Economics Bulletin

Volume 42, Issue 4

Time varying causality between Economic policy uncertainty and stock prices in BRIC countries: A rolling-window bootstrap approach

Riadh El Abed
University of Tunis El Manar

Noura Harboub
University of Monastir

Abstract

In this paper, we use the rolling window bootstrap causality test to examine the dynamic causality according to the bivariate framework between economic policy uncertainty and stock prices in BRIC countries. We employed monthly data during the period span from March 2003 to February 2022. Empirical results indicate the evidence of unidirectional and absence of causality between variables. In addition, the causal relationship between stock prices and economic uncertainty is time varying. The causal periods coincide with periods of exceptional events such as financial crisis and the Covid-19 pandemic.

Citation: Riadh El Abed and Noura Harboub, (2022) "Time varying causality between Economic policy uncertainty and stock prices in BRIC countries: A rolling-window bootstrap approach", *Economics Bulletin*, Volume 42, Issue 4, pages 1767-1781
Contact: Riadh El Abed - riadh.abed@gmail.com, Noura Harboub - nouraharboub@gmail.com.
Submitted: July 20, 2022. **Published:** December 30, 2022.

1. Introduction

After the global subprime crisis (2008), which affected the real estate sector in the United States, the economy in the world is characterized by uncertainty and there have been various debates on the uncertainty of economic policies. Economic uncertainties can be transmitted from one country to another for various reasons. Indeed, the fluctuation of the interest rate, employment, production, exchange rate and shares cause the economic and financial instability of the markets.

The study of the effects of economic policy uncertainty is crucial as uncertainty drives investors and companies to choose investment strategies and minimize risk. When the share price increases over time, the company is characterized by good performance. On the other hand, the decline in share prices indicates poor performance and high risk. Economic policy uncertainty causes fluctuations in employment and investment (Bernanke, 1983). Indeed, investors stop investing until the uncertainty disappears. As a result, high uncertainty has a negative effect on investment and economic growth (Antonakakis et al., 2013). In addition, the other macro-economic variables are affected by the uncertainty. Stock indices are related to FDI, employment and economic growth. Thus any change in uncertainty affects stock prices.

Many empirical methodologies are used to study the interaction between stock prices and economic policy uncertainty. For example, Arouri et al. (2016) studied the effect of economic policy on U.S. stock market returns during the period from 1900 to 2014. The results show that economic policy has a greater negative effect on stock market returns during periods of high volatility. In the other hand, Sum (2019) studied the effect of economic policy on stock markets using the ordinary last square method during the period from 1993 to 2010. The results show a comparative study between European and non-European countries.

Recently, Khan et al (2020) studied the effect of economic policy uncertainty on the U.S. stock market using the non-linear ARDL model and threshold cointegration. The data are monthly from 1985 to 2020. The results show that a positive or negative shock to economic policy uncertainty generates a negative response in shares prices of 10% in the short term. In the long term, an increase in economic policy uncertainty of 10% causes a decrease in share prices of the same magnitude.

The main objective of this paper is to study the causality between stock prices and economic policy uncertainty in Brazil, Russia, India and China (BRIC countries). The choice of BRIC countries is explained as follows: the economy of these countries is important and they receive a very important part of the world flows. These countries dominate developing market economies. The BRIC countries accounted for 21% of global gross domestic product in 2018. At the same time, these countries are home to 41% of the world's population (World Bank, 2019).

We use the time-varying causality test that has the advantage of localizing periods of causality over time. Specifically, we employ the bootstrap Granger causality test and the rolling window estimation to study the time-varying dependence between economic policy uncertainty and stock prices for Brazil, Russia, India and China during periods of economic turbulence such as the global financial crisis and the COVID-19 pandemic. Empirical analysis of the causal relationship between economic policy uncertainty and stock prices can lead to biased results when the full sample indicates structural changes (Balcilar et al., 2010). This can be addressed by allowing the causal relationship between the two series to be time-varying instead of using full-sample data that assumes the single causality holds in every time period.

This paper is organized as follows. Section 2 discusses the data and preliminary analysis. Section 3 describes the empirical methodology. Section 4 presents the empirical results and Section 5 concludes the paper.

2. Data and preliminary analysis

The strong uncertainty of economic policies which is at the origin of world events such as crises, the Covid-19 pandemic and geopolitical risks leads to strong fluctuations in assets. Indeed, the volatility of stock market indices can affect multinational companies as well as consumer behavior. In addition, the high uncertainty allows a reduction in trade between countries. These different economic considerations lead us to study the interaction between uncertainty and stock prices while using the bootstrap rolling window Granger causality approach.

In this paper, we investigate the possible causality between economic policy uncertainty and stock prices in BRIC countries during the period span from March 2003 to February 2022 (monthly frequency). The stock prices and EPU index are sourced from www.investing.com and www.policyuncertainty.com.

Figure 1 (see appendix (A)) illustrates the uncertainty of economic policies and stock prices for the BRIC countries during the study period. On the right vertical axis we observe the EPU values and on the left vertical axis we observe the stock price trends. The observed trends indicate that uncertainty and stock prices are affected by the financial crisis of 2008 for the BRIC countries. Brazil admits the highest value of EPU in 2019 and for India, the peak of uncertainty is observed for the year 2014. The increase in uncertainty explains the weakness of stock prices for these two countries. Looking at the financial market, the attitudes and reactions of companies and investors to positive and negative shocks vary considerably. The high uncertainty as well as the fluctuations of stock prices leads us to study the causality between the uncertainty of economic policies and stock prices while considering the bootstrap rolling windows.

In the first part of empirical analysis, we perform the descriptive analysis for economic policy uncertainty (EPU) and all stock prices. Summary statistics are displayed in Table 1 (Panel A). We observe that SSE and CHEPU are most volatile as measured by the standard deviation, while BSESN and INDEPU are the least volatile with a standard deviation. Besides, we observe that RUSEPU has the highest level of excess kurtosis, indicating that extreme changes tend to occur more frequently for the economic uncertainty. The null hypothesis of the presence of unit roots is rejected by using ADF and Ng-Perron-MZa tests on first difference (panel B). All series are I (1).

Table1. Descriptive statistics and unit root tests

	BOVESPA	BVPEPU	IMOEX	RUSEPU	BSESN	INDEPU	SSE	CHEPU
Panel A: Descriptive Statistics								
Mean	60.2910	167.1886	1703.166	179.6974	22.6769	91.5657	2660.704	260.5808
Maximum	126.8020	677.0000	4150.000	794.0000	59.3069	284.0000	5954.770	970.8299
Minimum	11.2740	22.0000	325.5600	24.0000	2.9597	23.0000	1060.740	26.1440
Std-Dev	26.1321	95.5026	811.5779	127.5830	13.0502	49.5810	886.6501	237.8800
Skewness	0.5001	1.6771	0.7561	1.8521	0.7629	1.3599	0.4101	1.3523
Excess Kurtosis	2.8800	7.2895	3.5531	7.7064	3.1684	4.9701	3.7311	3.8276
Jarque-Bera	9.6421***	281.6934***	24.6319***	340.7898***	22.3873***	107.1564***	11.4721***	76.0068***
Prob	0.0080	0.0000	0.0000	0.0000	0.0000	0.0000	0.0032	0.0000
Panel B: Unit root test								
ADF-test								
Level	0.8891(2)	-1.3984(1)	-0.1952(1)	-0.4739(1)	2.5410(2)	-1.3118(1)	-0.1398(1)	-0.6917(2)
Prob	0.8996	0.1505	0.6149	0.5094	0.9975	0.1750	0.6345	0.4164
First difference	-12.4783***(1)	-12.705***(2)	-9.5143***(1)	-10.6143***(2)	-14.58***(2)	-18.0530***(1)	-8.6199***(2)	-15.49***(1)
Prob	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NgPerron MZa-test								
Level	0.5511	-6.3513*	-0.5982	-3.1635*	-1.6921	-2.9096*	-1.0855	-1.4134
Critical value	(-1.9422)	(-1.9422)	(-1.9422)	(-1.9422)	(-1.9422)	(-1.9422)	(-1.9422)	(-1.9422)
First difference	-12.3320*	-16.4885*	-9.5446*	-10.5969*	-14.6645*	-2.9266*	-8.6289*	-17.6519*
Critical value	(-1.9422)	(-1.9422)	(-1.9422)	(-1.9422)	(-1.9422)	(-1.9422)	(-1.9422)	(-1.9422)

Notes: *** denote significance at 1% and the values in parentheses indicate the critical values at a threshold of 5%. BOVESPA, IMOEX, BSESN and SSE are the stock prices of Brazil, Russia, India and China respectively. BVPEPU, RUSEPU, INDEPU and CHEPU are the economic policy uncertainty of Brazil, Russia, India and China respectively. The values in the parentheses represent the optimal lag structure for the ADF test, determined by the Akaike information criterion (AIC).

3. Empirical methodology

Bootstrap full-sample causality test

To study the possible link between economic policy uncertainty and stock prices in BRIC countries, we use the bootstrap rolling window Granger causality test introduced by Balcilar et al. (2010). This method has been considered by various works such as Su et al. (2021) and Sun el al. (2021). We adopt the test of non-causality in the sense of Granger introduced by Engle and Granger (1987) based on the bivariate VAR model. It is suggested in the literature that this test verifies whether the information relating to one variable makes it possible to improve the prediction of another variable and vice versa. The classic statistics of Granger's causality test namely the Wald test, the likelihood ratio LR test and the Lagrange multiplicator (LM) test do not present a standard asymptotic distribution when the series is I (1) or not stationary in level.

The empirical estimation of the VAR model by the Granger causality test will be more difficult. Therefore, we perform Toda and Yamamoto's (1995) modified Wald test of the bivariate VAR model on rolling window sub-samples. A disadvantage of standard Granger causality tests is that they are not suitable for small samples and can produce non-asymptotic critical values. To solve this problem, we employ the residual-based (RB) bootstrap method advanced by Shukur and Mantalos (2004). Shukur and Mantalos (2000) indicate that small sample modified-LR tests provide better power and size properties, even in small samples. So, we use the RB-based modified-LR method to study the causal relationship between economic policy uncertainty and stock prices in BRIC countries. The equation for the bivariate VAR model is as follows:

$$y_0 = \emptyset_0 + \emptyset_1 y_{t-1} + \dots + \emptyset_p y_{t-p} + \varepsilon_t, \quad t=1,2,\dots\dots\dots\dots T \tag{1}$$

Where $(\varepsilon_{1t}, \varepsilon_{2t})'$ is the white noise process with zero mean and covariance matrix. the optimal lag is determined by referring to the SBIC information criterion.

$y_t = (SP_t, EPU_t)'$. Where, SP is the stock price and EPU is the economic policy uncertainty for the BRIC countries. using two sub-vectors, equation (1) is written as follow:

$$\begin{Bmatrix} SP_t \\ EPU_t \end{Bmatrix} = \begin{Bmatrix} \emptyset_{10} \\ \emptyset_{20} \end{Bmatrix} + \begin{Bmatrix} \emptyset_{11}(L)\emptyset_{12}(L) \\ \emptyset_{21}(L)\emptyset_{22}(L) \end{Bmatrix} \begin{Bmatrix} SP_t \\ EPU_t \end{Bmatrix} + \begin{Bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{Bmatrix} \tag{2}$$

Where $\emptyset_{ij}(L) = \sum_{k=1}^{p} \emptyset_{ij,k} L^k$ and the lag operator (L) is expressed as follow: $L^k x_t = x_{t-k}$

Referring to equation (2), when $\emptyset_{12,k} = 0$, the stock price does not cause the EPU in the Granger sense. In addition, when $\emptyset_{21,k} = 0$, the EPU does not cause the stock price in the Granger sense. The stability tests of the short term and long parameters and the bootstrap sub-sample rolling-window causality tests are displayed in the appendix (B).

4. Empirical results

4.1. Causality analysis: Full-sample

By studying stationarity, we found that all variables are stationary in first difference (I (1)). Referring to equation (2) and to study the causal link between the economic policy uncertainty and stock prices in BRIC countries, the bivariate VAR model is used. Based on SBIC information criterion, we adopt the optimal lag of order 1.

In this article, we choose a window size composed of 24 observations. The results of the estimates of the modified LR tests based on RB, the stability of the parameters and the rolling window causality tests are interpreted for each country in the sample. Table 2 displays the results of the RB-based modified-LR tests. By referring to bootstrap p-value and considering the cases of Brazil and China, we observe the absence of causality at 1% and 5% and 10% levels between the stock prices and EPU. However, the causality between variables is unidirectional by considering the Russian and Indian cases. These results are confirmed by the work of Pástor and Veronesi (2012), Brogaard and Detzel (2013) and Antonakakis et al. (2013) which have justified the evidence of a bidirectional and unidirectional causality between economic uncertainty and stock prices.

In the presence of structural changes, the parameters of the full-sample VAR model for the four countries used will vary over time. Thus, the causality between uncertainty and stock prices is unstable. Zeileis et al. (2005) argue that full-sample causality tests with assumptions of constant parameters and the existence of unidirectional causality throughout the sampling period are no longer effective, and the results that will be obtained lack meaning. To verify the evidence of structural changes and for the purpose of studying the short-term and long-term stability of the VAR system parameters, the Sup-F, Ave-F, Exp-F and Lc tests are employed. The results of the parameter stability tests are displayed in Table 3.

Considering the case of Brazil, we see from the Exp-F statistic the evidence of a sudden structural change in the BOVESPA and BVPEPU equations as well as than in the VAR system for a level of 1%. On the other hand, the Ave-F and Sup-F statistics justifies the absence of a sudden structural change in the BOVESPA equation. In addition, the Ave-F indicates the absence of a sudden structural change in the VAR system. For Russia, the result of the Sup-F and Ave-F statistics suggests the absence of a structural change in the IMOEX equation. However, we detect the presence of a sudden structural change in the IMOEX equation by observing the Exp-F statistic. The Sup-F and Exp-F indicates the evidence of a sudden structural change in the VAR system for a level of 1%. The RUSEPU equation shows that only the Ave-F statistic allows the existence of a sudden structural change.

For India, we observe from the Ave-F and Exp-F statistics the absence of a sudden structural change in the BSESN equations. However, the Sup-F and Exp-F statistics shows that the presence of sudden structural change in VAR system. This same result is observed for the INDEPU equation. Ultimately and for China, we see the existence of a sudden structural change for the CHEPU equation by considering the Sup-F, the Exp-F and the Ave-F statistics. In addition, we detect the presence of a sudden structural change for the VAR system by observing the Sup-F and Exp-F statistics. Empirical results for China suggest the presence of a sudden structural change for the SSE equation (Sup-F). Finally, for the BRIC countries, the Lc test shows that the parameters in the VAR system follow a random walk process at the 1% level. These results show that the parameters of estimated VAR models using full-sample data indicate short-term instability.

Table2. Full Sample Granger Causality Tests: Bootstrap LR Test

Test	H0: does not Granger cause (statistics)	p-value	VAR(p)	H0: does not Granger cause (statistics)	p-value	VAR(p)
Pair (BOVESPA-BVPEPU)	**H0: BOVESPA does not Granger cause BVPEPU**			**H0: BVPEPU does not Granger cause BOVESPA**		
Bootstrap LR-Test	4.9798	0.1100	(1)	4.6943	0.1100	(2)
Pair (IMOEX-RUSEPU)	**H0: IMOEX does not Granger cause RUSEPU**			**H0: RUSEPU does not Granger cause IMOEX**		
Bootstrap LR-Test	3.3093	0.2000	(1)	20.9747***	0.0000	(2)
Pair (BSESN-INDEPU)	**H0: BSESN does not Granger cause INDEPU**			**H0: INDEPU does not Granger cause BSESN**		
Bootstrap LR-Test	0.0788	0.9700	(2)	9.4832***	0.0100	(1)
Pair (SSE-CHEPU)	**H0: SSE does not Granger cause CHEPU**			**H0: CHEPU does not Granger cause SSE**		
Bootstrap LR-Test	1.2167	0.5800	(1)	3.8103	0.1200	(1)

Notes: *** denotes significance at 1%. P-values are calculated using 1000 bootstrap repetitions. Number in parentheses indicates the optimal lags Based on SBIC information criterion.

Table3. Parameters stability tests

	Brazil					
	BOVESPA equation		BVPEPU equation		VAR System	
	Statistics	**P-Value**	**Statistics**	**P-Value**	**Statistics**	**P-Value**
Sup-F	6.5985	0.7769	56.9373***	0.0016	4.1166***	0.0000
Ave-F	1.8241	0.9418	12.4361***	0.0000	1.6709	0.4600
Exp-F	3.3405***	0.0050	23.4026***	0.0000	3.3405***	0.0050
Lc					6.6695***	0.0000
	Russia					
	IMOEX equation		**RUSEPU equation**		**VAR System**	
	Statistics	**P-Value**	**Statistics**	**P-Value**	**Statistics**	**P-Value**
Sup-F	7.3983	0.6801	12.1224	0.2044	4.1401***	0.0000
Ave-F	1.9813	0.9120	5.4310*	0.0880	1.5303	0.5106
Exp-F	7.3555***	0.0060	3.6236	0.1874	7.8049***	0.0000
Lc					4.9960***	0.0000
	India					
	BSESN equation		**INDEPU equation**		**VAR System**	
	Statistics	**P-Value**	**Statistics**	**P-Value**	**Statistics**	**P-Value**
Sup-F	3.8831*	0.0995	20.5244***	0.0093	4.7798***	0.0000
Ave-F	1.5904	0.9760	6.3400	0.1081	1.9967	0.7202
Exp-F	0.8068	0.9921	5.8328**	0.0266	1.7268***	0.0000
Lc					5.1280***	0.0000
	China					
	SSE equation		**CHEPU equation**		**VAR System**	
	Statistics	**P-Value**	**Statistics**	**P-Value**	**Statistics**	**P-Value**
Sup-F	4.6787*	0.0799	65.5772***	0.0000	4.6461***	0.0000
Ave-F	1.6633	0.9668	7.1016*	0.0665	1.8616	0.6803
Exp-F	0.8402	0.9882	27.7137***	0.0000	1.4787***	0.0040
Lc					5.4960***	0.0000

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. P-values are calculated using 1000 bootstrap repetitions.

4.2. Time varying causality analysis

In the following, we employ subsample bootstrap rolling-window Granger causality method to analyses the causal relationship between economic policy uncertainty and stock prices in BRIC countries because empirical results suggest the existence of a time-varying causality. Using the RB based modified-LR causality tests with the null hypothesis that the stock prices does not Granger cause EPU and vice versa, the bootstrap p-values of LR-statistics are estimated from the VAR models in Eq. (2). We choose a rolling window of 24 months. The optimal window size depends on the subsample size and the persistence. A large window size can improve the validity of the estimate. However, a small window size can reduce the effect of potential heteroscedasticity. In this case, the estimated variance will be larger and the efficiency will be weakened. Pesaran and Timmermann (2005) found that the autoregressive (AR) parameter deviation can be decreased in the presence of frequent interruptions. According to these authors, a window width greater than 20 is a valid selection.

Figures 2, 3, 4 and 5 (see appendix (C)) illustrate the bootstrap probability value as well as the direction and size of the stock prices on economic policy uncertainty and vice-versa. The magnitude of the impact of stock prices on EPU and that of EPU on stock prices is calculated for the four BRIC countries. Considering the case of Brazil, figure 2 shows that the null hypothesis according to which the stock price (BOVESPA) does not cause in the sense of Granger the economic policy uncertainty (BVPEPU) for a significance of 10% is rejected when the p-values (PV) are placed below the line horizontal dotted in pink. This figure allows the rejection of the causality hypothesis for the following periods: 2005M03-2007M12 and 2007M10-2007M12. From the impact of BVPEPU on BOVESPA, the rejection of the causality hypothesis is for the following periods: 2007M01-2007M05, 2008M01-2008M06, 2014M03-2014M06 and 2016M02-2016M12. These different periods coincides with some economic and financial crisis such as the subprime (2008). This same figure 2 illustrates the bootstrap estimation of the sum of the rolling coefficients for the impact of BOVESPA on BVPEPU and vice versa. In periods of no causality, we note that the impact of stock price on economic uncertainty and the opposite effect are negative during the periods. For the other periods, the effects are significant and positive.

By adopting the case of Russia, for the effect of IMOEX on RUSEPU we observe from Figure 3 the rejection of the causality hypothesis for the following periods: 2007M10-2008M06 and 2014M06-2015M06. However, the absence of causality for the effect of RUSEPU on IMOEX is detected from the following periods: 2007M02-2007M07, 2017M08-2017M12, 2020M03-2020M12 and 2022M01-2022M02. These periods are marked by exceptional events such as the financial crisis, the Covid-19 pandemic and recently the Russian war. The Bootstrap estimation of the sum of the rolling coefficients for the impact of IMOEX on RUSEPU and the impact of RUSEPU on IMOEX is illustrated in figure3. During the period of absence of causality, effects of IMOEX on RUSEPU and vice versa are negatives. However, the impact of stock price on uncertainty is positive in these periods: 2011M06-201M10, 2015M01-2015M06 and 2017M01-2020M12. On the other hand, the impact of uncertainty on stock prices is positive for the periods: 2008M06-2011M10, 2015M01-2016M12 and 2020M03-2021M12.

Figure 4 illustrates the Rolling window estimation results for relation between BSESN and INDEPU. The absence of causality for the impact of BSESN on INDEPU is observed from the two periods: 2012M03-2012M09 and 2017M02-2017M12. However the absence of causality for the impact of INDEPU on BSESN is detected in some periods: 2006M01-2006M05, 2008M07-2008M08, 2009M06-2011M08, 2013M05- 2014M06 and 2021M02-2022M02. While observing the Bootstrap estimation of the sum of the rolling coefficients for the impact of BSESN on INDEPU and the impact of INDEPU on BSESN, it is found that the effects are generally negative during periods of absence of causality. The effect of BSESN on INDEPU is positive in these periods: 2007M06-2009M03, 2011M08-2012M10 and 2019M06-2020M02 and the opposite effect is positive in these periods: 2006M01-2007M12, 2016M01-2018M01 and 2021M01-2022M02.

Finally from China (figure5), we see the absence of causality in these periods: 2010M02-2010M08 and 2015M06-2015M11(impact of SSE on CHEPU). For the effect of CHEPU on SSE, we see the absence of causality in some periods. This same figure traces the Bootstrap estimation of the sum of the rolling coefficients for the impact of SSE on CHEPU and the impact of CHEPU on SSE. In each period of absence of causality, the impact of economic policy uncertainty on stock price and the impact of stock price on uncertainty are negative.

5. Conclusion

In this paper, we study the causal interaction between stock prices and economic policy uncertainty in BRIC countries. We employ the bootstrap rolling windows Granger causality approach focused on bootstrap full-sample Granger causality test and sub-sample rolling window causality estimation. The main objective of this study is to examine the stability or variability of this interaction over time. All data are in monthly frequency during the period span from March 2003 to February 2022.

Empirical results indicate that the causality between economic policy uncertainty and stock prices is unidirectional for Russia and India. However, we see the absence of causality for Brazil and China. In addition, we observe the presence and the absence of sudden structural change in each equation such as stock prices and economic policy uncertainty and in the VAR system. We see that the causality between stock price and economic uncertainty is time-dependent. Some periods of bidirectional causality coincide with the financial crisis and the Covid-19 pandemic. Economic uncertainty generates high volatility in the exchange rate and the inflation rate, two determining variables in stock market investment decisions. Thus, uncertainty about future government actions will affect stock prices. If investors have confidence, prices will remain stable. Otherwise, economic instability could make stock prices unstable [Pastor and Veronesi (2013)].

Uncertainty weighs on the business climate and implies a kind of wait-and-see attitude among investors, which has a negative impact on the level of growth and the dividends distributed at the end of the year. Such a context will lead to the deterioration of the fundamentals and the attractiveness of equity investments, insofar as the purchase of shares is motivated by the prospects for economic growth. To reduce this instability, it is necessary to establish more transparency and to put in place stable economic policies. Investors will be better informed and this will reduce the high volatility on the financial markets.

References

Andrews, W. (1993). Tests for parameter instability and structural change with unknown change point. Journal of the Econometric Society, **61** (4), 821-856.

Andrews, W., & Ploberger, W. (1994). Optimal tests when a nuisance parameter is present only under the alternative. Journal of the Econometric Society, **62** (6), 1383-1414.

Antonakakis, N., Chatziantoniou, I., Filis, G. (2013). Dynamic Co-movements between Stock Market Returns and Policy Uncertainty, Economics Letters, **120** (1), 87-92.

Arouri et al. (2016). Economic Policy Uncertainty and Stock Markets: Long-Run Evidence from the US, Finance Research Letters.

Balcilar, M., & Ozdemir, Z. A. (2013). The export-output growth nexus in Japan: A bootstrap rolling window approach. Empirical Economics, **44** (2), 639-660.

Balcilar, M., Ozdemir, Z. A., & Arslanturk, Y. (2010). Economic growth and energy consumption causal nexus viewed through a bootstrap rolling window. Energy Economics, **32** (6), 1398-1410.

Bernanke, B. S. (1983). Irreversibility, uncertainty, and cyclical investment. The Quarterly Journal of Economics, **98** (1), 85-106.

Brogaard, J., Detzel, A. (2013). The asset pricing implications of government economic policy uncertainty. Working paper series.

Engle, R. F., & Granger, C. W. J. (1987). Co-integration and error correction: Representation, estimation, and testing. Econometrica, **55**, 251-276.

Hansen, E. (1992). Test for parameter instability in regressions with I(1) processes. Journal of Business and Economic Statistics, **10**, 321-336.

Khan et al (2020). US Policy Uncertainty and Stock Market Nexus Revisited through Dynamic ARDL Simulation and Threshold Modelling, Mathematics, **8**, 2073; doi:10.3390/math8112073.

Minlah, M. K., and Zhang, X. (2021). Testing for the Existence of the Environmental Kuznets Curve (EKC) for CO2 Emissions in Ghana: Evidence from the Bootstrap Rolling Window Granger Causality Test. *Environ. Sci. Pollut. Res.* **28** (2), 2119–2131. doi:10.1007/s11356-020-10600-x

Nyblom, J. (1989). Testing for the constancy of parameters over time. Journal of the American Statistical Association, **84**, 223-230.

Pesaran, M.H., Timmermann, A.(2005): Small sample properties of forecasts from autoregressive models under structural breaks. J. Econom. **129** (1–2), 183–217.

Shukur, G., & Mantalos, P. (2000). A simple investigation of the Granger-causality test in integratedcointegrated VAR systems. Journal of Applied Statistics, **27**(8), 1021-1031.

Shukur, G., & Mantalos, P. (2004). Size and power of the RESET test as applied to systems of equations: A Bootstrap approach. Journal of Modern Applied Statistical Methods, **3**(2), 370-385.

Su, C. W., Wang, X. Q., Tao, R., & Oana-Ramona, L. (2019). Do oil prices drive agricultural commodity prices? Further evidence in a global bio-energy context. Energy, **172**, 691–701. https://doi.org/10.1016/j.energy.2019.02.028.

Su, Y., Cherian, J., Sial, M. S., Badulescu, A., Thu, P. A., Badulescu, D., & Samad, S. (2021). Does tourism affect economic growth of China? A Panel Granger Causality Approach. Sustainability, **13** (3), 1349.

Sum, V. Economic policy uncertainty and stock market performance: Evidence from the European Union, Croatia, Norway, Russia, Switzerland, Turkey and Ukraine. J. Money Invest. Banking 2019, **25**, 99–104. [CrossRef].

Sun, X., Chenggang, Y., Khan, A., Hussain, J., & Bano, S. (2021). The role of tourism, and natural resources in the energy-pollution-growth nexus: An analysis of Belt and Road Initiative countries. Journal of Environmental Planning and Management, **64** (6), 999–1020.

Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. Journal of Econometrics, **66** (1-2), 225-250.

Wang, L., Chang, H-L., Sari, A., Sowah, J. K., & Cai, X-Y. (2020a). Resources or development first: An interesting question for a developing country. Resources Policy, **68**, 101-714.

Zeileis A, Leisch F, Hornik K, Kleiber C. (2005). Monitoring structural change in dynamic econometric models. Journal of Applied Econometrics, **20**, 99-121.

Appendix (A)

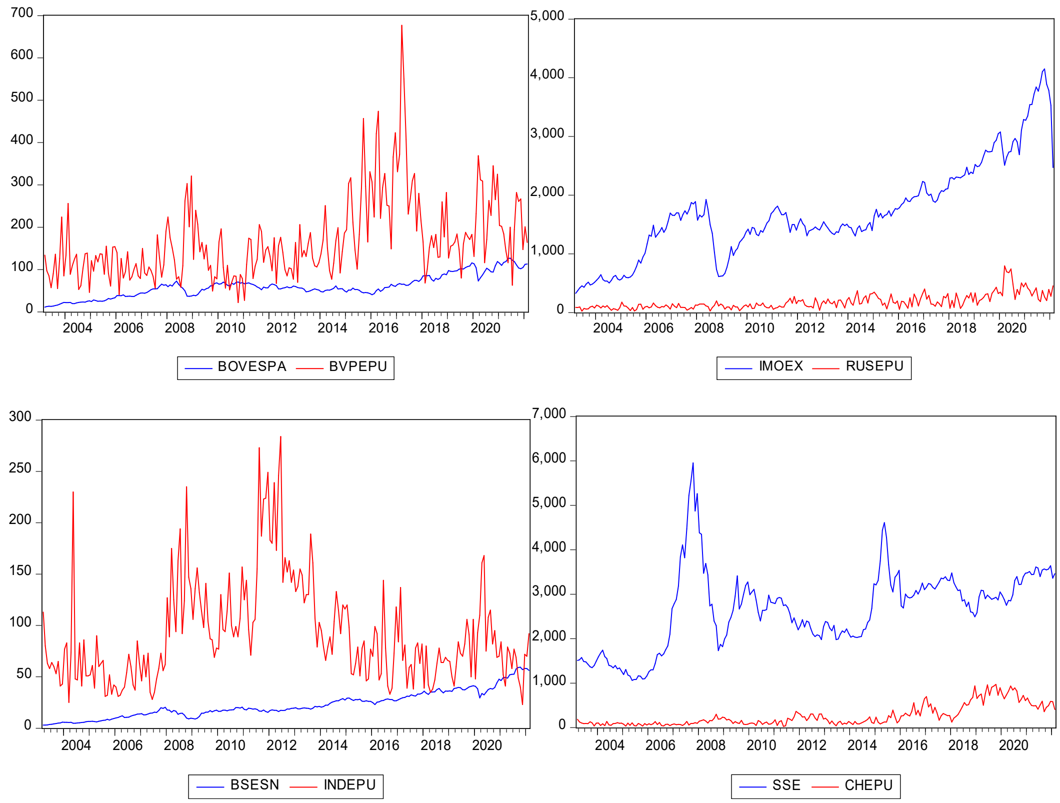


Figure1. Economic policy uncertainty and stock prices behavior over time

Appendix (B)

Parameter stability tests

It is suggested in the empirical literature that the VAR model parameters indicate instability when the full sample data are marked by the presence of structural changes (Su et al, 2019). Indeed, Balcir and Ozdemir (2013) claim that the sample marked by the presence of a high number of observations results in structural mutations that occur in the component variables of the complete sample. Thus, the interaction between the two variables shows an unstable effect during the sample period.

To overcome the instability problem, the stability tests of the short-term parameters namely, Sup-F, Exp-F and Mean-F (Andrews (1993); Andrews and Ploberger (1994)) and the stability Lc test of the long term (Nyblom, 1989; Hansen, 1992) must be evaluated. If the parameters are time-varying, this indicates that we should employ the sub-sample test to investigate the Granger causal relationship between EPU and stock prices.

Bootstrap sub-sample rolling-window causality test

When the assumption of parameter instability is not accepted, Balcilar et al. (2010) suggest dividing the entire time series into subsamples based on the width of the sliding window l. Wang et al. (2020a) indicate that this approach takes into account the variation of the causal relationship between the variables and the presence of instability due to structural changes.

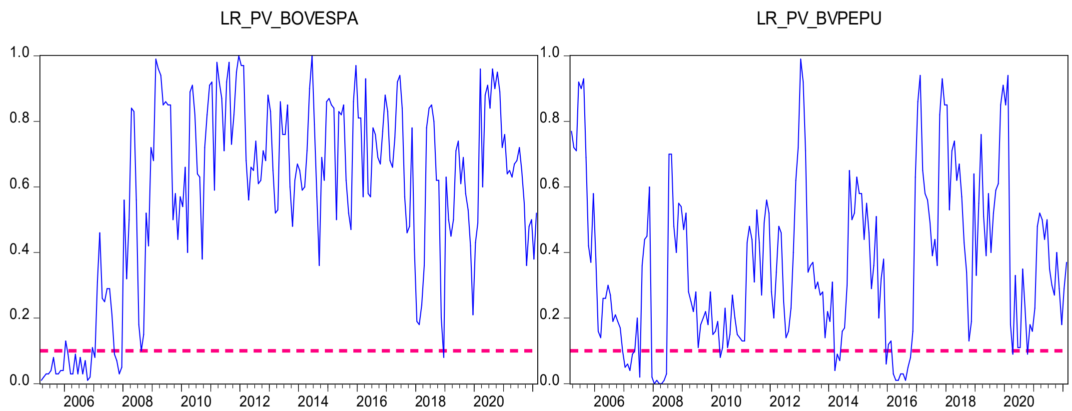
To investigate the causal relationship between the variables in the subsamples, the modified RB-based LR test is performed. Bootstrap p values and LR statistics for the T-1 subsamples allow us to identify temporal variations in the causal relationship between the two series.

$N_b{}^{-1}\sum_{k-1}^{p}\widehat{\emptyset}_{12,k}{}^{*}$ and $N_b{}^{-1}\sum_{k-1}^{p}\widehat{\emptyset}_{21,k}{}^{*}$ denote the average of a large number of estimations, indicating the impact of stock prices on EPU for BRIC countries and the effect of EPU on stock prices, respectively. The bootstrap estimates from the VAR models are $\widehat{\emptyset}_{12,\mathrm{k}}{}^{*}$ and $\widehat{\emptyset}_{12,\mathrm{k}}{}^{*}$. N_b represent the number of bootstrap repetitions. We calculate the 90% confidence intervals, where the lower and upper bounds equal the 5th and 95th quantiles of each of $\widehat{\emptyset}_{12,\mathrm{k}}$ and $\widehat{\emptyset}_{12,\mathrm{k}}$.

Appendix (C)

Case of Brazil

Bootstrap p-values of LR test statistic testing the null hypothesis that BOVESPA does not Granger cause BVPEPU and BVPEPU does not Granger cause BOVESPA



Bootstrap estimation of the sum of the rolling coefficients for the impact of BOVESPA on BVPEPU and the impact of BVPEPU on BOVESPA

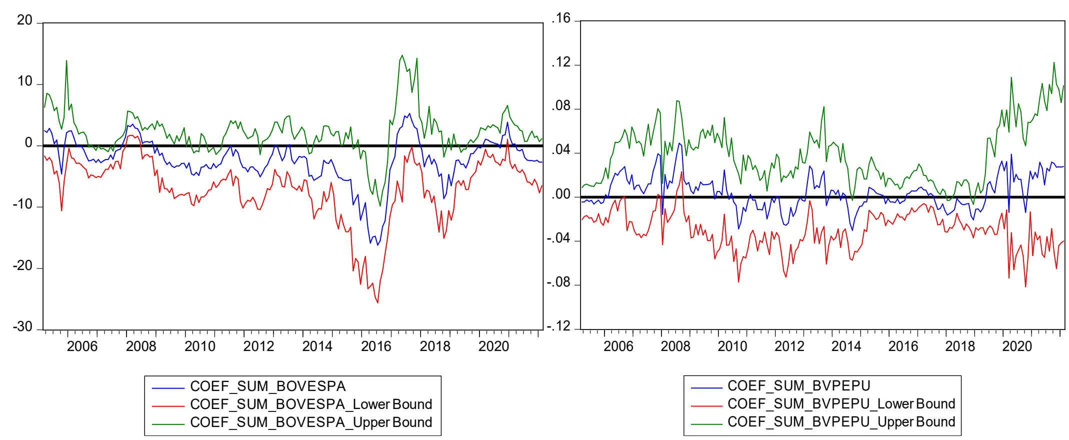
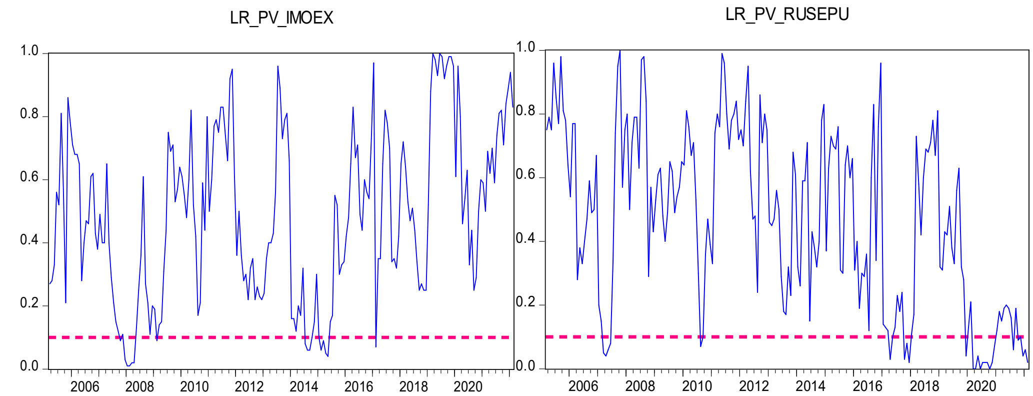


Figure2. Rolling window estimation results for relationship between BOVESPA and BVPEPU

Case of Russia

Bootstrap p-values of LR test statistic testing the null hypothesis that IMOEX does not Granger cause RUSEPU and RUSEPU does not Granger cause IMOEX



Bootstrap estimation of the sum of the rolling coefficients for the impact of IMOEX on RUSEPU and the impact of RUSEPU on IMOEX

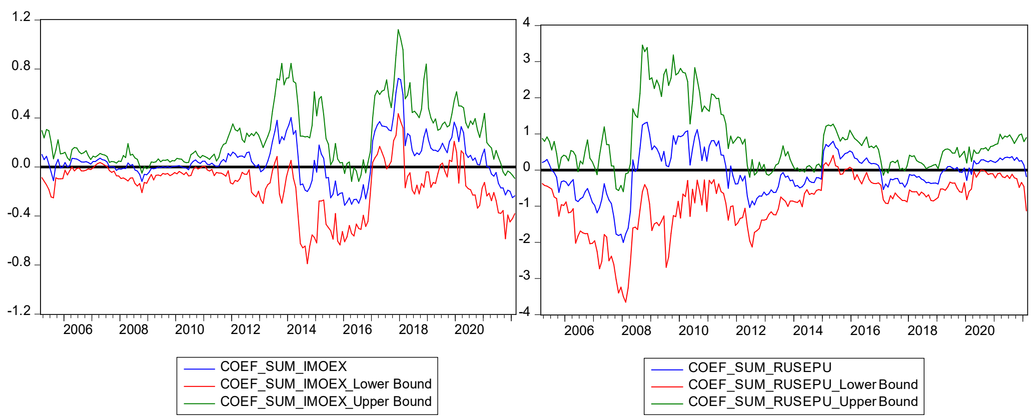
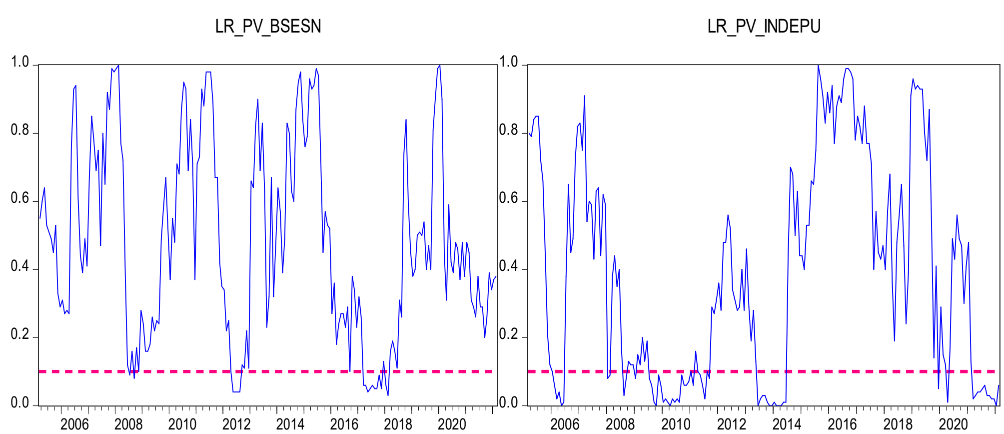


Figure3. Rolling window estimation results for relationship between IMOEX and RUSEPU

Case of India

Bootstrap p-values of LR test statistic testing the null hypothesis that BSESN does not Granger cause INDEPU and INDEPU does not Granger cause BSESN



Bootstrap estimation of the sum of the rolling coefficients for the impact of BSESN on INDEPU and the impact of INDEPU on BSESN

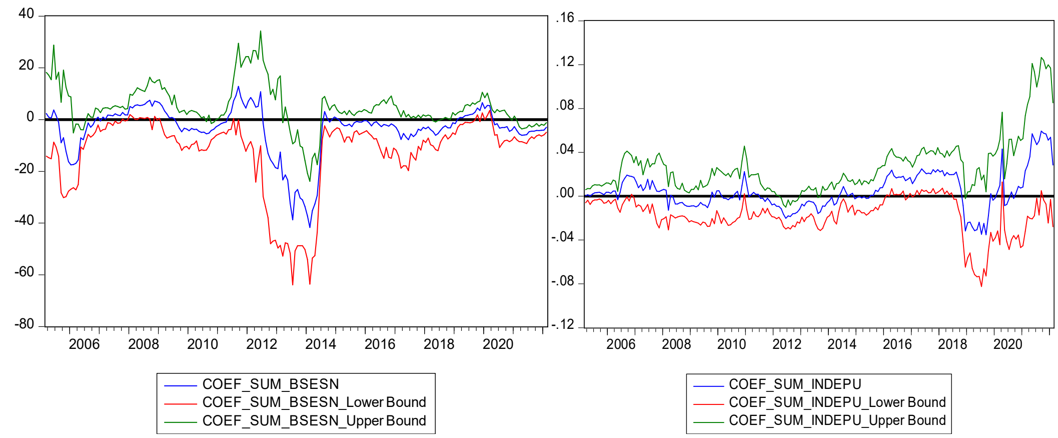
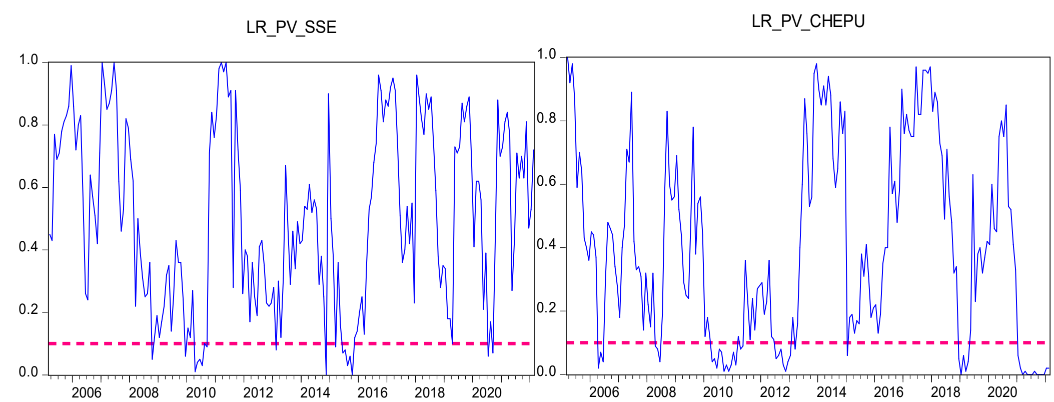


Figure4. Rolling window estimation results for relationship between BSESN and INDEPU

Case of China

Bootstrap p-values of LR test statistic testing the null hypothesis that SSE does not Granger cause CHEPU and CHEPU does not Granger cause SSE



Bootstrap estimation of the sum of the rolling coefficients for the impact of SSE on CHEPU and the impact of CHEPU on SSE

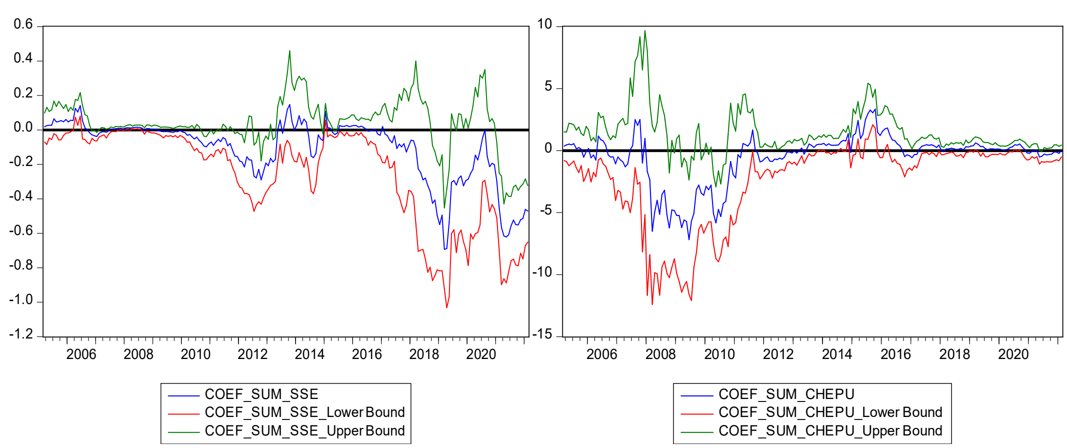


Figure5. Rolling window estimation results for relationship between SSE and CHEPU