0001) while volatility spillover of the HUF/EUR on oil prices was also insignificant (p=0.0745). Similar results were obtained for Poland and Czech Republic. Accordingly, oil price volatility transmissions on the PLN/EUR and CZK/EUR exchange rates are both substantial at the 1% level. Also, the volatility transmission from the HUF/EUR, PLN/EUR and CZK/EUR exchange rates to Brent oil prices is substantial at the 1% level. Thus, the volatility vectors change overtime, the co-volatility between

currency rates and oil prices in the CEE-3 countries is highly reciprocating and interdependent. Also, the volatility spillover of Hungary news based policy uncertainty on the HUF/EUR exchange rate was positively significant (p=0.000) as revealed by the coefficient 0.027813. Conversely, the HUF/EUR exchange rate volatility transmission on news economic policy uncertainty of the Hungarian economy was insignificant (p=0.6689) with a negative coefficient. However, the Polish and Czech news based economic policy uncertainties were significant in influencing the PLN/EUR and CZK/EUR exchange rates respectively. The coefficients of all the variance equations and covariance specifications of the diagonal BEKK-GARCH are all significant for Hungary, Poland and Czech. This shows that BEKK-GARCH does sufficiently estimate impact of fluctuations in oil prices on the currency rates of the CEE-3 countries **of** Europe.

Table 2. BEKK- GARCH estimates for Hungary.

Variables	**Coefficient**	**P-value**	**Variables**	**Coefficient**	**P-value**
Constant	0.808***	0.000	Constant	0.785***	0.000
OILVOL	0.045**	0.000	HUNNEWS	0.028***	0.000
Constant	1.533***	0.000	Constant	4.109***	0.000
HUF/EUR	0.039**	0.001	HUF/EUR	-0.001	0.669
Variance equation coefficients					
Variables	Coefficient	P-value	Variables	Coefficient	P-value
C(5)	0.069	0.000	C(5)	1.185	0.000
C(6)	0.036	0.000	C(6)	3.975	0.004
C(7)	2.043	0.000	C(7)	-0.071	0.000
C(8)	1.844	0.000	C(8)	0.011	0.000
C(9)	-0.218	0.999	C(9)	0.879	0.844
C(10)	0.131	0.028	C(10)	-0.041	0.000
Covariance specification: Diagonal BEKK					
Covariance structure	Coefficient	P-value	Covariance structure	Coefficient	P-value
M(1,1)	0.007	0.000	M(1,1)	0.010	0.000
M(2,2)	0.026	0.000	M(2,2)	0.008	0.004
A1(1,1)	1.013	0.000	M(1,1)	2.145	0.000
A1(2,2)	1.844	0.000	M(2,2)	2.136	0.000
B1(1,1)	-2.182	0.991	M(1,1)	-0.013	0.844
B1(2,2)	0.139	0.028	M(2,2)	0.181	0.000

Note: Significance is indicated at 1%, 5%, respectively, by ***, **.
Source: Authors' Eviews 13 results (2024)

Table 3. BEKK-GARCH estimates for Poland.

Variables	**Coefficient**	**P-value**	**Variables**	**Coefficient**	**P-value**
Constant	1.038**	0.003	Constant	0.171***	0.000
OILVOL	13.488***	0.000	POLNEWS	1.047**	0.002
Constant	1.093*	0.000	Constant	1.039***	0.000
PLN/EUR	1.029***	0.000	PLN/EUR	1.095	0.061
Variance equation coefficients					
Variables	Coefficient	P-value	Variables	Coefficient	P-value
C(5)	1.388	0.000	C(5)	1.185	0.000
C(6)	3.104	0.000	C(6)	3.102	0.000
C(7)	-0.194	0.000	C(7)	-0.123	0.000
C(8)	1.079	0.000	C(8)	0.062	0.000
C(9)	0.943	0.000	C(9)	0.103	0.000
C(10)	-7.044	0.000	C(10)	-6.021	0.000
Covariance specification: Diagonal BEKK					
Covariance structure	Coefficient	P-value	Covariance structure	Coefficient	P-value
M(1,1)	2.479	0.000	M(1,1)	1.289	0.000
M(2,2)	3.175	0.000	M(2,2)	3.913	0.000
A1(1,1)	-0.194	0.000	M(1,1)	-0.287	0.000
A1(2,2)	1.016	0.000	M(2,2)	0.017	0.000
B1(1,1)	0.239	0.000	M(1,1)	0.103	0.000
B1(2,2)	-0.158	0.000	M(2,2)	-6.041	0.000

Note: Significance is indicated at 1%, 5%, and 10%, respectively, by ***, **, and *.
Source: Authors' Eviews 13 results (2024)

Table 4. BEKK- GARCH estimates for Czech Republic.

Variables	Coefficient	P-value	Variables	Coefficient	P-value
Constant	0.436*	0.000	Constant	0.179***	0.000
OILVOL	2.481***	0.000	CZENEWS	0.161***	0.000
Constant	1.209	0.225	Constant	1.190***	0.000
CZK/EUR	0.104**	0.003	CZK/EUR	2.102	0.061
Variance equation coefficients					
Variables	Coefficient	P-value	Variables	Coefficient	P-value
C(5)	7.361***	0.000	C(5)	1.156	0.000
C(6)	0.287***	0.000	C(6)	0.194	0.000
C(7)	-0.029***	0.000	C(7)	-0.588	0.000
C(8)	0.287***	0.000	C(8)	0.206	0.000
C(9)	0.188***	0.000	C(9)	0.039	0.000
C(10)	-0.023***	0.000	C(10)	-0.561	0.000
C(11)	5.192***	0.000	C(11)	9.476	0.000
Covariance specification: Constant conditional corr.					
Covariance structure	Coefficient	P-value	Covariance structure	Coefficient	P-value
M(1,1)	5.239	0.000	M(1,1)	1.089	0.000
M(2,2)	1.075	0.000	M(2,2)	0.191	0.000
A1(1,1)	-0.156	0.000	M(1,1)	-0.587	0.000
A1(2,2)	2.011	0.000	M(2,2)	0.271	0.000
B1(1,1)	0.879	0.000	M(1,1)	0.066	0.000
B1(2,2)	-8.236	0.000	M(2,2)	-9.561	0.000

Note: Significance is indicated at 1%, 5%, and 10%, respectively, by ***, **, and *.
Source: Authors' Eviews 13 results (2024)

Tables 5, 6 and 7 are the CCC-GARCH estimates for Hungary, Poland and Czech respectively. The significance of oil price volatility transmission on HUF/EUR, PLN/EUR, and CZK/EUR at the 1% level with a p-value of 0.000 was identified. The volatility transmission from HUF/EUR, and PLN/EUR on oil price volatility was insignificant with the p-values, 0.8679, and 0.1567 respectively. Only the CZK/EUR exchange rate volatility spillover had significant influence on oil prices. The news based policy uncertainty of Hungary had insignificant effect on HUF/EUR exchange rate as reported by high p-value of 0.6121. Nonetheless, the effects of the Polish and Czech news based economic policy uncertainty indices on the PLN/EUR, and CZK/EUR exchange rates are considerable given the zero p-value for each currency. The HUF/EUR exchange rate volatility spillover on Hungary news based uncertainty was significant with a negative value. Similarly, CZK/EUR rate had a significant coefficient given by 0.00395**. This shows significant volatility transmission from the CZK/EUR to the Czech policy uncertainty. Hence, the price of oil fluctuates in tandem with economic policy in the Hungary. The coefficients of the variance equations and covariance specification of the CCC-GARCH model were all significant with p-value less than 0.05. This shows that CCC-GARCH sufficiently estimate oil price volatility spillover on currency rate and currency rate volatility spillover transmission on oil price in the CEE-3 countries.

Table 5. CCC-GARCH estimates for Hungary.

Variables	Coefficient	P-value	Variables	Coefficient	P-value
Constant	26.037***	0.000	Constant	0.862***	0.000
OILVOL	-11.964**	0.002	HUNNEWS	0.002	0.612
Constant	1.569***	0.000	Constant	3.062***	0.000
HUF/EUR	6.187	0.868	HUF/EUR	0.005***	0.000
Variance equation coefficients					
Variables	Coefficient	P-value	Variables	Coefficient	P-value
C(5)	1.1854	0.224	C(5)	0.002	0.017
C(6)	3.975	0.000	C(6)	2.929	0.000
C(7)	-0.071	0.948	C(7)	1.061	0.991
C(8)	0.011	0.000	C(8)	0.002	0.059
C(9)	0.879	0.000	C(9)	2.772	0.000
C(10)	-0.049	0.477	C(10)	0.019	0.627
C(11)	0.122	0.252	C(11)	-0.054	0.416
Covariance specification: Constant conditional correlation					
Covariance structure	Coefficient	P-value	Covariance structure	Coefficient	P-value
M(1)	1.182	0.000	M(1)	2.383	0.000
A1(1)	1.089	0.000	A1(1)	5.001	0.000
B1(1)	-0.002	0.000	B1(1)	0.011	0.000
M(2)	0.011	0.000	M(2)	1.885	0.000
A1(2)	0.879	0.000	A1(2)	3.569	0.000
B1(2)	-0.011	0.000	B1(2)	0.485	0.000
R(1,2)	0.158	0.000	R(1,2)	-0.813	0.0000

Note: At 1%, 5%, respectively, ***, ** indicate significance.
Source: Authors' Eviews 13 results (2024)

Table 6. CCC-GARCH estimates for Poland.

Variables	**Coefficient**	**P-value**	**Variables**	**Coefficient**	**P-value**
Constant	0.157***	0.000	Constant	0.807	0.625
OILVOL	0.014***	0.000	POLNEWS	0.047***	0.000
Constant	1.797	0.234	Constant	1.532***	0.000
PLN/EUR	0.001	0.157	PLN/EUR	0.039	0.069
Variance equation coefficients					
Variables	Coefficient	P-value	Variables	Coefficient	P-value
C(5)	0.975***	0.000	C(5)	1.216**	0.019
C(6)	0.219***	0.001	C(6)	18.155***	0.007
C(7)	0.011**	0.000	C(7)	-0.065**	0.010
C(8)	0.003***	0.000	C(8)	3.962**	0.004
C(9)	0.165**	0.000	C(9)	5.332***	0.000
C(10)	0.069**	0.000	C(10)	-0.717***	0.000
C(11)	0.107***	0.000	C(11)	1.145***	0.000
Covariance specification: Constant conditional correlation					
Covariance structure	Coefficient	P-value	Covariance structure	Coefficient	P-value
M(1)	0.157***	0.004	M(1)	1.0158	0.011
A1(1)	0.076***	0.000	A1(1)	1.005***	0.007
B1(1)	0.011***	0.000	B1(1)	-0.065**	0.000
M(2)	0.003***	0.000	M(2)	3.961***	0.004
A1(2)	0.002***	0.000	A1(2)	5.332***	0.000
B1(2)	0.002***	0.007	B1(2)	-0.712**	0.000
R(1,2)	0.101***	0.002	R(1,2)	1.146***	0.000

Note: At 1%, 5%, respectively, ***, ** indicate significance.
Source: Authors' Eviews 13 results (2024)

Table 7. CCC-GARCH estimates for Czech Republic.

Variables	**Coefficient**	**P-value**	**Variables**	**Coefficient**	**P-value**
Constant	0.561**	0.000	Constant	0.808***	0.000
OILVOL	0.021***	0.000	CZENEWS	0.047***	0.000
Constant	1.451***	0.000	Constant	1.532	0.143
CZK/EUR	0.176***	0.000	CZK/EUR	0.004**	0.001
Variance equation coefficients					
Variables	Coefficient	P-value	Variables	Coefficient	P-value
C(5)	2.383	0.001	C(5)	0.002	0.002
C(6)	5.001	0.008	C(6)	2.925	0.008
C(7)	0.011	0.793	C(7)	1.868	0.005
C(8)	1.853	0.000	C(8)	0.003	0.000
C(9)	3.698	0.000	C(9)	1.722	0.000
C(10)	0.458	0.000	C(10)	0.019	0.000
C(11)	-0.829	0.000	C(11)	-0.054	0.000
Covariance specification: Constant conditional correlation					
Covariance structure	Coefficient	P-value	Covariance structure	Coefficient	P-value
M(1)	0.975	0.000	M(1)	1.185	0.000
A1(1)	0.219	0.000	A1(1)	3.975	0.000
B1(1)	0.013	0.000	B1(1)	-0.007	0.000
M(2)	0.046	0.000	M(2)	0.011	0.000
A1(2)	0.164	0.000	A1(2)	0.894	0.000
B1(2)	0.098	0.000	B1(2)	-0.047	0.000
R(1,2)	0.107	0.000	R(1,2)	0.125	0.000

Note: At 1%, 5% respectively, ***, ** indicate significance.
Source: Authors' Eviews 13 results (2024)

From Tables 8, 9 and 10 which report the VECH-GARCH estimates for Hungary, Poland and Czech Republic, the mean equation of the VECH-GARCH shows that oil price volatility spillover on the HUF/EUR, PLN/EUR, and CZK/EUR was significant (p=0.000) while the HUF/EUR and PLN/EUR volatility effect on oil price volatility were insignificant. Also, the influence of HUNNEWS uncertainty on the HUF/EUR exchange rate was significant (p=0.0072) while HUF/EUR exchange rate volatility spillover on news based HUNNEWS uncertainty was also significant (p=0.0000). This shows significance of the mean vector coefficient of the GARCH equation. Same results were obtained for the Czech Republic. The coefficients of the variance equations and covariance specification of the VECH-GARCH coefficients are all significant. This shows that VECH-GARCH only sufficiently estimated oil price volatility spillover on currency rate, but not the reverse. However, the reciprocal volatility spillover exists between oil price variation and news based uncertainties in high income nations in Europe.

Table 8. VECH-GARCH estimates for Hungary.

Variables	Coefficient	P-value	Variables	Coefficient	P-value
Constant	0.436***	0.000	Constant	0.104***	0.000
OILVOL	0.018***	0.000	HUNNEWS	0.059**	0.007
Constant	1.395**	0.000	Constant	1.023**	0.006
HUF/EUR	1.953	0.661	HUF/EUR	-0.002***	0.000
Variance equation coefficients					
Variables	Coefficient	P-value	Variables	Coefficient	P-value
C(5)	0.067***	0.000	C(5)	0.058***	0.000
C(6)	0.393***	0.000	C(6)	0.104***	0.000
C(7)	3.195***	0.000	C(7)	2.811***	0.000
C(8)	-1.529***	0.000	C(8)	-1.791**	0.000
Transformed variance coefficients					
Covariance structure	Coefficient	P-value	Covariance structure	Coefficient	P-value
M(1,1)	0.023***	0.000	M(1,1)	0.008***	0.000
M(2,2)	0.039***	0.000	M(2,2)	0.010***	0.000
A1	3.195**	0.000	A1	2.811**	0.002
B1	-2.035***	0.852	B1	-1.095***	0.000

Note: At 1%, 5% respectively, ***, ** indicate significance.
Source: Authors' Eviews 13 results (2024)

Table 9. VECH-GARCH estimates for Poland.

Variables	Coefficient	P-value	Variables	Coefficient	P-value
Constant	0.808***	0.000	Constant	0.808**	0.000
OILVOL	0.045***	0.000	POLNEWS	0.047***	0.000
Constant	1.533	0.286	Constant	1.533**	0.000
PLN/EUR	0.033	0.061	PLN/EUR	0.004	0.061
Variance equation coefficients					
Variables	Coefficient	P-value	Variables	Coefficient	P-value
C(5)	0.187**	0.000	C(5)	0.010***	0.001
C(6)	1.603***	0.003	C(6)	0.089***	0.000
C(7)	5.109***	0.000	C(7)	1.587***	0.000
C(8)	3.025***	0.000	C(8)	2.131***	0.000
Transformed variance coefficients					
Covariance structure	Coefficient	P-value	Covariance structure	Coefficient	P-value
M(1,1)	1.349**	0.000	M(1,1)	0.007***	0.001
M(2,2)	7.467**	0.008	M(2,2)	0.039	0.002
A1	1.210***	0.000	A1	0.195***	0.000
B1	5.039***	0.000	B1	-9.467***	0.000

Note: At 1%, 5%, respectively, ***, ** indicate significance.
Source: Authors' Eviews 13 results (2024)

Table10. VECH-GARCH estimates for Czech Republic.

Variables	Coefficient	P-value	Variables	Coefficient	P-value
Constant	0.153	0.327	Constant	0.088***	0.000
OILVOL	5.019***	0.000	CZENEWS	0.011***	0.000
Constant	1.133***	0.000	Constant	1.099***	0.000
CZK/EUR	5.044	0.356	CZK/EUR	1.568***	0.000
Variance equation coefficients					
Variables	Coefficient	P-value	Variables	Coefficient	P-value
C(5)	0.897***	0.000	C(5)	0.103***	0.000
C(6)	6.011***	0.000	C(6)	0.879***	0.000
C(7)	3.098***	0.000	C(7)	2.091***	0.000
C(8)	-2.568***	0.000	C(8)	5.879***	0.000
Transformed variance coefficients					
Covariance structure	Coefficient	P-value	Covariance structure	Coefficient	P-value
M(1,1)	0.567***	0.000	M(1,1)	0.103***	0.000
M(2,2)	6.009***	0.000	M(2,2)	0.239***	0.000
A1	3.115***	0.000	A1	2.099***	0.000
B1	-2.016***	0.000	B1	5.898***	0.000

Note: At 1% respectively, *** indicate significance.
Source: Authors' Eviews 13 results (2024)

4.1. Discussion

The results demonstrate considerable volatility transmission from HUF/EUR, PLN/EUR and CZK/EUR exchange rates to Brent oil prices. The BEKK-GARCH results uphold an extremely interconnected co-variability between currency rates and oil prices in the CEE-3 countries. The findings of this study are consistent with those of Li and Chen (2023) and Ding, Zheng, Cui, and Du (2023) respectively. The research results of Li and Chen (2023) confirm that there are transmission intensity changes between energy costs and the RMB exchange rate. The covariance between fluctuations in energy prices and those in exchange rates and oil prices was econometrically clarified by Ding et al. (2023). The implication associated with the research was that a continuous reduction in the co-movement between the fluctuations of oil prices and currency rates in developing economies is indispensable.

The findings of the resent research agrees with those of Adi, Adda, and Wobilor (2022) where it was established that that there was a non-reciprocating volatility transmission from the price of Brent oil to the effective exchange rate market, but a considerable reversible volatility transmission between the energy price (Brent oil) and the dollar-naira exchange rate. These authors established that Nigeria had loosened the fixed exchange rate regime during the post-structural adjustment programme era, which had a substantial impact on the naira's strong depreciation against other currencies, particularly the US dollar. Also, the present research outcome aligns with the outcome of Balcilar and Usman (2021) empirical research which reveals significant volatility in both the price of oil and the currency rate. Our results also agree with Chang and Tan (2008) who identified a remarkable link between the world oil prices and the stock performance of the BRICS countries. Throughout the whole study period, the relationship's degree fluctuates depending on which countries import and export oil. Countries that export oil typically have a stronger and more positive correlation with changes in oil prices than those relying on imported oil, which typically have a negative correlation.

The findings are consistent with the research of Seguino (2020) which discovered significant correlations at truncated frequencies, indicating a significant long-term impact on currency rates and equity market returns of G7 countries. In addition, the result agrees with the work of Salisu, Rufai, and Nsonwu (2025) who found that the typical market index went straight down by 35 per cent both within the group of nations using the hit associated with the pandemic. The BRICS and Group 7 countries' market indices went straight down as well because the lives of individuals are greatly impacted during this period. Also, the result corroborated the findings of Salimi et al. (2023) who discovered robust connectivity at low frequencies shows that Covid-19 cases have a major long-term influence on the stock market and exchange rate returns of the most afflicted countries under consideration.

5. Conclusion

The study evaluates whether or not there is a notable variation in the outcomes of volatility spillover amongst oil prices, exchange rates and uncertainty basing analysis on multivariate GARCH estimations in for the CEE-3 countries, namely Czech Republic, Hungary and Poland. The summary of research findings are as follows: The BEKK-GARCH model does not sufficiently estimate oil price volatility spillover on currency rate and its volatility spillover on oil price in the CEE-3 countries. The CCC-GARCH sufficiently estimated fluctuation of the oil price that affects the exchange rate and volatility transmission in exchange rate on oil price in the CEE-3 countries. On its part, the VEC-GARCH only sufficiently estimated oil price volatility spillover on exchange rate. However, the reciprocal volatility spillover exists between oil price and news-based uncertainties in high income nations in Europe. We found evidence of transmission of oil price fluctuations on exchange rate in high income nations in Europe.

The foreign currency market's significance cannot be overestimated in an open economy. Based on findings, it is concluded that increase in volatility spillovers in oil price and news-based uncertainties leads to dynamic changes in foreign exchange returns in in the CEE-3 countries. The national currency's value should be stabilized by the government through the implementation of a flexible currency regime that is sufficiently adaptable to be adjusted at whim. In any economy, the balance of payments will improve with policies that promote the normalization of currency rates. The government could execute a discretionary policy on exchange rate management. Other econometrics multivariate modeling approaches like O-GARCH are suggested in further studies.

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