THE DYNAMIC RELATION BETWEEN ECONOMIC POLICY UNCERTAINTY AND STOCK MARKET VOLATILITY IN TWO COUNTRIES: UNITED STATES AND S. KOREA

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ABSTRACT

The financial industry has become one of the most data-driven industries and the recent technological developments in big data, financial services, consumer-data management, social network services, and filtering data quality has made better interpretation of analyzed data possible in the finance industry. Financial data consist of a huge volume of quotes, market data, historical trade data, and time-sequenced transaction data used to model market and customer behavior. Many papers found that the stock market Volatility and Economic Policy Uncertainty (EPU) are closely correlated.

This study aims to find (1) the EPU index generated by big data can trace the volatility of the stock market and (2) the long-run equilibrium and shot-run relation between EPUs and Volatility index in the two countries are existed. The study has utilized the Vector Error Correction Model (VECM) to seek the dynamic relation between EPU and stock market volatility of the U.S. and S. Korea. The main findings of the study are (1) In most cases, the long-run equilibrium relation between EPU index and Volatility index exists, (2) a positive bi-directional relation between US_EPU and VIX and a positive uni-directional relation between KOR_EPU and VKOSPI, US_EPU and VKOSPI, KOR_EPU and VIX were found in the short-run, and finally (3) the EPU index in both countries affects the volatility of the stock market significantly. The paper concludes that the EPU index in different countries that have co-movements in stock price can provide useful information to investors in the stock and derivatives markets.

RESEARCH BACKGROUND

This paper utilized time series analysis that is one of the technics of traditional analytics and applied the important idea of data analysis derived from the current big data analytics. Lohr (2013) indicates that big data has been using since the 1990s and it represents the information assets characterized by such a high volume, velocity, and variety to require specific technology and analytical methods for its transformation into value. Kaplan and Haenlein (2018) define big data as data sets that are characterized by huge amounts of frequently updated data in various formats such as numeric, textual, images, and videos. Big data has attracted increasing attention in data management and analytics companies and has already proved its importance and value in several areas including the financial industry.

The financial industry has become one of the most data-driven industries and the recent technological developments in big data, financial services, consumer-data management, social network services, and filtering data quality has made better interpretation of analyzed data possible in the finance industry. Financial data consist of a huge volume of quotes, market data, historical trade data, and time-sequenced transaction data used to model market and customer behavior. These financial data helped FinTech companies develop automated solutions and products for stock investment strategy and risk management.

However, the stock market is full of uncertainties and is affected by many factors that cannot be controlled and automated by computerized products. Among the many factors, the stock market volatility and economic policy uncertainty are closely correlated (Pástor and Veronesi, 2012; Li and Peng, 2017). S. Korea's stock market looks heavily influenced by its economic policy uncertainty for domestic and foreign country markets (Choi S. J., 2017; Cheng, 2017; Kim, 2009; Shin, 2014). A good example was when S. Korea applied for a bailout to the IMF in November 1997, the stock price fell to its lowest level in a decade. Many times, the U.S. economic uncertainty such as the collapse of Lehman Brothers in September 2008 plunged S. Korea's stock price to 27.2 percent. Lee (2002) insisted that the co-movements between the U.S. and S. Korea's stock prices started to deepen at the end of 1990s. As well as we can find the significant co-movement of non-fundamental factors between the U.S. and S. Korea's stock prices (Jeon, 2017; Jeon & Lee, 2017; Jeon, 2018; and Jun and Choi, 2003). This phenomenon continues, because the economic structures of the U.S. and S. Korea are closely linked in terms of trade and finance. (Lee and Yu, 2018).

LITERATURE REVIEW AND RESEARCH PURPOSE

There are many prior studies on EPU (Economic Policy Uncertainty) and stock market volatility in the field of finance and real estate (Andre et al., 2013; Antonakakis et al., 2013; Antonakakis et al., 2015; Antonakakis & Floros, 2016; and Gao et al., 2019). Jurado et al. (2015) have introduced new measures of time series analysis in their study of the U.S. macro-economic uncertainty. These indexes have two attractive features: (1) the proxies of uncertainty cover a broad range of indicators spanning the entire macro-economy, and (2) the indexes are more persistent than stock market volatility. The EPU index based on the data suggested by Baker et al. (2016) is made by the index value from the newspaper article on focusing the role of the policy uncertainty in the U.S. since 1985. The index is generated by three types of components. The first component quantifies newspaper coverage of policy-related economic uncertainty, the second one reflects on the reports by the congressional budget office that compiles lists of federal tax code provisions set to expire in future years and the third component draws on the survey of professional forecasters of the federal reserve bank of Philadelphia.

Many prior U.S. studies have used the VIX or EPU index as a proxy for uncertainty (Apergis, 2015; Baker et al., 2016; Choi and Shim, 2016; Karnizova, 2014; and Nodari, 2014). Prior studies in S. Korea investigated the dynamic relationships between the uncertainty (EPU) measure and aggregate economic activity volatility (VKOSPI) index (Choi, 2017).

As we have seen in the previous study, U.S. and S. Korea stock markets are closely related, but the research on the relation between economic policy uncertainty and stock market volatility in the two countries is insufficient. Thus, this study aims to find the EPU index generated by big data can trace the volatility of the stock market and the long-run equilibrium and shot-run relation between EPUs and Volatility index in the two countries are existed.

DATA AND METHODOLOGY

Data

The study used monthly data of EPU and volatility Indexes in the U.S. (VIX) and S. Korea (VKOSPI) spanning from January 2003 to December 2018 as you see in Figures 1 and 2. Figure 1 shows the US EPU and VIX by the events of U.S. economic policy of uncertainty such as Gulf War II, Stimulus Debate, Lehman Failure, TARP (Troubled Asset Relief Program), Eurozone Crisis, Debt Ceiling Debate, Fiscal Cliff, Brexit, Trump Election, Rising Tariffs & Trade Tensions between the United States & China, and Government Shutdown I & II.

Figure 1
US EPU and VIX indexes from January 2003 to December 2018
source : www.policyuncertainity,com and CBOE

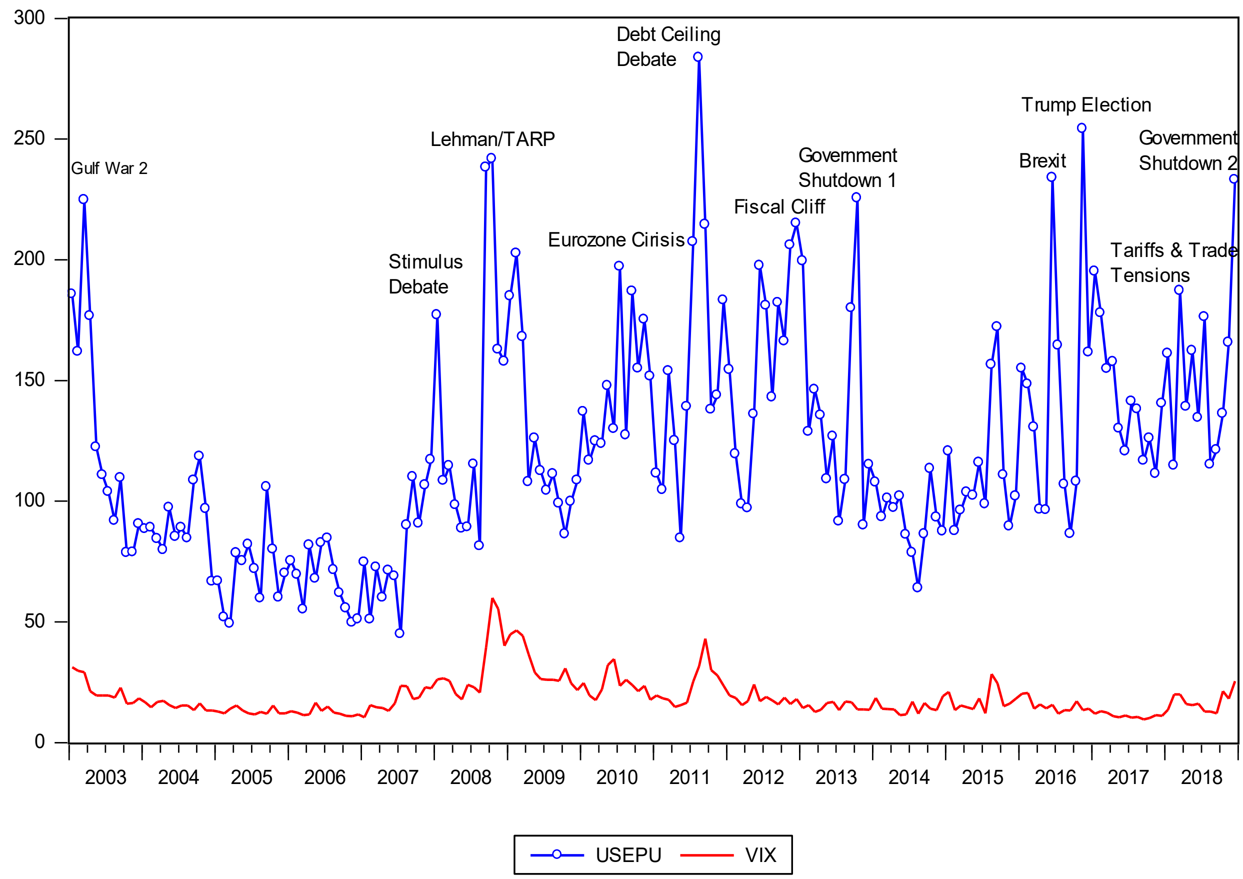
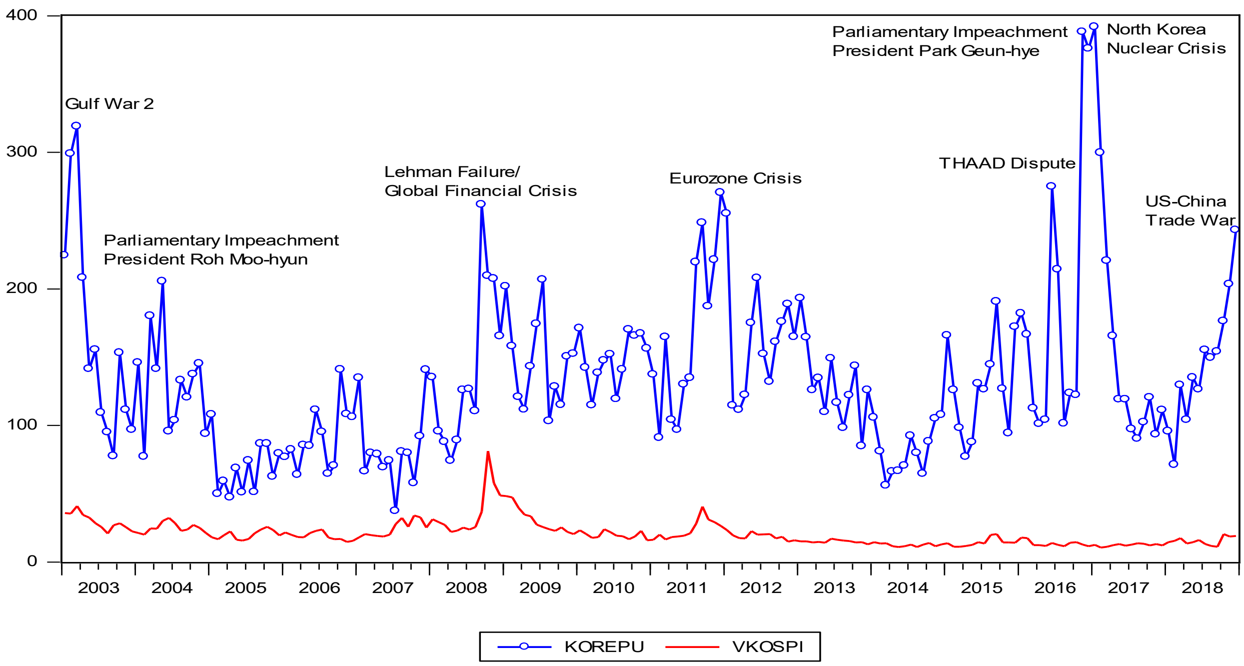


Figure 2 shows the Korean EPU and VKOSPI by the events of S. Korea economic policy of uncertainty such as Gulf War II, Parliament Impeaches President Roh, Lehman Failure & Global Financial Crisis, Eurozone Crisis, THAAD Dispute & Fears, Parliament Impeach of President Park, N. Korea Nuclear Crisis, and the U.S.-China Trade War.

Figure 2
KOR_EPU AND VKOSPI INDEX
S. Korea EPU and VKOSPI indexes from January 2003 to December 2018
source : www.policyuncertainity,com and KRX



EPU Index

The index is estimated by the data collected from 10 leading newspapers in the U.S. - USA Today, the Miami Herald, the Chicago Tribune, the Washington Post, the Los Angeles Times, the Boston Globe, the San Francisco Chronicle, the Dallas Morning News, the New York Times, and The Wall Street Journal. The basic data for the EPU index are derived from a monthly count of newspaper articles containing mainly three terms: “Economic,” “Policy,” and “Uncertainty.”

VIX and VKOSPI Index

The Chicago Board Options Exchange (CBOE) introduced the Volatility Index (VIX) in 1993 and the S. Korea Exchange (KRX) introduced the Volatility Index (VKOSPI) in 2009, VKOSPI index has been providing since 2003 by applying the fair variance swap method retrospectively. VKOSPI index was retrospective until 2003 because there was a lack of options needed to produce the index before that (Choi and Han, 2009; Lee, 2009).

The VIX or VKOSPI Index is a calculation designed to produce a measure of the constant, 30-day expected volatility of the U.S. or S. Korea stock market, derived from real-time, quote prices of S&P 500 or KOSPI 200 Index call and put options. These indexes have been acted as the benchmark for stock market volatility and have been proven to be very useful in forecasting the future stock market direction. (Corrado and Miller, 2005; Carr and Wu, 2006).

Methodology

This study searches for the relationships between economic policy uncertainties and stock market volatility in the U.S. and S. Korea for the period of 2003-2018 by time-series analyses. To determine the short run and long run equilibrium. relation between the uncertainties and the volatility, the Cointegration test and the VECM model were applied.

First, the study has conducted a unit root test to check whether the time series is stationary. The simple unit root test is valid only if the series is an AR (1) process. If the series is correlated at higher-order lags, the assumption of white noise disturbances is violated. If the series is described as a non-stationary process by the augmented Dicky-Fuller (ADF) tests and Pillips-Perron (PP) tests, differencing a series using differenced operations such as the first differenced values or the second differenced values is required.

Second, Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series may be stationary. If a linear combination exists, time series is said to be cointegration. The stationary linear combination may be interpreted as a long-run equilibrium relation between time series (Granger, 1969). Johansen's (1991) method can be used to test the restriction imposed by the cointegration term on the unrestricted VAR. The cointegration term is known as the error correction terms in the deviation from the long run equilibrium.

If several variables ($X_{i,t}$, $Y_{i,t}$) is found to be cointegrated, there always exists a corresponding error correction term which implies that changes in the dependent variable are a function of the level of disequilibrium in the co-integrating relation as well as changes in other explanatory variables. The VECM (Vector Error Correction Model) including the lagged error correction term is used in this study as the following 3-Equations:

$$\Delta Y_{i,t} = \alpha_i + \delta_i \, ECT_{t-1} + \sum_{j=1}^{P} \beta_{i,j} \, \Delta Y_{i,t-j} + \sum_{j=1}^{P} \gamma_{i,j} \, \Delta X_{i,t-j} + \varepsilon_{i,t} \qquad (1)$$

$$\Delta X_{i,t} = \alpha_i + \delta_i ECT_{t-1} + \sum_{j=1}^{P} \beta_{i,j} \, \Delta X_{i,t-j} + \sum_{j=1}^{P} \gamma_{i,j} \Delta Y_{i,t-j} + \varepsilon_{i,t} \qquad (2)$$

$$ECT_{t-1} = Y_{i,t-1} - \alpha_i - \theta_i X_{i,t-1} \qquad (3)$$

Where $X_{i,t}$ & $Y_{i,t}$ are dependent and independent variables such as USEPU, KOREPU, VIX, and VKOSPI; α_i are coefficients of drift terms; β_i & γ_i are the coefficient estimates for independent variables that reflect short-run relationships between variables. i reflects country such as US and S. Korea; p is maximum of lag order; t is period (1, 2, ..., T); and δ_i denote the speed that deviations from the long-run equilibrium are removed due to variations in each variable. $\varepsilon_{i,t}$ is a random error term; ECT is the error correction term that reflects long-run relationships between variables; and θ_i is cointegrating coefficients.

So, the long-run equilibrium and short-run relation between the EPU index and Stock market volatility index is interpreted by the asset of coefficients on the lagged values of independence in the VECM as follows:

Table 1 THE LONG- RUN EQUILIBRIUM AND SHORT- RUN RELATION IN VECM		
Relation	No Relation Exist	Relation Exist
Long-run equilibrium	$\delta_i = 0 \text{ or } \theta_i = 0$	$\delta_i \neq 0 \text{ and } \theta_i \neq 0$
Short-run	$\beta_i = 0 \text{ and } \gamma_i = 0$	$\beta_i \neq 0 \text{ or } \gamma_i \neq 0$

EMPIRICAL RESULTS

Unit Root Tests

Unit root tests are conducted to check whether the time series is stationary. Table 2 shows that the time series is stationary because there is no unit root in the level and first difference data.

Table 2
UNIT ROOT TESTS

		ADF Test		PP Test	
		Level	1st Difference	Level	1st Difference
US_EPU	Con.	-6.041***	-12.403***	-5.737***	-27.805***
	Con. & Trend	-6.833***	-12.427***	-6.686***	-28.912***
KOR_EPU	Con.	-5.580***	-10.886***	-5.422***	-21.958***
	Con. & Trend	-5.810***	-10.907***	-5.648***	-23.052***
VIX	Con.	-4.060***	-11.824***	-2.994***	-15.374***
	Con. & Trend	-4.013***	-11.818***	-3.946***	-15.353***
VKOSPI	Con.	-4.072***	-4.006***	-3.885***	-15.628***
	Con. & Trend	-12.282***	-12.275***	-4.579***	-15.601***

This table shows the unit root tests by ADF test and PP test. US_EPU & KOR_EPU indicate separately Economy Policy Uncertainty Index and VIX & VKOSPI indicate Stock market volatility Index. ADF and PP denote Augmented Dickey-Fuller (1979) and Phillips-Perron (1986) respectively. Con. and Con. & Trend denotes constant and constant & trend respectively. The asterisk ***, **, and * are significant levels at 1%, 5%, and 10%.

Lag Order Selection

Before examining the VECM, the optimum lag length should be selected by AIC (Akaike Information Criterion) or SIC (Schwarz Information Criterion). According to the principle of parsimony SIC is better than AIC. So, this study selected the optimal lag by SIC. Table 3 shows the optimum lag length and the optimal lag order selection for VECM. The asterisk * means the optimal lag selected.

Table 3
LAG ORDER SELECTION

Lag	US_EPU & VIX	KOR_EPU & VKOSPI	US_EPU & VKOSPI	KOR_EPU & VIX
0	17.327	18.238	17.725	17.969
1	15.768*	16.442*	16.010*	16.208*
2	15.814	16.500	16.015	16.300
3	15.872	16.582	16.090	16.382
4	15.906	16.674	16.110	16.475
5	15.969	16.754	16.175	16.540

Cointegration Test

The study checked whether time series has a long run equilibrium relationship through the cointegration test. As a result, it rejects the null hypothesis (Ho) of no cointegration existence at 1% and 5% level of significance and shows in Table 4. This table shows the results of the cointegration test by Johansen test. Here, ***, **, and * are significant levels at 1%, 5%, and 10%. The results of Cointegration in the U.S. and S. Korea indicate that there are existence long-run cointegrating relation among the variables.

Table 4
COINTEGRATION TEST

Country	Ho	Relation	Trace	λmax
US	None	US_EPU &VIX	15.494***	26.491***
	At most 1		14.741***	14.741***
S. Korea	None	KOR_EPU & VKOSPI	41.541***	29.553***
	At most 1		11.988***	11.988***
US & S. Korea	None	US_EPU & VKOSPI	36.432***	25.861***
	At most 1		10.571***	10.571***
	None	KOR_EPU & VIX	43.302***	14.939***
	At most 1		14.264***	14.939***

The Long-run Equilibrium and Short-run Relation Under VECM

Table 5 reveals the results of VECM. Here, ***, **, and * are significant level at 1%, 5%, 10% levels. The table shows that the coefficient of $\theta_1\ (-0.950)$is significant at a 1% level of significance and the coefficients of δ_1 (0.012) is not significant. It means that there is no long-run equilibrium relation between US_EPU and VIX. Table 5 also shows that the coefficient of $\gamma_{1,1}(0.028)$ in Equation (1) is significant at a 1% level of significance and the coefficients of $\gamma_{2,1}$ (1.099) in Equation (2) is significant at a 10% level of significance. It indicates that there exists a positive bi-directional relation between US_EPU and VIX in the short- run.

Table 5

THE RELATION BETWEEN US_EPU AND VIX UNDER VECM

Long- Run equilibrium	Equation (3): ECT (-1) =VIX (-1) +96.295 - 0.950*** US_EPU				
Short -Run	Variable	Equation (1) D (VIX)		Equation (2) D (US_EPU)	
	ECT (-1)	δ_1	0.012	δ_2	0.363
	D (VIX (-1))	$\beta_{1,1}$	-0.1094	$\gamma_{2,1}$	1.099*
	D (US_EPU (-1))	$\gamma_{1,1}$	0.028***	$\beta_{2,1}$	-0.079
	C	α_1	-0.026	α_2	0.442
R-squared		4.746%		18.902%	
Adj. R-squared		3.210%		17.594%	
F-statistic		3.089		14.451	

Table 6 shows the results of VECM. Here, ***, **, and * are significant levels at 1%, 5%, and 10%. This table shows that the coefficient of $\theta_1\ (0.585)$is significant at a 1% level of significance and the coefficients of δ_1 (-0.022) is significant at a 10% level of significance. It means that there is a long- run equilibrium relation between KOR_EPU and VKOSPI. Table 6 also shows that the coefficient of $\gamma_{1,1}(0.029)$ in Equation (1) is significant at a 1% level of significance and the coefficients of $\gamma_{2,1}$ (0.820) in Equation (2) is not significant at all levels of significance. It indicates that there exists a positive uni-directional relation between KOR_EPU and VKOSPI in the short- run.

Table6 **THE RELATION BETWEEN KOR_EPU AND VKOSPI UNDER VECM**					
Long-Run equilibrium	Equation (3): ECT (-1) =VKOSPI (-1) - 98.295 + 0.585*** KOR_EPU				
Short-run	Variable	Equation (1) D (VKOSPI)		Equation (2) D (KOR_EPU)	
	ECT (-1)	δ_1	-0.022**	δ_2	-0.460***
	D (VKOSPI (-1))	$\beta_{1,1}$	-0.095	$\gamma_{2,1}$	0.820
	D (KOR_EPU (-1))	$\gamma_{1,1}$	0.029***	$\beta_{2,1}$	-0.027
	C	α_1	0.348	α_2	-0.221
R-squared		8.051%		15.457%	
Adj. R-squared		6.568%		14.904%	
F-statistic		5.428		11.336	

Table 7 reveals the results of VECM. Here, ***, **, and * are significant level at 1%, 5%, 10% levels. The table shows that the coefficient of θ_1 $(0.641)$is significant at a 1% level of significance and the coefficients of δ_1 (-0.031) is significant at a 1% level of significance. It means that there is a long-run equilibrium relation between US_EPU and VKOSPI. Table 7 also shows that the coefficient of $\gamma_{1,1}(0.045)$ in Equation (1) is significant at a 1% level of significance and the coefficients of $\gamma_{2,1}$ (0.127) in Equation (2) is not significant. It indicates that there exists a positive uni-directional relation between US_EPU and VKOSPI in the short-run.

Table 7 **THE RELATION BETWEEN US_EPU AND VKOSPI UNDER VECM**					
Long-run equilibrium	Equation (3): ECT (-1) =VKOSPI (-1) - 98.131 + 0.641*** US_EPU				
Short-run	Variable	Equation (1) D (VKOSPI)		Equation (2) D (US_EPU)	
	ECT (-1)	δ_1	-0.031***	δ_2	-0.425***
	D (VKOSPI (-1))	$\beta_{1,1}$	-0.121*	$\gamma_{2,1}$	0.127
	D (US_EPU (-1))	$\gamma_{1,1}$	0.045***	$\beta_{2,1}$	0.074
	C	α_1	-0.092	α_2	0.377
R-squared		11.708%		16.148%	
Adj. R-squared		10.284%		14.795%	
F-statistic		8.222		11.939	

Table 8 shows the results of VECM. Here, ***, **, and * are significant levels at 1%, 5%, and 10%. This table shows that the coefficient of θ_1 $(-0.156)$is significant at a 1% level of significance and the coefficients of δ_1 (0.006) is significant at a 10% level of significance. It means that there is a long-run equilibrium relation between KOR_EPU and VIX. Table 8 also shows that the coefficient of $\gamma_{1,1}(0.012)$ in Equation (1) is significant at a 10% level of significance and the coefficients of $\gamma_{2,1}$ (1.561) in Equation (2) is not significant at all levels of significance. It indicates that there exists a positive uni-directional relation between KOR_EPU and VIX in the short-run.

Table 8

THE RELATION BETWEEN KOR_EPU AND VIX UNDER VECM

Long-run equilibrium	Equation (3): ECT (-1) = VIX (-1) +188.653 – 1.560*** KOR_EPU				
Short-run	Variable	Equation (1) D (VIX)		Equation (2) D (KOR_EPU)	
	ECT (-1)	δ_1	0.006*	δ_2	0.194***
	D (VIX (-1))	$\beta_{1,1}$	-0.072	$\gamma_{2,1}$	1.561
	D (KOR_EPU (-1))	$\gamma_{1,1}$	0.012*	$\beta_{2,1}$	-0.018
	C	α_1	-0.025	α_2	-0.219
R-squared		2.414%		17.154%	
Adj. R-squared		0.840%		15.817%	
F-statistic		1.533		12.833	

CONCLUSIONS

This paper looked at whether the EPU index generated by big data has information capability in the volatility of the stock market and at whether there are existed the long-run equilibrium and short-run relation between the U.S. and S. Korea stock market. To determine the dynamic relation between Economic Policy Uncertainty (EPU) and Stock market volatility of the U.S. and S. Korea, the study utilized the Vector Error Correction Model (VECM). The data span to estimate the empirical analysis was from January 2003 to December 2018 in the study.

The main findings of the study are as follows. First, in most cases the long-run equilibrium relation between EPU index and Volatility index exist. This indicates that Volatility index converge long-run equilibrium level by Error Correction Term (ECT). Second, there exists a positive bi-directional relation between US-EPU and VIX and exists a positive uni-directional relation between KOR-EPU and VKOSPI in the short-run. These results support the previous studies and indicate that the U.S. and S. Korea also have a significant relation between economic policy uncertainty and stock market volatility in the short- run. But the relation has different characteristics. In the U.S., the relation is bi-directional that means economic policy affects the stock market and the volatility of the stock market also affects the economic policy uncertainty while it is uni-direction in S. Korea from economic policy uncertainty to stock market volatility.

Third, there are a positive uni-directional relation from US-EPU to VKOSPI, from KOR-EPU to VIX in the short-run. It shows that U.S. and S. Korea between stock market volatility and economic policy uncertainty exists co-movement phenomenon.

Overall, the paper findings reveal that the EPU index in both the U.S. and S. Korea affects the volatility of the stock market significantly, which in turn, indicates that the EPU index can provide useful and meaningful information to investors in the stock and derivatives markets in both countries.

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