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Revisiting the relation between stock price and exchange rate - An asymmetric panel ARDL analysis

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Abstract

This study explores the long-run relation between stock prices and exchange rates of ASEAN-5 countries by using 105 monthly observations from August 1998 to January 2017. Specifically, this study analyzes whether stock prices of ASEAN-5 countries would respond asymmetrically to appreciation and depreciation in the exchange rates by employing the nonlinear autoregressive distributed lags (NARDL) approach. Given that cross sectional dependence is likely to present in the panel data, the second-generation unit root and cointegration tests are adopted. The empirical findings from pooled-mean-group (PMG) reveals a significant and positive long-run effect of exchange rate appreciation on stock prices of ASEAN-5, and that the stock prices do not respond to exchange rate depreciation. The findings suggest that the long-run relations between stock market and foreign exchange market in ASEAN-5 are asymmetric rather than symmetric.

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1. INTRODUCTION

It is common that there is interaction between macroeconomic indicators. Therefore, it is plausible that the interaction holds in the linkage between stock market price and exchange rate. The relation between stock price and exchange rate has drawn a special attention to several parties. On micro scale, investors are interested on the movements of both stock and foreign exchange markets, as these movements would affect their portfolio standing. On macro level, governments and monetary policy regulators pay great attention on these two markets as changes in stock price and exchange rate generally reflect the financial and economic stability of a country.

Intuitively, exchange rate plays an important role in determining stock price. The flow-oriented model (Dornbusch and Fisher, 1980) demonstrated how exchange rate movements influence the stock price of domestic firms through the changes in their trade competitiveness. Suppose there is a currency depreciation, export-oriented firms tend to export more due to the increase in trade competitiveness, which leads to higher profits and share prices. Domestic firms that are less-export oriented will experience higher costs of import, which later results in lower expected future cash flows and ultimately share prices. In other words, an episode of currency depreciation (or currency appreciation) could drive stock price to change in either direction. On the other hand, the theory of asymmetric hedging behavior (Miller and Reuer, 1998) predicts that the firms' exposure during episodes of currency appreciation is different to periods of depreciation if they use real options to hedge against exchange rate changes. The likelihood of default by a domestic borrower who held foreign currency denominated debts tend to be higher when the home currency is depreciating. This is less likely when home currency appreciates relatively.

Despite originating from different angles, the flow-oriented model and the theory of asymmetric hedging behavior explained why currency appreciations could lead to nonlinear or asymmetric response in stock price as compared to currency depreciations. Nonetheless, most of the existing empirical findings on the relationship between exchange rate and stock price often presumed a linear relationship[1] and remained inconclusive. Given the possible nonlinearity within the relation, this study aims to find out whether the relation between stock prices and exchange rates in the ASEAN-5 countries are asymmetric. Specifically, this study attempts to examine the existence of asymmetric cointegrating relationship between stock prices and exchange rates of ASEAN-5 countries by using an asymmetric panel cointegration approach.

The novelty of this study is threefold. First, while the application of nonlinear ARDL is not new in the literature, this study makes the first attempt to apply the partial sum decomposition technique in a panel data setting to analyze the stock market – currency market asymmetry. Salisu and Isah (2017) and Salisu et al. (2019) is the closest in methodological spirit with this study, who examined the asymmetric relationships between oil price and stock price in a panel data setting. Second, the adoption of nonlinear ARDL technique in a dynamic panel setting is superior[2] to linear modeling and other nonlinear modeling techniques in terms of capturing asymmetric long-run and short-run relations. Third, this study applies the Pesaran (2007) cross-sectionally augmented Dickey-Fuller (CADF) unit root test and the Westerlund (2007) panel cointegration test, which

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[1] See Bahmani-Oskooee and Saha (2015) for a detailed review on the related empirical studies.
[2] See Shin et al. (2014) and Salisu and Isah (2017) for discussion on the superiority.

provide robust test results even under the presence of cross-sectional dependence (CSD) of panel data.

The structure of the remainder is as follow. Section 2 briefly reviews the relevant empirical evidence. Section 3 describes the methodology and data of this study. Section 4 reports and discusses the empirical findings. Section 5 concludes.

2. BRIEF LITERATURE REVIEW

Beginning from the pioneering works of Franck and Young (1972), Aggarwal (1981), and Giovannini and Jorion (1987), the ever-expanding literature of the relation between stock market and currency market under three broad themes. The first theme emphasizes on short-run and long-run relationship between stock price and exchange rate. Within this theme, some empirical studies have found existence of a long-run relationship between stock price and exchange rate (Mukherjee and Naka, 1995; Qiao, 1996; Ajayi and Mougoue, 1996; Cheah et al., 2017; Zarei, et al. 2019; Long et al., 2021), while some others have found no cointegration between the two variables (Bahmani-Oskooee and Sohrabian, 1992; Mansor, 2000; Nieh and Lee, 2001; Muhammad and Rasheed, 2003). The second theme mainly investigates the short-run causality between stock price and exchange rate. This theme also reported mixed findings, as some authors found the existence of bi-directional causality between the two variables (Bahmani-Oskooee and Sohrabian, 1992; Hatemi and Roca, 2005; Pan et al., 2007; Yang et al., 2014), several authors documented only a one-way causality running from one market to another (Mansor, 2000; Granger et al., 2000; Hatemi and Roca, 2005; Hau and Rey, 2005, 2006; Lau and Go, 2019; Lin, 2012, Ibrahim, 2000; Wu, 2000), while others reported there is no causality between stock price and exchange rate (Franck and Young, 1972, Solnik, 1987, Chow et al., 1997).

The studies of the two main themes above have reached to their findings by employing various methodological designs, which includes different estimation methods, sampled countries, observation periods, and different measurements used mainly for exchange rates. However, these empirical studies shared a common feature that they assumed the relation between stock price and exchange rate is of linear setting. This practice could lead to biased estimates and misleading findings if exchange rate movements would asymmetrically influence the changes in stock prices.

Finally, the third theme emerged given these theoretical arguments of asymmetric relationship between stock price and exchange rate. Even though the size of this theme is considerably smaller than the studies that assumed linear relation, it is growing in size and the related studies has reported convincing evidence on the existence of nonlinear relationship. For instance, Lee and Wang (2015) documented that the relationship between stock market movement and foreign exchange could be asymmetric in different time horizons. Using a panel dataset consists of 29 countries from 2000 to 2011, they found that the relationship between stock price and exchange rate are negative in the short-run, but it turns to positive in the long-run. By employing the recently developed nonlinear ARDL approach (Shin et al., 2014), Bahmani-Oskooee and Saha (2016) found evidence of asymmetric responses from stock prices to the change in exchange rates of 9 countries in both short run and long run. In a more recent study, Ajaz et al.

(2017) found that the stock price in India is asymmetrically responding to changes in exchange rate and interest rate.

In the context of Southeast Asia, Ismail and Isa (2009) used Malaysian monthly data for period 1995-2005 and found that their regime Markov-switching VAR model outperform linear model in fitting the cointegration between stock returns and exchange rates. Similarly, the nonlinear ARDL analysis in Cheah et al. (2017) demonstrated that the Malaysian stock price respond only to currency depreciation in the long run. The authors also found that the asymmetric cointegration between stock price and exchange rate is sensitive to change of exchange rate regime.

The empirical studies reviewed imply the possibility where exchange rates can relate to stock prices asymmetrically. Consequently, the following sections are structured to analyze the asymmetric relationships between stock prices and exchanges of the five ASEAN economies in a panel setting.

3. METHODOLOGY

3.1 The Model

As per preceding discussion, this study employs the nonlinear ARDL model by Shin et al. (2014). There are at least two favorable features of this technique. First, the mechanism of the nonlinear ARDL model is excellent in capturing the asymmetries within the long run and short run relation. This in turn allows for the analysis on asymmetry due to positive versus negative changes of the regressor, as well as the asymmetry between short run and long run dynamics. Second, it yields unbiased estimates even if there are variables with mixed integrated orders, given that the integrated order is at most one or $I(1)$.

Initially designed for time series analysis of one country as in Shin et al. (2014), Salisu and Isah (2017) showed that, however, the nonlinear ARDL model could be extended to cater for panel data. The nonlinear panel ARDL model is then technically equivalent to the dynamic heterogeneous panel data model, which is commonly employed in study with large *T* panels. Consequently, the nonlinear panel ARDL model accounts for inherent heterogeneity that usually observed in financial variables, which includes stock price and exchange rate.

To begin with, consider the following long-run panel model for stock price of country i ($i = 1, 2,\dots, N$) at period t ($t = 1, 2,\dots, T$):

$$SP_{it} = c_{0,i} + c_{1,i}EXC_{it} + c_{2,i}M2_{it} + c_{3,i}IPI_{it} + e_{it} \tag{1}$$

where *SP* is the log of stock price, *EXC* represents the log of exchange rate, *M2* is the log of nominal money supply, *IPI* is the log of industrial production, c_0 is the constants, c_1, c_2, c_3 are the long-run elasticities, and e_{it} is the white noise error term. As demonstrated in Shin et al. (2014), Equation (1) can be written in the ARDL framework as:

$$\Delta SP_{it} = \beta_{0,i} + \beta_{1,i}SP_{i,t-1} + \beta_{2,i}EXC_{i,t-1} + \beta_{3,i}M2_{i,t-1} + \beta_{4,i}IPI_{i,t-1} + \sum_{p=1}^{n1} \theta_{1,i}\Delta SP_{i,t-p} + \sum_{p=0}^{n2} \theta_{2,i}\Delta EXC_{i,t-p} + \sum_{p=0}^{n3} \theta_{4,i}\Delta M2_{i,t-p} + \sum_{p=0}^{n4} \theta_{5,i}\Delta IPI_{i,t-p} + \mu_i + \varepsilon_{it} \quad (2)$$

where β is the long run parameter, θ denotes the short run coefficient, μ_i indicates the group-specific effect, and ε_{it} is the error term. Equation (1) represents the symmetric version of the ARDL model, as the model assumes any exchange rate movement would linearly affect change in stock price. To assess the asymmetric impact of exchange rate appreciation and depreciation on stock price, the exchange rate *EXC* can be decomposed as:

$$POS_t = \sum_{j=1}^{t} \Delta EXC_{i,j}^{+} = \sum_{j=1}^{t} \max\left(\Delta EXC_{i,j}, 0\right) \quad (3)$$

and

$$NEG_t = \sum_{j=1}^{t} \Delta EXC_{i,j}^{-} = \sum_{j=1}^{t} \min\left(\Delta EXC_{i,j}, 0\right) \quad (4)$$

where POS_t and NEG_t are the partial sums which capture the positive changes (appreciations) and negative changes (depreciations) of *EXC*, respectively. Combining Equation (3) and (4) to Equation (2) yields:

$$\Delta SP_{it} = \beta_{0,i} + \beta_{1,i}SP_{i,t-1} + \beta_{2,i}POS_{i,t-1} + \beta_{3,i}NEG_{i,t-1} + \beta_{4,i}M2_{i,t-1} + \beta_{5,i}IPI_{i,t-1} + \sum_{p=1}^{n1} \theta_{1,i}\Delta SP_{i,t-p} + \sum_{p=0}^{n2} \theta_{2,i}\Delta POS_{i,t-p} + \sum_{p=0}^{n3} \theta_{3,i}\Delta NEG_{i,t-p} + \sum_{p=0}^{n4} \theta_{4,i}\Delta M2_{i,t-p} + \sum_{p=0}^{n5} \theta_{5,i}\Delta IPI_{i,t-p} + \mu_i + \varepsilon_{it} \quad (5)$$

Equation (5) is the asymmetric panel ARDL representation of the stock price model in (1), which can be used to analyze the nonlinear effect of exchange rate on stock price. Specifically, the existence of long-run asymmetry is valid if the null hypothesis of $\beta_2 = \beta_3$ is rejected. If $\beta_2 = \beta_3$ is true, then there is no long-run asymmetry within the relationship between stock price and exchange rate and Equation (2) suffices. Therefore, Equation (5) is the preferred model for estimation in this study.

This study will estimate both Equation (2) and (5) for the sake of comparison. The estimation of these panel ARDL models will undergo some procedures. First, this study will apply various cross-sectional dependency (CSD) tests to detect for the potential presence of CSD in the panel data. CSD in panel data has drawn rising attention in recent years. It refers to the correlation arising from common shocks with heterogeneous impacts across different countries. It also refers to the result of local spillover effects between regions or countries. Ignoring CSD in panel data estimation, especially in panel unit root analysis and cointegration test, may lead to the loss of estimator efficiency and result in invalid test statistics due to unaccounted dependency among the residuals. This study adopts two CSD tests, namely the Breush-Pagan (LM) test and the Pesaran CD test. The Breusch-Pagan (1980) Lagrange Multiplier (LM) test is the pioneer and the most commonly applied test for detecting CSD. However, one of the shortcomings of the Breusch-Pagan LM test is that it is not appropriate for testing CSD in large *N* and small *T* panel. To overcome the limitation, Pesaran (2004) suggested an alternative test known as the CD test, which is a scaled version of the standard LM test. The Pesaran (2004) CD test is often applied when the panel has small *N* and large *T*.

If the problem of CSD is confirmed in the panel data, the first-generation unit root tests such as LLC (Levin, Lin and Chun, 2002) and IPS (Im, Pesaran and Shin, 2003) panel unit root tests are inappropriate, as these tests fail to account for the issue of CSD. In this regard, Pesaran (2007) proposed the cross-sectionally augmented Dickey-Fuller (CADF) test, which runs the *t*-test for unit roots in heterogeneous panels with cross-section dependence. Similar to the IPS test, it is based on the mean of individual ADF test statistics of each unit in the panel. The standard ADF regressions are augmented with the cross section averages of lagged levels and first-differences of the individual series in order to eliminate the cross dependence effect in the series.

After identifying the integrated order of each variable and if there is no variable comes with integrated order of more than one, then this study will proceed to test the cointegrating relationship. Similar to the unit root tests, the first generation cointegration tests (Pedroni, 1999; 2004; Kao, 1999) are not applicable under the presence of CSD. Westerlund (2007) developed an error correction based panel cointegration test, which provide robust test results even under the presence of CSD. The objective of the test is to examine the absence of cointegration by determining if error correction does exist among the individual panel members or among the whole panel.

Having confirmed the existence of long run cointegration, the last stage involves model estimation by using both the mean-group (MG) and pooled-mean-group (PMG) estimator. The MG estimator relies on estimating *N* time series regressions and averaging the coefficients, which is preferable when the errors are heterogeneous, while the PMG estimator involves the combination of pooling and averaging of coefficients (Blackburne and Frank, 2007). Both estimators are later subjected to the Hausman test for checking the heterogeneity of the models.

3.2 The Data

The panel dataset employed in this study covers five ASEAN countries (Indonesia, Malaysia, Philippines, Thailand, and Singapore) from August 1998 to January 2017. All data are obtained from the International Financial Statistic database (International Financial Statistic, 2018), except stock prices are obtained from the Bloomberg terminal (Bloomberg, 2018). Variable wise, the stock price (*SP*) is indicated by the stock market indices of each country, exchange rate is indicated by real effective exchange rates (*EXC*), nominal money supply is indicated by *M*2, and the industrial production level is indicated by the industrial production indices (*IPI*). Table A1 in the appendix section provides a detailed description for each data and indicator.

Table 1 below shows the summary statistics of the data. As shown in the table, Philippine has the highest mean (3475.13) as well as the standard deviation (2174.68) in their stock market index, while Thailand has the lowest reading in both mean (822.84) and standard deviation (417.77). In terms of relative performance, Singapore stock market provides the highest risk adjusted monthly return given the highest mean-to-SD ratio (3.640) and Malaysian stock market follows the next with mean-to-SD ratio of 2.747. In term of effective exchange rate, Ringgit Malaysia seems to fluctuate the least among the ASEAN-5 countries over the observation period, mainly due to the dollar peg spanning from September 1999 to July 2005.

Table 1. Descriptive Statistics

Country	Statistics	*SP* (Index)	*EXC* (Index)	*M2* (LCU, in millions)	*IPI* (Index)
Indonesia	Mean	2329.05	85.81	2,010,118,014	84.39
	Std. Dev	1762.68	11.05	1,320,564,508	38.51
	Min.	276.15	45.64	531,977,000	32.47
	Max.	5518.68	102.6	5,004,976,786	162.11
Malaysia	Mean	1170.54	97.18	854,775	89.83
	Std. Dev	426.03	4.35	452,714	16.02
	Min.	302.91	84.33	284,336	64.95
	Max.	1882.71	106.93	1,651,223	113.9
Philippines	Mean	3475.13	95.86	2,418,221	86.72
	Std. Dev	2174.68	12.04	1,491,252	16.78
	Min.	993.35	73.19	818,135	49.28
	Max.	7963.11	118.70	6,068,287	109.98
Singapore	Mean	2483.01	100.05	320,369	94.54
	Std. Dev	682.01	7.82	136,332	11.40
	Min.	856.43	88.83	131,438	73.90
	Max.	3805.7	114.1	564,199	124.69
Thailand	Mean	822.84	94.20	10,369,086	85.02
	Std. Dev	417.77	7.30	4,069,260	18.25
	Min.	214.53	81.89	5,679,607	57.77
	Max.	1597.86	110.46	18,330,846	109.2
All	Mean	2056.11	94.62	404,816,093	88.10
	Std. Dev	1625.17	10.14	996,175,946	22.56
	Min.	214.53	45.64	131,438	32.47
	Max.	7963.11	118.7	5,004,976,786	162.11

4. RESULTS AND DISCUSSIONS

As aforementioned, the preliminary checking on CSD and the identification of the stationarity of each variable will precede the estimation of the asymmetric panel ARDL model. Table 2 below tabulates the results of the CSD tests and CADF test.

Table 2. Cross Sectional Dependence and CADF Test

Variable	*SP*	*EXC*	*IPI*	*M2*
Breush-Pagan (LM)	-1862.***	-0597.***	-1435.***	-2163.***
Pesaran CD	-43.12***	-15.99***	-37.29***	-46.51***
CADF Test (level)	-2.830	-2.736	-2.528	-1.515
CADF Test (first difference)	-6.190***	-6.190***	-6.150***	-6.190***

Note: Critical values of the CADF test (1%) are taken from Pesaran (2007) Table 2b. *** indicates significance at 1%. The null hypothesis for LM and CD test examines the validity of no CSD in the series. The null hypothesis for CADF test examines non-stationarity of the series.

Table 3. Westerlund Panel Cointegration Test

Statistic	Value	Z-value	*p*-value	Robust *p*-value
<u>Equation 2: Symmetric ARDL</u>				
G_t	-3.259	-2.433	0.008	0.033
G_a	-17.521	-2.083	0.019	0.000
P_t	-6.917	-2.482	0.007	0.000
P_a	-15.859	-2.864	0.002	0.000
<u>Equation 5: Asymmetric ARDL</u>				
G_t	-3.290	-1.977	0.024	0.000
G_a	-19.070	-1.784	0.037	0.000
P_t	-6.708	-1.758	0.039	0.033
P_a	-15.876	-1.938	0.026	0.000

The results from the LM and CD tests indicate the existence of CSD in the data. This directs us to the CADF test to test for unit root in the series instead of using the first-generation unit root tests. The CADF test reveals that the each of the variables is integrated at order one, or *I*(1). This indicates the possible existence of cointegrating relation, and it satisfies the prerequisite of estimating the asymmetric ARDL model. The cointegrating relation is examined by using Westerlund (2007) cointegration test as mentioned above. The results are shown in Table 3. From the results, the long run cointegration is established in Equation 2 and Equation 5. The *p*-value and robust *p*-value for all four test statistics support the rejection of the null hypothesis of no cointegration. In other words, the variables are parallel and move in the same direction in the long run.

Next, Table 4 reports the estimated long run relations for both Equation (2) and (5). In particular, we will estimate the symmetric version of the panel ARDL model (Equation 2) and then proceed with the asymmetric version (Equation 5) using both MG and PMG estimator. As the Hausman tests indicate that PMG is the preferred estimator, as the null hypothesis of homogeneity is not rejected for both symmetric model and asymmetric model. Thus, the following result reporting and discussions will only focus on the PMG estimators[3].

As far as the symmetric panel long-run model is of concern, the results indicate that exchange rate movements do not have significant effect on the changes in stock price in the long run at all conventional significance levels. This finding is consistent with numerous past studies which found weak evidence of the long-run link between exchange rate and stock price (see, for

[3] However, the results of MG estimation are available upon request.

examples, Mansor, 2000; Nieh and Lee, 2001; Muhammad and Rasheed, 2003). However, as Bahmani-Oskooee and Saha (2015) commented, these findings of weak long-run links are often left unexplained.

Table 4. Long-run Estimates: PMG Estimator

Dependent variable: *SP*		
Independent Variable	Symmetric (Equation 2)	Asymmetric (Equation 5)
EXC	-0.188- [0.707]	-
POS	-	**1.494** [0.012]
NEG	-	-0.140 (0.845)
*M*2	***0.771*** [0.000]	0.322 [0.202]
IPI	**-0.714**- [0.019]	**-1.156**- [0.024]
ECT(-1)	**-0.045**- [0.019]	***-0.037***- [0.000]
Hausman test (PMG/MG is preferred)	PMG	PMG

Note: Figures in parentheses represent the probability values. *, **, and *** indicate the rejection of null hypothesis at 10%, 5% and 1%, respectively.

The asymmetric long run model shows some interesting results. Instead of using the linear term of log exchange rate, the asymmetric model partitions the exchange rate (*EXC*) to exchange rate appreciations (*POS*) and depreciations (*NEG*). The estimated coefficients of *POS* in both models show that exchange rate appreciations exert significant and negative impact on ASEAN stock prices in the long run. Specifically, the stock price will decrease by 1.51% and 1.46% over the long run if REER appreciates by 1.0%, respectively. However, the coefficients of *NEG* show that depreciation has no significant effect on changes in stock price. In short, the asymmetric panel ARDL models above clearly show that stock price would only respond to currency appreciation in the long run, and that currency depreciation has no significant impact on the stock markets. This result of asymmetry is consistent with the early findings in Bahmani-Oskooee (2015) and Cheah et al. (2017), who have found similar result in the case of U.S. and Malaysia, respectively.

In terms of the controlled variables, all models report that stock price will respond positively with expansionary monetary policy over the long run. However, it seems that stock price is not responsive to the industrial production level. Table 2 also reports the error-correction term (ECT). The ECT in both symmetric and asymmetric models are significant at 5% level with magnitudes range from -0.0564 to -0.0528. This implies that the long run model specification is a proper mechanism for error correction of the short run dynamics. Specifically, any short-run deviations would be adjusted back to the equilibria at a speed of about 4.5% to 3.7% per year. Given that the estimation outputs of all models above are statistically similar except the part for exchange rate, it further emphasizes that there is a strong asymmetry lie within the relationship between stock price and exchange rate.

5. CONCLUSION

This paper questions on the existence of asymmetric cointegrating relationship between stock prices and exchange rates of ASEAN-5 countries. By using an asymmetric panel cointegration approach and monthly data of ASEAN-5 countries from August 1998 to January 2017, this paper yields some important findings. First, exchange rates and stock prices are cointegrated in the context of ASEAN-5, but the long-run relation is statistically insignificant if a linear or symmetric model specification is applied. Second, the long-run relations between stock market and foreign exchange market are asymmetric rather than symmetric, in which the stock prices are only responding to currency appreciation. Although this study does not directly address the reason behind this asymmetry, asymmetric hedging (Miller and Reuer, 1998) behavior of securities holders and asymmetric default risk might hold the explanations. Third, these findings are robust to the use of different indicators of exchange rate.

The findings above carry several implications. From the prospect of stock market investor, it is advisable to stay responsive to the fluctuations of exchange rate, particularly when the currency is appreciating. As the results indicate that stock prices will likely to drop in the long run when currency appreciates, participants in stock markets of ASEAN-5 are expected to adjust their investment decisions accordingly to their short-long position. Some implications are applicable to monetary policymaking as well. Monetary policy makers are advised to be more attentive to any policy change that would affect currency rate and interest rate, as these policies might bring persistent shocks to stock market. Additionally, it is suggested to include the element of asymmetry within dynamic adjustments whenever a study is designed to examine the equity-exchange rate nexus.

The findings are subject to some limitations. First, the study focused on the ASEAN-5 market, a regional economic bloc in Southeast Asia that consists of both developed and emerging economies. Therefore, it is advised to be cautious in making inferences about the equity-exchange rate relationship in other countries or economic blocs. Likewise, it is recommended to examine the existence of the asymmetric relationship in other country groups or regions that are similar in terms of economic cooperation or integration. Second, the results are obtained using monthly data as some of the variables employed are not available in higher frequency. Therefore, future research can consider using daily or higher frequency data to re-examine the asymmetric relationship found in this study.

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