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ARE THE POLICY UNCERTAINTY AND CLI 'EFFECTIVE' INDICATORS OF VOLATILITY? GARCH-MIDAS ANALYSIS OF THE G7 STOCK MARKETS

Abstract. *The paper aims at the investigation of two important economic indicators, the economic policy uncertainty (EPU) and composite leading indicator (CLI) of OECD for their leading potential in forecasting the stock market volatility in G7 stock markets. To overcome the frequency discrepancy, the mixed sampling strategy is conducted with GARCH-MIDAS modeling. By utilizing a total of 42 estimations, the study has several contributions: i. both EPU and CLI are major leading indicators, ii. the model specification, rolling window, and fixed, matters, no a priori decision should be made by the researchers, iii. the positive (negative) influence of increases in EPU (CLI) cannot be rejected and should be kept in policy decisions. Lastly, comparative analysis revealed that CLI is a more efficient indicator however is closely followed by another efficient indicator, the EPU, for G7 stock markets' volatility.*

Keywords: *Economic Policy Uncertainty, Composite Leading Indicators, GARCH, Mixed Data Sampling.*

JEL Classification: C58, E32, G17

1. Introduction

Throughout the decision-making processes involving the financial market returns, investments, and policy decisions involving the financial markets, the macroeconomic factors play crucial roles. The effects of the macroeconomic factors are not only on the financial returns but also have strong effects on the distributional characteristics through volatility. Recently, the influence of economic policy uncertainty index (EPU) gained popularity in the literature and an

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amount of papers showed its potential on the market volatility in crude oil and commodities markets not to mention the applications to developing country markets. The EPU is a monthly while the financial markets are generally analyzed in daily frequency. As a result, such setting requires a mixed data sampling (MIDAS) strategy in modeling.

Within this discussion, the paper aims at the investigation of EPU not only on the developed country stock markets, the G7, but also it aims to provide a comparative analysis of the leading potential of EPU to the CLI, the composite leading indicator of OECD. This type of investigation is quite interesting since such markets are expected to be more in line with the efficient market hypothesis, EMH, a-la Fama (1970), so that no additional information could be obtained from economic fundamentals since all the information from economic news is perfectly reflected to the stock prices in the efficient markets assuming rational information. As a result, changes in economic policies should not lead to further fluctuations in stock index volatility. The paper does not aim to investigate the EMH. However, if it is likely to obtain significant information regarding the market volatility so that such economic news play important roles in improving the forecasting capabilities of the econometric models, such indices could play crucial potential for policy makers and investors. However, there is a loophole, i.e. frequency mismatching: the markets are generally analyzed and evaluated with daily data while the economic fundamentals are generally announced monthly. To overcome this difficulty, (Engle et.al., 2013)'s GARCH-MIDAS model plays a crucial role. The model allows the inclusion of macroeconomic factors to the volatility equations through a form of transformation to overcome the frequency mismatching for our purposes of the quest for 'leading' economic indicators.

2. Research questions

The paper has three research questions. These questions generally focus on the exploring of EPU for its leading potential and econometric significance of the GARCH-MIDAS specification as done in the literature.

It could be argued that the effects of economic fundamentals are significant, but 'historical'. Therefore, the information that could be obtained from macroeconomic variables should already be embedded in the stock prices. This should especially so for the developed country stock markets for those the likelihood of being an efficient market is more likely. With this respect, the first research question is whether this is so for the G7 markets. In other words, the same question is: is the so-called 'leading' indicators in our study have a 'leading' potential or not? For our knowledge, no throughout analysis is conducted so far for the whole G7 markets simultaneously. We assume that if the GARCH-MIDAS models with EPU or CLI does improve the forecasting performance over the RV (realized variance) based GARCH-MIDAS models, then the 'leading' potential should be taken seriously by the policy makers and investors.

The second question or purpose of the study is to compare the two indices, the EPU and CLI among themselves in terms of their potential in improving the forecast performances of the GARCH-MIDAS models. Lastly, a third research question is purely econometric. We aimed at testing the two specifications of estimation in GARCH-MIDAS modeling, the rolling window or the fixed sampling strategies. So far, the literature showed that they lead to similar parameter estimates therefore one could not be preferred over another. It is likely to expect that due to its nature, the rolling windows is more effective. However, it could not be so and deserves investigation. As a result the last question of the paper is: “What is the sensitivity of performances of EPU and CLI-based GARCH-MIDAS model estimations to the rolling or fixed settings?” Hence, we estimated a total of 42 different models with various specifications to evaluate research questions given above.

The paper is structured as follows. Section 2 includes the evaluation of the EPU and CLI indicators and the related literature in addition to the selected econometric literature. The GARCH-MIDAS methodology is given in Section 3. Empirical results are in Section 4 in addition to discussions and policy implications. The conclusion is given in the final section.

3. EPU and CLI leading indicators and the literature review

Macroeconomic indicators and their leading potential have been investigated by (Schwert, 1989) who determined the links between stock volatility and real and nominal macroeconomic indicators. (Fama, 1970) and (Roberts, 1967) also showed that in efficient markets, the available ‘economic information’ from macroeconomic indicators, have already been integrated effectively into the financial asset prices so no further gains are likely and this is especially so for the efficient markets. In contrast, (Cutler et al., 1989) and Roll (1988) demonstrated that news and major movements influence the market trends however, these effects are generally ‘historical’ in the sense that they are already embedded in the price changes. More recently, leading economic indicators were investigated in various research studies such as (Diebold and Rudebusch, 1991) and (Binner et al., 2005). The links of economic factors such as the agricultural commodities to market volatility was noted by (Roache, 2010).

In terms of the implications on market volatility, the EPU has gained popularity recently. CLI on the other hand, has not found many applications within GARCH-MIDAS setting as of our knowledge. Developed by (Baker et.al., 2015), EPU is a news-based index based on a selected vocabulary of keywords related to policy uncertainty. EPU also includes sentiments on market volatility; (Baker et. al., 2015) states that EPU searches for specific terms related to policy uncertainty by using three components: headline references to economic uncertainty; Congressional Budget Office reports with news on temporary budget and tax revisions; Central Bank surveys for professional forecast reports. As a result, EPU also deals with future expectations (Baker et.al., 2015).

CLI, developed by (OECD, 2012), is based on forecast projections, business surveys, consumer expectations in addition to various economic factors within a weighting scheme. CLI, with this perspective, includes not only ‘present’ but also 'future' expectations. OECD declares that CLI is a leading index designed to provide early signaling of economic cornerstones (OECD, 2012). The index is based on a variety of important macroeconomic variables related to production, business climate, international trade, and national budget along with financial indicators in addition to surveys as discussed above. The OECD measures CLI for 33 OECD countries as the amplitude adjusted CLI and the de-trended CLI, and the latter is considered as the headline CLI index (OECD, 2012).

An important number of studies utilize the GARCH-MIDAS model with various macroeconomic fundamentals. (Karali and Power, 2013) applied IPI as the fundamental variable on short and long run market volatility. (Frankel, 2014) and (Dönmez and Magrini, 2013) analyzed the impact of various monetary policy indicators on market volatility. (Girardin and Joyeux, 2013) noted the effects of inflation rates on volatility among other economic variables and (Asgharian et al., 2013) showed the effects of interest rates, term premium, default rates, exchange rates, inflation, production, and the unemployment rates in the US stock market volatility. (Conrad and Loch, 2015) proposed a forecasting model for variance risk premium for the US stock returns and confirmed the effects of economic uncertainty proxies.

EPU is investigated by various studies with classic VAR models without a MIDAS setting. Among these, (Sum, 2013) determined the influence of the U.S.A.'s EPU for stock markets of five Asian tigers. (Kang et al., 2017), with the SVAR model show that positive EPU shocks had a negative impact on total asset returns of oil and gas companies.

Recently, a relatively few amount of papers investigated EPU with GARCH-MIDAS setting for mostly developing markets in addition world markets of oil and commodities. (Ma et. al, 2019) analyzes the impact of EPU on oil markets and underline the positive effects on the crude oil return volatility. (Zhou et al., 2020) studies the impacts of EPU on the Chinese exchange rate market volatility. (Yu and Huang, 2021) evaluates the impact of Chinese EPU on Chinese stock market volatility. Among other GARCH-MIDAS applications, (Fang et. al., 2018) use the global version of EPU, the GEPU with regards to its influence on the gold futures within the GARCH-MIDAS context.

4. Empirical methodology

The GARCH-MIDAS model of (Engle et.al., 2008, 2013) utilized the mixed data sampling methodology (MIDAS) of (Ghysels et al., 2006), to investigate the effects of the economic factors at lower frequencies on the different components of volatility. According to (Engle et.al., 2008), the conditional (demeaned) returns $r_{i,t}$ at the i^{th} day of the t^{th} month follow the following process,

$$r_{i,t} - E_{i-1,t}(r_{i,t}) = \sqrt{\tau_t \cdot g_{i,t}}\varepsilon_{i,t} \quad \text{and} \quad \varepsilon_{i,t}|\Phi_{i-1,t} \sim N(0,1) \qquad (1)$$

where the heteroskedasticity process consists of its secular component τ_t and the short-run component. $\varepsilon_{i,t}$ is a normal i.i.d. white noise process. $\Phi_{i-1,t}$ is the set of information in i-1st day of the tth month. $g_{i,t}$ follows GARCH(1,1) process as,

$$g_{i,t} = (1- \alpha - \beta) + \alpha \frac{\left(r_{i-1,t} - E_{i-1,t}(r_{i,t})\right)^2}{\tau_t} + \beta g_{i-1,t} \quad (2)$$

Similar to the GARCH models, the $(\alpha + \beta) < 1$ is a necessity for stability. Following (Engle et.al., 2013), several formulizations are derived for tau. The first is to employ the realized variance (RV_t),

$$\tau_t = m + \theta \sum_{k=1}^{K} \varphi_k(\omega_1, \omega_2) RV_{t-k} \quad (3)$$

$$RV_t = \sum_{i=1}^{N'} r_{i,t}^2 \quad (4)$$

In this way, τ_t is modeled with the RV_t so that the model is univariate. Further, RV_t is obtained from daily $r_{i,t}^2$ series through the MIDAS procedure (Engle et.al., 2008, 9). The multivariate model is obtained by the following tau specification,

$$\tau_t = m + \theta \sum_{k=1}^{K} \varphi_k(\omega_1, \omega_2) X_{t-k} \,. \quad (5)$$

where, $\varphi_k(\omega_1, \omega_2)$ is either the beta polynomial or exponential functions to deduct the monthly variable into higher frequencies as of (Ghysels et.al., 2006). K is the MIDAS lags. (Engle et.al., 2013) suggest fixed and rolling windows (*rw*) sampling. Compared to the fixed version given Eq.(1-5), the *rw* specification allows τ process to follow for the realized variance and for the multivariate specifications,

$$\tau_t^{(rw)} = m^{(rw)} + \theta^{(rw)} \sum_{k=1}^{K} \varphi_k(\omega_1, \omega_2) RV_{t-k}^{(rw)} \quad (6)$$

$$\tau_t^{(rw)} = m^{(rw)} + \theta^{(rw)} \sum_{k=1}^{K} \varphi_k(\omega_1, \omega_2) X_{t-k}^{(rw)}. \quad (7)$$

(Engle et. al. ,2008) assume tau to be constant for a fixed time and in the *rw* version (Engle et.al. 2008, 6). Following Engle et.al. (2013), two weighting functions $\varphi_k(\omega_1, \omega_2)$ are the beta polynomial and the exponential functions,

$$\varphi_k(\omega_1, \omega_2) = \frac{(k/K)^{\omega_1 - 1}(1-k/K)^{\omega_2 - 1}}{\sum_{j=1}^{K}(j/K)^{\omega_1 - 1}(1-j/K)^{\omega_2 - 1}} \quad (8)$$

$$\varphi_k(\omega) = \omega^k / \sum_{j=1}^{K} \omega^j \quad (9)$$

ω_1, ω_2 are the weights strictly positive and sum to 1 so that $\varphi_k(\omega_1, \omega_2) \geq 0$ and $\varphi_k(\omega) \geq 0$. Engle et.al. (2013) showed that both (8) and (9) lead to similar results. Following (Conrad and Loch, 2015), we utilized the beta polynomial and assumed $\omega_1 = 1$ for parsimony and to assure a monotonically decaying weighting scheme.

5. Data and Descriptive Statistics

The GARCH-MIDAS models are empirically estimated with i. RV-based univariate, ii. CLI-based and iii. EPU based multivariate specifications with fixed and *rw* settings. RV based model provides a baseline specification for comparative purposes with the EPU and CLI-based models to investigate their 'leading' indicator potentials. As a result, a total of 42 models are estimated and tested for in-sample and out-of-sample forecasts.

5.1. Data

The daily G7 stock exchange market data and the monthly EPU and CLI indexes are obtained from the DATASTREAM database. We preferred the broad definitions of stock indexes for the G7 stock exchange markets since they included a bigger percentage of the stocks traded and hence had a higher country-wide representative power of the indexes selected. The stock market indices are the *All Tradable Index* for France, *HDAX(Xetra)* for Germany, *All Share Price Index (FTAS)* for England, *FTSE – MIB Index* for Italy, *TOPIX Index* for Japan, and *S&P/TSX Composite Index* for Canada. Stock index returns, $r_{c,t}$, are calculated as log first differencing and therefore daily % returns measured as $r_{c,t} = ln(SI_{c,t}) - \ln(SI_{c,t-1})$ where $SI_{c,t}$ represents the value of the stock index of country *c* at day *t*. For the daily series, the sample covers the January 2nd, 1998 - December 31th, 2019 period, and the sample size is 5739. OECD publishes three distinct versions of CLI, Our study uses the amplitude adjusted CLI, known as the headline CLI. EPU is obtained from economicuncertainty.com following Baker et.al. (2015). The monthly sample covers January 1998 to December 2019 with n=264 months. Similar to the daily stock returns, the CLI and EPU are subject to natural logarithmic transformation followed by first differencing.

5.2. Descriptive statistics and unit root tests

The descriptive statistics for monthly and daily series are reported in Table 1. All daily returns of G7, aside from France, are left-skewed and excess kurtosis is a striking feature of leptokurtic distribution with heavy tails. The JB test results favor the rejection of normality for the CLI and all stock returns data in G7 countries. For EPU, normality cannot be accepted for four out of seven countries analyzed, the US, France, Italy, and Japan. ADF and KPSS tests revealed that all series are first difference stationary at conventional significance levels. We also investigated the correlations between the CLI's (EPU's) for different G7 markets and noted that the correlation statistics for CLI and EPU for G7 countries determine the interconnectedness of policy uncertainties among these countries with significant positive correlations. EPU correlations are substantially lower than CLI correlations, implying that CLI demonstrates a stronger association with the business cycles while EPU is a more country-specific indicator. To save space, correlation analysis is not included and is available upon request.

Table 1. Descriptive statistics and unit root tests

Countries:	*CAN*	*US*	*FR*	*DE*	*UK*	*IT*	*JP*
			Stock index returns*, daily % changes, n=5738*				
Mean	0.022	0.027	0.023	0.031	0.015	0.011	0.015
SD.	1.046	1.169	1.302	1.397	1.078	1.500	1.309
JB	22489.98***	17815.83***	7175.28***	5185.82***	9490.61***	5668.77***	10217.94***
ADF	-35.928***	-57.948***	-36.916***	-75.806***	-36.712***	-36.167***	-74.624***
KPSS	0.039	0.137	0.070	0.056	0.041	0.080	0.099
			CLI*, monthly % changes, n=264*				
Mean	-0.006	-0.006	-0.001	-0.007	-0.004	-0.005	0.002
SD.	0.184	0.208	0.132	0.242	0.223	0.155	0.158
JB	76.85***	224.89***	11.53***	117.12***	287.16***	63.06***	85.18***
ADF	-5.621***	-5.281***	-4.667***	-4.772***	-5.299***	-4.995***	-5.459***
KPSS	0.023	0.029	0.031	0.024	0.021	0.027	0.047
			EPU*, monthly % changes, n=264*				
Mean	0.005	0.002	0.005	0.003	0.008	0.002	-0.003
SD.	0.284	0.183	0.404	0.391	0.300	0.329	0.193
JB	3.67	90.82***	11.46***	2.68	0.48	6.49**	6.19**
ADF	-12.310***	-12.350***	-17.154***	-11.673***	-22.135***	-15.333***	-13.617***
KPSS	0.082	0.348*	0.180	0.114	0.019	0.017	0.202

Notes: SD, JB, ADF, and KPSS are the standard deviation, Jarque-Berra, ADF and KPSS test results. For ADF, lag length is selected with Schwarz information criterion. ***, **, and * denote significance at 1%, 5%, and 10% significance levels. For KPSS, stationarity is under the null. At conventional 5% significance level, all series are confirmed to follow I(1) processes.

5.3. Model estimation results

In this section, 3 different model groups are estimated. To investigate the impacts of EPU and CLI, a univariate model, the realized variance (RV) based GARCH-MIDAS setting is also tested. All model groups are estimated with two different specifications separately: *fixed* and *rolling windows*, therefore, no a-priori selection is conducted. As to be seen, both methods perform well in different conditions.

The estimation results are given in Table 2 which constitutes of 3 sections. The first is the RV-based univariate model that is the baseline model. The 2^{nd} and 3^{rd} parts include the CLI and EPU included GARCH-MIDAS model estimations. Further, single weight parameter, ω_2, is estimated by assuming ω_1=1 for parsimony. The estimated values of ω_2 using fixed and rolling windows are equivalent in practically all of the cases with few exceptions. The MIDAS lags are assumed as 30 for all models and all seven countries.

If an overlook is presented, the parameters are statistically significant with minor exceptions at different levels of significance and the stability condition is achieved in all models estimated. Most importantly, the θ parameters, which play a crucial role on the impact of the economic variable, are statistically significant. As a result, the EPU and CLI indicators, as well as the RV, have significant effects on the conditional volatility of the stock index returns in G7 stock markets. In the first part of Table 2 where the RV-based estimations are reported, the θ estimates are highly positive and significant suggesting positive impacts on the long run component of volatility. For CLI based models, the θ parameters are significantly negative, implying that the expectations of inclines in the business cycle in the future, effectively lower the volatility in all G7 countries. This result is robust for both fixed or rolling specifications. The findings are consistent with economic expectations: declines in CLI signals a potential economic slowdown, which leads to increases in market volatility. We noted that the estimated θ could differ depending on the fixed and rolling window specification for Canada, France, and Japan; and are similar for the US, the UK, Germany, and Italy. However, the signs of the parameter estimates are the same for all methods used confirming the above-mentioned result.

The EPU based estimations are given in the last section of Table 2. Similar to the EPU and RV based models, all models satisfy the stability conditions. The θ values are strongly significant for all G7 countries except for only the rolling specification for France. For the fixed specification, the θ is significant for the whole G7. In contrast to CLI based models, the θ parameters are positive for all G7 markets for the EPU based estimations. The economic policy uncertainties have positive and significant effects on the conditional variances of stock markets of G7. It should be noted that for Germany, θ is statistically significant at 5% with a fixed specification but with the rolling specification only at 10%. The estimated values of θ for Canada, the US, and France follow the same manner and depend highly on the choice of rolling and fixed specifications.

The overall results favor the efficiency in terms of fit of GARCH-MIDAS models to the data. If the LL, AIC, and BIC statistics reported for the in-sample fit of the models are examined, the CLI-based models outperform the EPU-based models for majority. As to be seen later on at Table 4, EPU based models also provide improvement over the RV based models in terms of forecasting.

For all models estimated for G7 stock market indices, graphical analysis of the total conditional variance accompanied with the secular components of volatility are reported in Figure 1. Note that to save space, only the *rolling windows*-based results are reported. The results for *fixed* specifications are available upon request. We noted that the short-run volatilities are very similar for both specifications however the fluctuations for long – run components might be more drastic for CLI and EPU based models depending on the theta parameters in *rw* and *fixed* specifications. However, overall result does not change and the dependence to the size of theta parameter is analyzed in detail in Table 3. Most importantly, both specifications lead to relatively improved forecast accuracy in both specifications.

Table 2. GARCH-MIDAS model estimation results

	CAN, fixed	CAN,rw	US,fixed	US, rw	FR, fixed	FR, rw	DE, rw
I. RV based results (baseline)							
μ	0.001***	0.0005***	0.0006***	0.0006***	0.0007***	0.0007***	0.0008***
	(0.0001)	(0.00009)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
α	0.094***	0.096***	0.111***	0.111***	0.115***	0.114***	0.099***
	(0.006)	(0.007)	(0.006)	(0.007)	(0.008)	(0.008)	(0.007)
β	0.872***	0.864***	0.852***	0.849***	0.836***	0.839***	0.866***
	(0.011)	(0.013)	(0.010)	(0.011)	(0.014)	(0.014)	(0.012)
θ	0.031***	0.034***	0.025***	0.027***	0.031***	0.031***	0.025***
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
ω	5.443***	6.775***	5.824***	6.887***	7.671***	7.589***	7.813***
	(1.323)	(1.456)	(1.525)	(1.854)	(1.781)	(1.928)	(2.518)
m	0.00002***	0.00002***	0.00005***	0.00004***	0.00005***	0.00004***	0.00007***
	(0.000005)	(0.000004)	(0.000006)	(0.000006)	(0.000007)	(0.000008)	(0.00001)
LL	19320.5	19324.2	18574.8	18578	17668.8	17666.8	17288.8
AIC	-38629	-38636.4	-37137.6	-37143.9	-35325.7	-35321.6	-34565.6
BIC	-38589.1	-38596.5	-37097.6	-37104.0	-35285.7	-35281.7	-34525.7
II. CLI based results							
	CAN, fixed	***CAN, rw***	***US,fixed***	***US, rw***	***FR, fixed***	***FR, rw***	***DE, rw***
μ	0.0004***	0.0004***	0.0006***	0.0006***	0.0006***	0.0006***	0.0008***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
α	0.053***	0.080***	0.064***	0.064***	0.067***	0.102***	0.091***
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)	(0.005)
β	0.894***	0.914***	0.875***	0.882***	0.868***	0.886***	0.895***
	(0.006)	(0.004)	(0.008)	(0.007)	(0.009)	(0.006)	(0.007)
θ	-0.004***	-0.032**	-0.025***	-0.029***	-0.025***	-0.062***	-0.042**
	(0.001)	(0.013)	(0.003)	(0.003)	(0.004)	(0.019)	(0.019)
ω	5.001*	1.349***	1.658***	1.480***	5.000***	5.162**	1.876***
	(2.616)	(0.418)	(0.159)	(0.127)	(1.172)	(2.062)	(0.639)
m	0.00005***	0.0001***	0.00007***	0.00007***	0.0001***	0.0002***	0.0002***
	(0.000002)	(0.00003)	(0.000002)	(0.000002)	(0.00003)	(0.00005)	(0.00003)
LL	19175.2	19316.8	18477.5	18491.8	17567.5	17655.4	17286.5
AIC	-38338.4	-38621.5	-36943.1	-36971.6	-35123.1	-35298.7	-34560.9
BIC	-38298.5	-38581.6	-36903.2	-36931.7	-35083.2	-35258.8	-34521.0
III. EPU based results							
	CAN, fixed	***CAN, rw***	***US,fixed***	***US, rw***	***FR, fixed***	***FR, rw***	***DE, fixed***
μ	0.0006***	0.0004***	0.0006***	0.0009***	0.0006***	0.0006***	0.0007***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
α	0.067***	0.066***	0.063***	0.137***	0.069***	0.103***	0.057***
	(0.005)	(0.005)	(0.007)	(0.011)	(0.005)	(0.006)	(0.004)
β	0.922***	0.854***	0.877***	0.735***	0.869***	0.888***	0.897***
	(0.005)	(0.009)	(0.008)	(0.015)	(0.005)	(0.007)	(0.007)
θ	0.0012***	0.0002***	0.0006***	0.00169***	0.0006***	0.0007	0.0002**
	(0.0002)	(0.00007)	(0.0001)	(0.0001)	(0.0002)	(0.0006)	(0.0001)
ω	2.137***	2.278***	3.398***	3.390***	3.596***	4.275	1.001***
	(0.323)	(0.667)	(0.956)	(0.382)	(0.972)	(4.122)	(0.026)
m	0.00001***	0.00005***	0.00006***	0.00009***	0.0001***	0.0002***	0.0001***
	(0.000001)	(0.000002)	(0.000002)	(0.000003)	(0.000003)	(0.00006)	(0.00004)
LL	17597.9	17538.5	16201.8	16141.6	15621.8	15689.1	16032.8
AIC	-35183.8	-35065.0	-32391.6	-32271.2	-31231.6	-31366.2	-32053.6
BIC	-35143.8	-35025.1	-32351.6	-32231.2	-31191.7	-31326.3	-32013.7

Notes: Country stock markets are coded as follows. CAN: Canada, US: USA, FR: France, DE: Germany, UK: United Kingdom, IT: Italy, JP: Japan. *rw* and *fixed* denote rolling window fixed window specification in estimation. *RV* is the baseline realized variance models without exogeneous variables to model the long-run component of the total conditional variance. LL is the log-likelihood, AIC and BIC are the Akaike and Bayesian (Schwarz) information criteria. Standard errors are in parentheses. *, **, *** denote significance at 10, 5 and 1% significance levels.

Table 2. GARCH-MIDAS model estimation results (continues.)

	DE, rw	*UK, fixed*	*UK, rw*	*IT, fixed*	*IT, rw*	*JP, fixed*	*JP, rw*
I. RV based results (baseline)							
μ	0.0008***	0.0004***	0.0004***	0.0005***	0.0005***	0.0005***	0.0005***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
α	0.099***	0.126***	0.125***	0.104***	0.102***	0.104***	0.102***
	(0.007)	(0.009)	(0.009)	(0.006)	(0.006)	(0.006)	(0.006)
β	0.861***	0.812***	0.810***	0.858***	0.858***	0.857***	0.858***
	(0.014)	(0.014)	(0.015)	(0.012)	(0.012)	(0.011)	(0.012)
θ	0.027***	0.031***	0.030***	0.033***	0.034***	0.033***	0.034***
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
ω	9.087***	8.624***	9.388***	4.659***	5.105***	5.402***	5.934***
	(2.934)	(1.621)	(2.018)	(1.074)	(1.271)	(1.237)	(1.446)
m	0.00006***	0.00003***	0.00003***	0.00005***	0.00005***	0.00005***	0.00004***
	(0.00001)	(0.000005)	(0.000005)	(0.000009)	(0.000009)	(0.000009)	(0.000009)
LL	17290.5	18876.1	18875.4	16848.1	16849.1	16848.0	16849.3
AIC	-34568.9	-37740.3	-37738.8	-33684.3	-33686.2	-33684.0	-33686.5
BIC	-34529.0	-37700.4	-37698.9	-33644.3	-33646.3	-33644.1	-33646.6
II. CLI based results							
	DE, rw	*UK, fixed*	*UK, rw*	*IT, fixed*	*IT, rw*	*JP, fixed*	*JP, rw*
μ	0.0008***	0.0004***	0.0004***	0.0004***	0.0005***	0.0007***	0.0006***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
α	0.092***	0.107***	0.107***	0.061***	0.063***	0.079***	0.102***
	(0.006)	(0.007)	(0.007)	(0.003)	(0.004)	(0.005)	(0.005)
β	0.894***	0.875***	0.876***	0.891***	0.878***	0.849***	0.877***
	(0.007)	(0.008)	(0.008)	(0.006)	(0.008)	(0.009)	(0.007)
θ	-0.047**	-0.025***	-0.026***	-0.046***	-0.037***	-0.013**	-0.025*
	(0.022)	(0.008)	(0.009)	(0.004)	(0.004)	(0.006)	(0.016)
ω	1.567***	1.749***	1.695***	2.566***	3.082***	1.001***	1.001***
	(0.443)	(0.427)	(0.440)	(0.282)	(0.451)	(0.074)	(0.074)
m	0.0002***	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***	0.0002***
	(0.00003)	(0.000001)	(0.000001)	(0.000005)	(0.000004)	(0.000004)	(0.000002)
LL	17285.9	18859.3	18858.7	16758.3	16739.9	17309.4	17350.6
AIC	-34559.9	-37706.5	-37705.4	-33504.6	-33467.8	-34606.7	-34689.2
BIC	-34520.0	-37666.6	-37665.5	-33464.7	-33427.8	-34566.8	-34649.2
III. EPU based results							
	DE, rw	*UK, fixed*	*UK, rw*	*IT, fixed*	*IT, rw*	*JP, fixed*	*JP, rw*
μ	0.0007***	0.0004***	0.0004***	0.0004**	0.0008***	0.0005***	0.0005***
	(0.0001)	(0.0001)	(0.0001)	(0.00015)	(0.0002)	(0.0001)	(0.0001)
α	0.054***	0.051***	0.117***	0.061***	0.069***	0.092***	0.089***
	(0.004)	(0.003)	(0.008)	(0.004)	(0.006)	(0.006)	(0.006)
β	0.910***	0.913***	0.859***	0.877***	0.879***	0.819***	0.826***
	(0.006)	(0.006)	(0.008)	(0.008)	(0.001)	(0.012)	(0.012)
θ	0.0002*	0.0003***	0.0005***	0.0015***	0.0027***	0.0012***	0.0015***
	(0.00013)	(0.000009)	(0.0002)	(0.00027)	(0.0005)	(0.0002)	(0.0002)
ω	1.001***	3.040***	2.803***	1.998***	2.109***	3.085***	3.109***
	(0.259)	(1.027)	(1.119)	(0.366)	(0.424)	(0.556)	(0.475)
m	0.0001***	0.00006***	0.00009***	0.0001***	0.0002***	0.0001***	0.0001***
	(0.00004)	(0.000002)	(0.00001)	(0.000004)	(0.000009)	(0.000004)	(0.000004)
LL	16047.4	16795.2	16855.8	14981.2	14925.6	15452.7	15458.9
AIC	-32082.8	-33578.3	-33699.5	-29950.3	-29839.2	-30893.3	-30905.7
BIC	-32042.9	-33538.4	-33659.6	-29910.4	-29799.3	-30853.4	-30865.8

Source: Authors' calculations.

Model / Country:	*GARCH-MIDAS, RV*	*GARCH-MIDAS, CLI*	*GARCH-MIDAS, EPU*

CAN

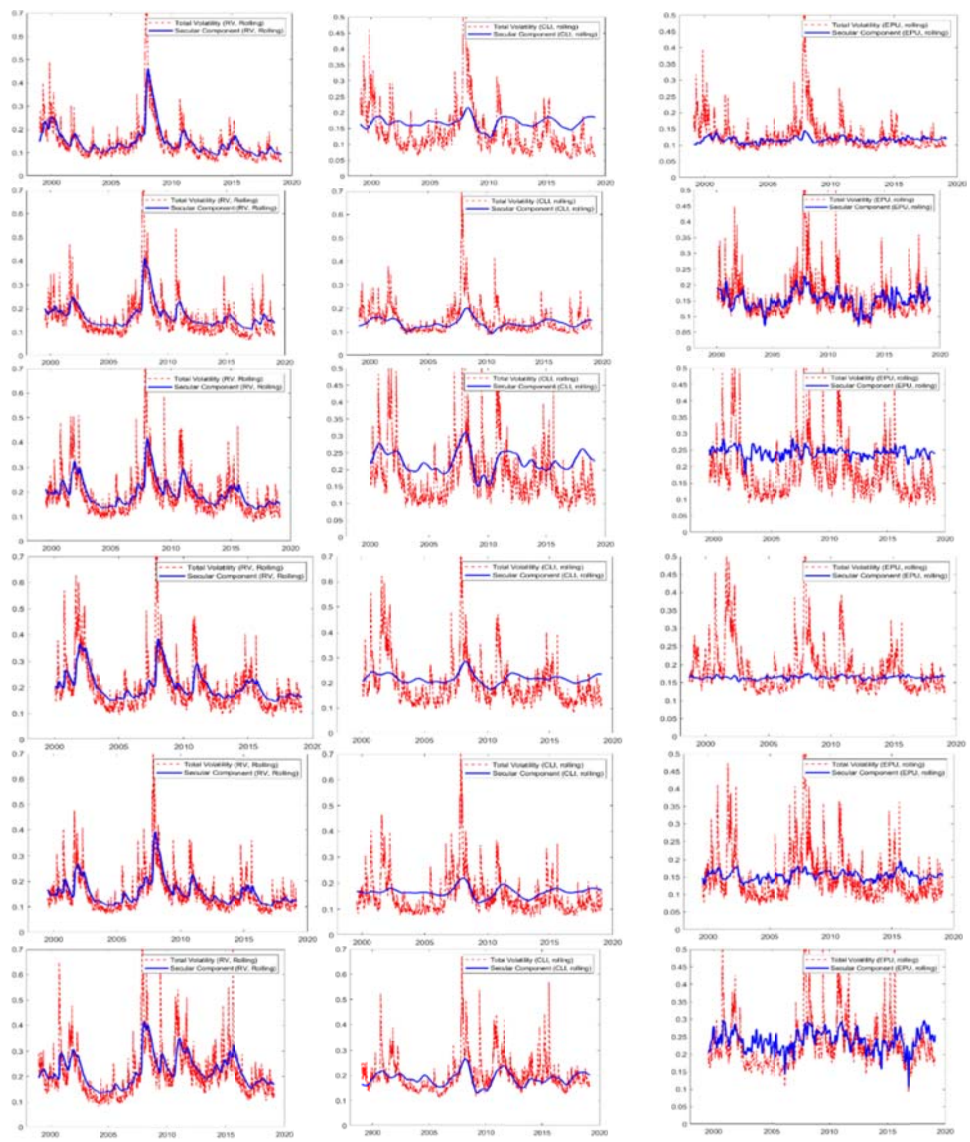
US

FR

DE

UK

IT



JP

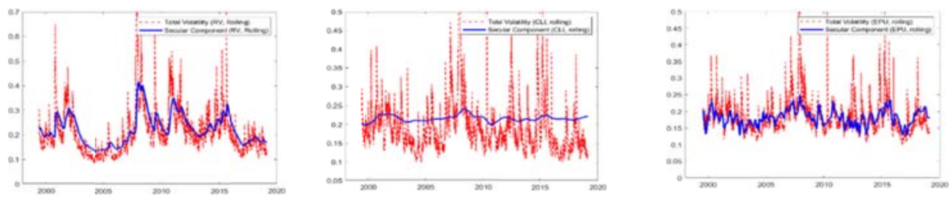


Figure 1. The total and long-run conditional volatilities of the estimated models

If an overlook is provided for the figures above, the secular components are noted to follow a relatively smooth path compared to daily total volatility for stock index return investigated. Depending on the sign and size of the theta parameter, the positive direction of co-movement between the total daily volatility and policy uncertainty (proxied with EPU) is evident in all G7 country markets.

The direction of long-run components are similar in both specifications and both fixed and rw specifications which confirms the effect of CLI and EPU. In both specifications, one clear and striking feature is the sharp incline in 2008-2009 global recession in total volatility and the long run component. Further, for the CLI-based results, long-run volatilities are relatively more volatile in the rw specification. This is expected since the theta parameters in the rw based models are larger in size for the majority of G7 markets. Such conclusion cannot be drawn for the EPU based models. The size of theta does not change for FR, DE and JP markets. We conclude that, both specifications confirm the negative impacts of CLI and positive impacts of EPU; fit of the models in addition to forecast accuracies should play crucial role on the model selection for the researcher

The RV based long-run specification has a tendency to pass just through the total volatility, so it might lead to the conclusion that RV produces a better explanatory tool. However, as to be seen for Table 6 where the RMSE's are reported, this is not the case. The CLI and EPU based models clearly perform better in forecasts for the majority of cases. At this stage, the results in Figure 1 give important but general information for the impact of policy uncertainty proxied with EPU and the leading potential of CLI index which includes professional forecasts and opinions for the markets in addition to economic indicators. If the results for EPU are evaluated, the countries with least stock market volatility in connection with the economic policy uncertainty are Germany and UK. For all other countries, moderate levels of volatilities occur in the long-run components which move with the same direction of total volatilities. Lastly, in terms of the CLI, the lowest levels of volatility in the long-run components are obtained for Japan followed by UK and Germany.

Before evaluating the forecasting performances, the long-run effects of the CLI and EPU are calculated. According to Table 5, as also noted for Figure 1, the direction of impact of the secular component is confirmed in both specifications while it could differ in magnitude depending on the size of the theta parameter. For the sample analyzed, the *rw* specified models with CLI led to larger effects of the secular component compared to the *fixed* setting for all G-7 except Italy. However, this conclusion cannot be drawn for the EPU based models. As noted, forecast evaluations will play crucial role and both specifications should be estimated for forecast comparisons. As a typical, a 1% increase in the CLI indicator for a country in period *t* results in a 2.45% or 2.56% decline in the secular component of volatility in the following month *t*+1 for the *fixed* and *rw* specifications[1]. The overall result is that, CLI has a significant effect on volatility for the G7 markets ranging from -2.5% to -5.5% with the *rw* method and from -1.3% (for Japan) to -4.30% with the *fixed* method confirming the negative impact in all cases. The only exception is Canada for which the estimates deviate by large proportions, -0.33% with the *fixed* and -3.15% with *rw*[2]. If the impact of EPU is evaluated, for all specifications, as noted before, the impact is significantly positive for all G7 markets. The impact vary in terms of magnitude for certain countries but for the majority, it does not. For Italy and US with *rw*, the impact is 0.26 and 0.158. For *fixed*, the impact of EPU is the largest for UK. Overall, the impacts of the EPU on the secular components of volatility range from 0.02 % to 0.26 % for the whole G7 countries with the *rw*; between 0.02% to 0.28% for the *fixed*. Results confirm that the impact of EPU is positive. As a result, the estimation specification matters and most importantly, the forecast performances of the models should be evaluated before selecting one model over another.

Table 3. The impacts of secular components on G7 stock market volatility

	CAN, fixed	***CAN,rw***	**USA,** ***fixed***	***USA, rw***	***FR, fixed***	***FR, rw***	***DE, fixed***
RV	2.566	2.659	2.123	2.212	2.473	2.473	2.063
CLI	-0.337	-3.153	-2.445	-2.558	-2.234	-5.514	-4.098
EPU	0.114	0.019	0.0561	0.158	0.05	0.06	0.020
	DE, ***rw***	***UK, fixed***	***UK, rw***	***IT, fixed***	***IT, rw***	***JP, fixed***	***JP, rw***
RV	2.150	2.394	2.258	2.855	2.855	2.842	2.842
CLI	-4.180	-2.437	-2.540	- 4.303	-3.386	-1.30	-2.50
EPU	0.020	0.280	0.047	0.145	0.260	0.112	0.139

Notes: The results are in (%) values. *fixed* and *rw* represent fixed and rolling specifications. RV, CLI, and EPU represent RV-based univariate while CLI and EPU represent models with CLI and EPU economic fundamentals taken into the models as their secular components.

The forecast evaluations will provide important information and the results are given in Table 4. The one-step-ahead forecast results are obtained for the RV, EPU, and CLI-based models for which the root mean squared errors (RMSE) are

[1] Note that these differences could be justified since the 'rolling' estimation results in a larger loss of observations during the estimation.

[2] Note that the *rw* specification leads to a loss in sample size which also leads to deviations in the results. However, the signs of theta parameters are confirmed by both specifications for EPU and CLI indicators. Our findings suggest that, in contrast to the majority in the literature, the forecasting results play crucial role on the selection of rw over fixed or visa versa. One should not choose one type over another a-priori and both specifications should be estimated.

reported. Since 6 models are estimated for each G7 market, with different specifications, a total of 42 models are evaluated for their respective forecast performances. The best model is reported for each G7 member with [1], representing the 1st place (with lowest RMSE), and the last model is denoted with [6] representing the 6th place (with highest RMSE).

According to our results, the 'fixed' specification produces the highest RMSE since the majority of the models with the 6th and 5th places are reported as having the 'fixed' specification, except, GARCH-MIDAS with EPU for Canada and GARCH-MIDAS with CLI for Italy, which took 2nd place with the fixed setting. Again, no first place is taken with a model with a 'fixed' specification. CLI-based models took 1st place in five out of six models with 'rolling' specifications, as RV-based models with 'rolling' specification took 1st place in 2 out of 6 models estimated. For the case of Canada, the RMSE values of both the RV specification and the CLI-based model are identical to each other, as we interpret that the RV with 'rolling' specification took 1st place in 3 out of 6 models. The overall results suggest that CLI based models provide improvement over the RV based models for the majority of results. If the results for EPU are investigated with the 'rolling' specification, no 1st place exists while 2nd place is only achieved for Japan. The model with the lowest RMSE for Japan is the *rw* specified model with CLI, a finding similar to the previous findings. An exception is Canada for which EPU-based model took 2nd place and for the 'fixed' specification. The RV-based models are better for Italy and the USA closely followed by CLI-based models.

Table 4. One-step ahead forecast evaluation

Model:	***GARCH-MIDAS, RV***	***GARCH-MIDAS, CLI***	***GARCH-MIDAS, EPU***	***GARCH-MIDAS, RV***	***GARCH-MIDAS, CLI***	***GARCH-MIDAS, EPU***
Type / Country:	*fixed*	*fixed*	*fixed*	*rw*	*rw*	*rw*
CAN	0.0003348 [3]	0.0003378 [4]	0.0003296 [2]	0.0003291 [1]	0.0003291 [1]	0.0003403 [5]
US	0.0004116 [6]	0.0004036 [3]	0.0004066 [5]	0.0003970 [1]	0.0004023 [2]	0.0004064 [4]
FR	0.0004400 [6]	0.0004308 [4]	0.0004318 [5]	0.0004270 [2]	0.0004262 [1]	0.0004284 [3]
DE	0.0004659 [4]	0.0004592 [2]	0.0004681 [6]	0.0004600 [3]	0.0004591 [1]	0.0004669 [5]
UK	0.0003095 [6]	0.0003000 [2]	0.0003056 [5]	0.0003004 [3]	0.0002999 [1]	0.0003005 [4]
IT	0.0005607 [6]	0.0005524 [2]	0.0005601 [5]	0.0005512 [1]	0.0005533 [3]	0.0005556 [4]
JP	0.0005609 [6]	0.0004629 [4]	0.0004621 [3]	0.0005512 [5]	0.0004591 [1]	0.0004612 [2]

Notes: f and rw are fixed and rolling windows. RV, CLI, and EPU represent RV-based univariate, CLI and EPU based models for their secular components. Number in brackets represent the relative rank of the model among the models estimated for the country group, ranked from lowest to highest RMSE forecast error.

The overall results suggest that the one-step-ahead forecast evaluations favor the CLI-based models over the EPU-based models in improving the predictive accuracy for the GARCH-MIDAS models estimated. Consequently, the CLI-based models produce lower RMSE in 5 out of 7 countries, the RV-based models with 'rolling' specifications compete well with the CLI-based 'rolling' models by producing 2 models with the lowest RMSE and 1 model with equal RMSE to that of CLI. The findings clearly favor the forecast gains of utilizing the CLI and EPU indicators in the GARCH-MIDAS models for the G7 markets and the overall result favors CLI over EPU while EPU performs improved accuracy in forecasts over the RV based models.

5.4 Discussion and policy implications

The findings of our study lead to important policy recommendations for policymakers and investors. The results of the one-step-ahead analysis are intriguing, and the evaluation should be made with caution. In terms of comparison, the total outcome for the forecasting practice revealed that the CLI index outperforms the EPU counterpart significantly. The CLI index aims at providing a leading indicator that is based on many macroeconomic variables in addition to business and consumer surveys for the future direction of the markets. Further, EPU constitutes three different components and the last component includes Central Bank professional forecaster surveys, a component similar to CLI. Therefore, both have important roles in providing information regarding future expectations in addition to being important indicators of stock market movements.

The forecasting results provide important policy implications. The policy ambiguity proxied with EPU were to be positive and significant for all of the countries analyzed and models estimated with both specifications. The implementation of CLI-based models further provided improved forecasting results. The positive impact of the innovations in the EPU in addition to the negative impact of the CLI innovations should be taken into considerations in investment and policy decisions. In forecasts, one could conclude that CLI provided an improvement over EPU while both provide improvements over RV-based volatility models. For turbulent periods, the predictive power of the EPU with GARCH-MIDAS models could further increase due to its characteristics. Further, these results might be different for emerging markets since the study focused solely on G7 markets. Lastly, based on the findings for the stock markets of the G7, the results might provide insights for the emerging markets since both CLI and EPU provide significant improvements in prediction and forecasting for the emerging market investor focusing on the fluctuations in the developed markets.

6. Conclusion

The study aimed at the analysis of the effects of the two economic indicators, the CLI and the EPU for their 'leading' economic indicator potential in G7 stock markets. To this end, the GARCH-MIDAS modeling methodology is selected for its capabilities in allowing the investigation of the effects of the monthly indicators on the secular component and in the short-run volatility in daily returns. The empirical findings provided interesting results compared to the literature. While EPU has gained relevance especially in the recent literature in GARCH-MIDAS modeling, our results indicated that the CLI is an equivalent, and in many cases, a more efficient 'leading' indicator in in-sample and out-of-sample forecasts in G7 developed country stock market volatility. The paper, in this sense, in addition to the confirmation of the importance of economic policy uncertainty for developed economy stock markets, the results also favored the CLI in this respect in many cases with different specifications. In forecast evaluations, the CLI-based models had beaten the EPU-based models in the improved predictive accuracy for the GARCH-MIDAS estimations: the CLI-based models led to lower RMSE in 5 out of 7 country stock markets. Further, the RV-based models competed quite well with the EPU based models if model specification was to be taken as the rolling windows.

In terms of parameter estimates and their signs, several suggestions were obtained for investors and policymakers. The impacts of CLI on the stock return volatility are statistically significant and negative for all G7 countries' stock index volatility without exceptions suggesting taking the rises in CLI into their decisions since they suggest rises in volatility and therefore risk in the short future horizons. The same statistical result was confirmed for EPU in the opposite direction. In comparison to the negative effects of CLI, the EPU innovations have positive impacts on volatility in the G7 stock markets.

If the findings were evaluated as a whole, the CLI was determined to be a leading indicator optimized for the turning point predictions for the majority of cases. Even though EPU had provided a significant positive impact on market volatility for G7, the predictive improvement of the models with EPU did not provide an equivalent improvement compared to those with CLI, however, EPU based models clearly provided improvement for the majority of G7 markets over the RV based models. The empirical results could also be thought as revealing that the EPU was largely dominated by its first component for the sample analyzed on the average, the political disputes, which might not be the case for the sample analyzed. This does not lead to the conclusion that EPU is not an effective indicator. Instead, in politically turbulent periods, the EPU is expected to perform well. Future studies should extend the analysis to developing country groups such as the E8.

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