The impact of real exchange rates on real stock prices

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Abstract

Purpose – The study examines the impact of real exchange rates and asymmetric real exchange rates on real stock prices in Malaysia, the Philippines, Singapore, Korea, Japan, the United Kingdom (UK), Germany, Hong Kong and Indonesia.

Design/methodology/approach – This study uses the asymmetric autoregressive distributed lag (ARDL) approach and non-linear autoregressive distributed lag (NARDL) approach.

Findings – The asymmetric ARDL approach shows more economic variables are found to be statistically significant than the ARDL approach. The asymmetric real exchange rate is mostly found to have a significant impact on the real stock price. Moreover, real output and real interest rates are found to have a significant impact on the real stock price. The Asian financial crisis (1997–1998) and the global financial crisis (2008–2009) are found to have a significant impact on the real stock price in some economies.

Research limitations/implications – Economic variables are important in the determination of stock prices.

Originality/value – It is important to examine the impact of asymmetric real exchange rate on the real stock price as the depreciation of real exchange rate could have different impacts than the appreciation of real exchange rate on the real stock price. The previous studies in the literature mostly found the significant impact of nominal exchange rate on the nominal stock price.

Keywords Real exchange rate, Asymmetric real exchange rate, Real stock price

Paper type Research paper

1. Introduction

The stock price can be influenced by many economic factors, such as the real exchange rate can affect the export and import of a company and therefore its profit (Mar Miralles-Quirós *et al.*, 2017; Eldomiaty *et al.*, 2020). When the profit of a company falls, its stock price likely shall be lower and vice versa. The real exchange rate highly fluctuates as it can be affected by many factors. The real exchange rate is crucial for firms in an open economy. Globalisation makes firms unlikely to avoid external shocks. The impact of appreciation or depreciation of the real exchange rate on firms may not be the same on the real stock price. Ding (2021) reports that the stock prices of the USA are closely linked with the appreciation (depreciation) of the US dollar, and the US stock prices are sensitive to the change of exchange rate. A rise in the real exchange rate could lead to a rise or a decrease in the real stock price. Depreciation of real exchange rates can boost the real stock prices. Depreciation of the real exchange rates suggests cheaper export prices. Firms can export more and earn more profits, which will

increase the real stock price. On the other hand, depreciation of the real exchange rate increases the costs of imported inputs for firms, which could increase selling prices and hence can reduce sales and profits. Thus, the real stock price of the firms would decrease (Bahmani-Oskooee and Saha, 2016). However, the empirical evidence does not always demonstrate the significant relationship between real exchange rate and real stock price. There is no significant relationship between real exchange rate and real stock price; this can be due to incomplete pass through from real exchange rate to export prices as firms adjust their profits from real exchange rate change (Kiliç, 2016). The impact of the real exchange rate on real stock price may be symmetric, that is, depreciation of the real exchange rate increases the real stock price whereas appreciation of the real exchange rate decreases the real stock price. However, the impact of real exchange rate on real stock price may be asymmetric, that is, appreciation of the real exchange rate can increase the costs of imported inputs and thus can lead to lower profit and real stock price whereas appreciation of the real exchange rate can also reduce the costs of imported inputs and thus can lead to more profit and higher real stock price (Bahmani-Oskooee and Saha, 2015). The Asian financial crisis (1997–1988) demonstrates that depreciation of the Thai baht causes depreciation of other currencies and leads to the downfall of stock markets in Asia (Dimitrova, 2005). The global financial crisis of 2008 also caused the downfall of stock markets in the world. The relationships between stock prices and exchange rates can affect economic growth and the success of government policies (Lin, 2012, p. 161; Sui and Sun, 2016).

This study examines the influence of real exchange rates and asymmetric real exchange rates on real stock prices in Malaysia, the Philippines, Singapore, Korea, Japan, the United Kingdom (UK), Germany, Hong Kong and Indonesia using the linear autoregressive distributed lag (ARDL) and nonlinear autoregressive distributed lag (NARDL) approaches (Pesaran *et al.*, 2001; Shin *et al.*, 2014). Therefore, the impact of real exchange rate on the real stock price is evaluated through the ARDL approach whereas the asymmetric real exchange rate on the real stock price is evaluated through NARDL. These economies adopt a different exchange rate regime (International Monetary Fund, 2021). Therefore, the relationship between real exchange rate and real stock price is inferred from a group of different exchange rate regimes. The impact of a change of real exchange rate on firms in an economy with a different exchange rate regime may not be the same. There are not many studies that investigated the asymmetric real exchange rate on the real stock price. Wong (2019) examines the link between real exchange rate returns and real stock price returns of some individual stocks in Malaysia over the sample period from January 2000 to June 2015. There is a link between the exchange rate market and the stock market, but not every real stock price return is significantly inked with real exchange rate return. The results of this study shall be practical for investors and relevant authorities in the economy.

2. Literature review

The real stock price can be affected by many economic factors. Peiró (2016) examines economic factors, namely the growth rates of industrial productions and long-term interest rates on stock returns in France, Germany, and the UK, respectively, over the period from 1969 to 2013. The results demonstrate that the growth rate of industrial production affects stock return positively while the growth rate of long-term interest rate influences stock return negatively in all the three countries examined. Similar conclusions are obtained by using different proxies of the growth rates of industrial productions and long-term interest rates and also sub-periods. Stock prices move simultaneously with interest rates and anticipate movements in industrial productions one year in advance. Future changes in industrial productions and current changes in long-term interest rates account for about one-half of stock returns. Nonetheless, this study does not investigate the influence of exchange rates on stock return.

Exchange rate and stock price are said to be closely linked (Wong, 2018). Multinational firms are involved in international transactions, and their profits are strongly influenced by real exchange rates. Moreover, the change of real exchange rates could have an asymmetric impact on the real stock price. Sui and Sun (2016) investigate the dynamic relationships among local stock returns, exchange rates, interest differentials and the US S&P 500 returns in Brazil, Russia, India, China and South Africa (BRICS). The results exhibit that the spillover effects are from exchange rates to stock returns in the short run and not vice versa. The spillover effects from the stock return to exchange rate are only found to be significant in Brazil and Russia. The US S&P 500 shocks influence stock markets in Brazil, China and South Africa. This indicates that the US stock price has the information to predict stock prices in BRICS. The spillover effects from exchange to stock returns are found to be increased in the financial crisis of 2008–2009. A well-managed exchange rate regime can stabilise the stock market in a financial crisis.

There are several studies that examined Granger causality between stock prices and exchange rates (Liang et al., 2013). Caporale et al. (2014) explore the linkages between stock market prices and exchange rates in six advanced economies, namely the USA, the UK, Canada, Japan, the euro area and Switzerland in the banking crisis over the period from 2007 to 2010. Bivariate unrestricted extended dynamic conditional correlation (UEDCC)-generalised autoregressive conditional heteroskedasticity (GARCH) models are estimated and found evidence of unidirectional Granger causality from stock returns to exchange rate changes in the USA and the UK, unidirectional Granger causality from exchange rate change to stock return in Canada and bidirectional Granger causality in the euro area and Switzerland. Moreover, Granger causality in variance from the stock return to exchange rate change is found in the USA, and Granger causality in variances from exchange rate changes to stock returns is found in the euro area and Japan. Bidirectional Granger causality in variances between exchange rate changes to stock returns is found in Switzerland and Canada. The results of the time-varying correlations display that dependence between stock return to exchange rate change is found to be increased in the financial crisis. This limits opportunities for investors to diversify their assets.

Ho and Huang (2015) inspect the causality invariance and the relationships between stock prices and exchange rates of Brazil, Russia, India and China (BRIC) using the Lagrange multiplier test. The weekly closing prices data from February 2002 to December 2013 are used. The sample period is divided into two sub-periods using the Chow breakpoint test and Quandt-Andrews unknown breakpoint test. For the full sample period, Granger causality from exchange rate to stock price is found in Brazil. Bidirectional Granger causality between stock price and the exchange rate is found in Russia. Granger causality from exchange rate to stock price is found in India. There is no Granger causality between stock price and exchange rate in China. Granger causality from exchange rate to stock price is found in the first sub-sample period, and no Granger causality between stock price and exchange rate in the second sub-period is found in Brazil. Granger causality from stock price to exchange rate in both the first sub-period and the second sub-period is found in Russia. Granger causality from exchange rate to stock price in both the first and the second sub-period is found in India. There is no Granger causality between stock price and exchange rate in the first sub-period in China and Granger causality from exchange rate to stock price in the second sub-period is found in China. This study claims that volatility can be transmitted between stock price and exchange rate although changes of stock price and exchange rate are either statistically uncorrelated or have no Granger causality in means. Tsagkanos and Siriopoulos (2013) probe the relationship between stock prices and exchange rates in European Union (EU) and the USA in the financial crisis of 2008–2012. The results are compared with a previous period where stock markets were operating under normal conditions. This study employs the structural nonparametric cointegrating regression. The results show Granger causality from

stock prices to exchange rates in the EU in the long run and Granger causality from stock prices to exchange rates in the USA in the short run. The study concludes that volatility can be transmitted between stock and exchange rate even when the returns of these two variables are either statistically uncorrelated or exhibit no causality in means.

There are studies that tested co-movement between stock price and exchange rate (Wong, 2017). Reboredo *et al.* (2016) investigate co-movement between stock price and exchange rate using copulas to measure downside and upside risk spillovers from one market to the other market by computing downside and upside conditional value at risk (CoVaR) and assessing spillover effects by testing for significant differences between the CoVaR and value at risk (VaR) values in Brazil, Chile, Colombia, India, Mexico, Russia, South Africa and Turkey. The sample is from April 2001 to November 2014. The results present a positive relationship between stock prices and exchange rates against the US dollar and the euro. Appreciation of home currencies leads to stock prices increase whilst depreciation of home currencies leads to stock prices decrease. Downside and upside spillover risk effects are found from currency returns to stock returns and from stock returns to currency returns. This is due to bullish stock markets attracting more foreign capital inflows for purchasing local assets and therefore increasing the value of the home currency. Conversely, bearish stock markets discourage foreign capital inflows for purchasing local assets and thus decrease the value of the home currency. Downside and upside spillover risk effects are asymmetric, that is, the downside spillover risk effect is greater than upside spillover risk effect. The spillover risk effect from and to the US dollar is greater than from and to the euro. This is because the US dollar is a more important vehicle currency than the euro in international transactions. The downside spillover risk effect is a result of flight to quality.

There are studies that found an insignificant influence of economic variables on stock returns. Maio and Philip (2015) use variance decompositions for stock returns by incorporating the information with a large economic panel dataset. This dynamic factor analysis summarises information from a panel of 124 economic variables from January 1964 to September 2010 into categories, namely into output and income, employment and labour force, housing, manufacturing, inventories and sales, money and credit, interest rates and bond yields, foreign exchange and price indices. The results of first-order vector autoregression show that adding economic variables with the market dividend yield does not improve significant information for stock returns. Moreover, the results show that economic variables contribute marginally to variance decompositions of the excess stock return. Moreover, adding economic variables in the two-factor model does not significantly improve the explanatory power in terms of pricing the traditional 25 size/book-to-market portfolios.

Some studies examined the asymmetric influence of exchange rates on stock prices. Bahmani-Oskooee and Saha (2015) investigate the impact of exchange rate on stock price using monthly data in the USA over the period from January 1973 to March 2014. The linear and nonlinear ARDL models are used in the estimations. This study estimates stock price as a function of nominal effective exchange rate, Industrial Production Index, Consumer Price Index and nominal money supply M2. The results show that exchange rate changes have short-run asymmetric effects on stock prices. Appreciation of the US dollar causes the profits of firms in the USA to decline, and this results in a negative impact on their stock prices. The NARDL model shows a more significant short-run and long-run impact of the exchange rate on stock price than the ARDL model. In another paper, Bahmani-Oskooee and Saha (2016) examine the impact of nominal effective exchange rate on the stock price using monthly data in Brazil, Canada, Chile, Indonesia, Japan, Korea, Malaysia, Mexico and the UK. The linear and nonlinear ARDL models are used. The other variables included in the estimation are Industrial Production Index, Consumer Price Index and nominal money supply M2. The results show that nominal effective exchange rates have significant long-run effects on stock

prices in Brazil and Korea. The nominal effective exchange rate is also found to have asymmetric effects on stock prices in the short run and long run.

There are many studies with different approaches to testing the relationship between stock prices and exchange rates. It is argued that there is a link between the stock market and the exchange rate market. Change of exchange rate influences trade flows and change of stock price influences capital movements. However, the empirical findings on the impact of exchange rate on stock price are inconclusive. The NARDL was relatively new introduced by Shin *et al.* (2014); therefore, the empirical evidence of the impact of asymmetric real exchange rate on real stock price is still limited. It is important to examine the impact of asymmetric real exchange rate on the real stock price as the depreciation of real exchange rate could have a different impact than appreciation of real exchange rate on the real stock price. The previous studies in the literature mostly found the significant impact of the nominal exchange rate on the nominal stock price. There are not many studies that examine the impact of real exchange rates on real stock prices and also evaluate the impact of the financial crisis on the real stock price.

3. Method
3.1 Data
A real exchange rate (E_t) is a real effective exchange rate. For Korea, Indonesia and Hong Kong, the real exchange rate is denoted as $E_t = ER_t \times \frac{CPI_{us,t}}{CPI_{d,t}}$, where ER_t is the domestic currency against the US dollar exchange rate, $CPI_{d,t}$ is domestic Consumer Price Index and $CPI_{us,t}$ is the US CPI. Real stock price (P_t) is the real domestic stock price, which is expressed as $P_t = \frac{SP_{d,t}}{CPI_{d,t}}$, where $SP_{d,t}$ is the domestic stock price. Real output (Y_t) is indicated by Industrial Production Index (2010 = 100) or Manufacturing Production Index (2010 = 100). For the Philippines, Singapore and Hong Kong, real output is expressed by Manufacturing Production Index (2010 = 100). Industrial Production Index or Manufacturing Production Index is said to be more relevant with stock return than gross domestic product (GDP), in which GDP is a broad variable likely with counter-cyclical components (Peiró, 2016). Real interest rate (i_t) is denoted as $i_t = ni_t - \pi_t$, where ni_t is the nominal interest rate, which is deposit rate or government bond yield and π_t is inflation, which is denoted as $\pi_t = \frac{CPI_t - CPI_{t-1}}{CPI_{t-1}} \times 100$. For the UK and Germany, the nominal interest rate is denoted by government bond yield. All the data were obtained from *International Financial Statistics* and International Monetary Fund. The data were seasonal adjusted using the census X13 multiplicative method and were transformed into the logarithm. The sample periods are from quarter 1, 1985 to quarter 4, 2016, except for Hong Kong and Indonesia, sample periods are from quarter 1, 1994 to quarter 4, 2016 and from quarter 3, 1995 to quarter 4, 2016, respectively. All data were transformed into the natural logarithms before estimation, except the real interest rate.

3.2 Research design
The augmented Dickey and Fuller (ADF) and the Phillips and Perron (PP) unit root test statistics are used to examine the stationary of the data. The Johansen likelihood ratio test statistics and the F-statistic for bounds testing are used to examine the long-run relationship of the real stock price model without asymmetric real exchange rate. The real stock price models estimated are an extension of the stock return model of Peiró (2016), including real exchange rate and asymmetric real exchange rate, respectively. Conversely, the estimated models of Bahmani-Oskooee and Saha (2015, 2016) are mainly based on the estimated model of Boonyanam (2014), in which the estimated model is in nominal terms. Bahmani-Oskooee and Saha (2015, 2016) estimate the stock price as a function of nominal effective exchange

rate, Industrial Production Index, Consumer Price Index and the nominal money supply M2. Therefore, it is good also to examine the impact of real exchange rate on real stock price, which can be more useful policy-relevant. The real stock price models to be estimated are specified as follows:

$$\log P_t = \beta_{11}D_{1,t} + \beta_{12}D_{2,t} + \beta_{13}\log Y_t + \beta_{14}i_t + \beta_{15}\log E_t + u_{1,t} \tag{1}$$

$$\log P_t = \beta_{21}D_{1,t} + \beta_{22}D_{2,t} + \beta_{23}\log Y_t + \beta_{24}i_t + \beta_{25}\log E_t^+ + \beta_{26}\log E_t^- + u_{2,t} \tag{2}$$

where the log is the natural logarithm, P_t is the real stock price, $D_{1,t}$ is the dummy variable to capture the Asian financial crisis (1997–1998) that is, 1 for the Asian financial crisis and 0 for other years, $D_{2,t}$ is the dummy variable to capture the global financial crisis (2008–2009), that is, 1 for the global financial crisis and 0 for other years, Y_t is real output, i_t is the real interest rate, E_t is the real effective exchange rate, $\log E_t^+ = \sum_{j=1}^{t} \Delta \log E_j^+$, where $\Delta \log E_j^+ = \max(\Delta \log E_t, 0)$, $\log E_t^- = \sum_{j=1}^{t} \Delta \log E_j^-$, where $\Delta \log E_j^- = \min(\Delta \log E_t, 0)$ and $u_{i,t}$ $(i = 1, 2)$ is a disturbance term. $\log E_t^+$ and $\log E_t^-$ are partial sum processes of positive and negative changes in $\log E_t$, respectively. The estimations of the real stock price models are based on the ARDL and NARDL approaches. The model selection method is based on the Akaike information criterion (AIC). The coefficient of real output is expected to be positive. An increase in real output usually leads to more profits for firms and therefore higher real stock prices. However, if an increase in real output leads to fewer profits for firms, the coefficient of real output is negative. The coefficient of the real interest rate is expected to be negative. The coefficient of the real exchange rate can be positive or negative depending on more firms gain or loss from real exchange rate depreciation. The coefficient of positive real exchange rate or negative real exchange rate can be positive or negative, respectively. There is an asymmetric effect in the long run if the coefficients of $\log E_t^+$ and $\log E_t^-$ are different. This can be tested using the Wald statistic.

The error correction models of the real stock price models, respectively, are as follows:

$$\Delta \log P_t = \beta_{30} + \beta_{31}D_{1,t} + \beta_{32}D_{2,t} + \sum_{i=0}^{p} \beta_{33i}\Delta \log Y_{t-i} + \sum_{i=0}^{q} \beta_{34i}\Delta i_{t-i} + \sum_{i=0}^{s} \beta_{35i}\Delta E_{t-i}$$
$$+ \sum_{i=1}^{v} \beta_{36i}\Delta \log P_{t-i} + \beta_{37i}ec_{t-1} + u_{3,t} \tag{3}$$

$$\Delta \log P_t = \beta_{40} + \beta_{41}D_{1,t} + \beta_{42}D_{2,t} + \sum_{i=0}^{w} \beta_{43i}\Delta \log Y_{t-i} + \sum_{i=0}^{x} \beta_{44i}\Delta i_{t-i} + \sum_{i=0}^{z} \beta_{45i}\Delta E_{t-i}^+$$
$$+ \sum_{i=0}^{a} \beta_{46i}\Delta E_{t-i}^- + \sum_{i=1}^{b} \beta_{47i}\Delta \log P_{t-i} + \beta_{48i}ec_{t-1} + u_{4,t} \tag{4}$$

where Δ is the first difference operator, ec_{t-1} is an error correction term and $u_{i,t}$ $(i = 3, 4)$ is a disturbance term. The error correction terms are obtained from the real stock price models, respectively. There is an asymmetric effect in the short run if the sum of the coefficients of $\sum \Delta \log E_{t-i}^+$ and $\sum \Delta \log E_{t-i}^-$ are not the same. This can be tested by using the Wald statistic. The ordinary least squares (OLS) estimator with Newey–West standard error is used when there is an autocorrelation problem in the disturbance term and the OLS estimator with Huber-White standard error is used when there is a heteroscedasticity problem in the disturbance term.

4. Results

The results of the ADF and PP unit root test statistics, which are not reported, exhibit that all the variables are non-stationary in their levels but become stationary after taking the first differences, except the ADF unit root test statistic for the real interest rate of the Philippines under the trend case and the ADF unit root test statistic for real output of Japan under the no trend case. There is no evidence of I(2) variable. This implies that the use of the ARDL or the NARDL approach in the estimation is suitable. The results of the Johansen likelihood ratio test statistics for the real stock price model without asymmetric real exchange rate, which are not reported, show that there is one cointegrating vector.

The results of the ARDL approach are reported in Table 1. For Malaysia, the Philippines, the UK and Germany, the F-statistics for bounds testing are found to be statistically significant at the 1% level whilst for Japan and Korea, the F-statistics for bounds testing are found to be statistically significant at the 10% level. For Hong Kong and Indonesia, the F-statistics for bounds testing is found to be statistically inconclusive at the 5% level. The F-statistic for bounds testing is found to be statistically insignificant for Singapore at the 10% level. Overall, the F-statistics for bounds testing show mostly there is evidence of cointegration. The coefficients of the error correction models are all found to be negative and statistically significant. Moreover, the values of the coefficients of the error correction models are found to be less than one. For Malaysia, Germany, Hong Kong and Indonesia, the estimated models fulfil the conditions of no autocorrelation, homoscedasticity of disturbance terms, no-functional form and the estimated models are mostly found to be stable. For Singapore and the UK, the estimated models fulfil the conditions of no-autocorrelation, homoscedasticity of disturbance terms and the estimated models are found to be stable. For the Philippines, Japan and Korea, the estimated models fulfil some conditions of the diagnostic tests for the models.

For Malaysia, the global financial crisis decreases the real stock price in the long run. An increase in the real interest rate will lead to a decrease in real stock prices in the short run whereas an increase in the real exchange rate will lead to an increase in the real stock price in the short run. For the Philippines, the real output or the global financial crisis decreases the real stock price in the long run. An increase in the real exchange rate will lead to an increase in the real stock price in the short run and long run. For Singapore, real output increases the real stock price in the long run whilst the global financial crisis decreases the real stock price in the long run. An increase in the real exchange rate will lead to a decrease in real stock prices in the short run. For Japan, an increase in the real output will lead to an increase in real stock prices in the short run. For Korea, an increase in the real interest rate or real exchange rate will lead to a decrease in real stock prices in the short run. For the UK, the global financial crisis decreases real stock prices in the short run. Economic variables are not important in real stock prices in the short run and long run. For Germany, the Asian financial crisis increases real stock prices in the long run while the global financial crisis decreases real stock prices in the long run. An increase in the real exchange rate will lead to a decrease in real stock prices in the short run. For Hong Kong, an increase in the real exchange rate will lead to a decrease in real stock prices in the short run. For Indonesia, an increase in the real output will lead to an increase in real stock price in the long run. The real exchange rate or the global financial crisis decreases real stock prices in the long run. An increase in the real interest rate or real exchange rate will lead to a decrease in real stock prices in the short run. Generally, economic variables do not much influence real stock price in the short run and long run in Japan, Korea, the UK and Hong Kong (see Table 1).

The results of the NARDL approach are reported in Table 2. For the Philippines and Indonesia, the F-statistics for bounds testing are found to be statistically significant at the 1% level while for Hong Kong, the F-statistic for bounds testing is found to be statistically significant at the 5% level. For Japan and Korea, the F-statistics for bounds testing are found to be inconclusive at the 5% level. The F-statistics for bounds testing are found to be statistically insignificant for Malaysia, Singapore and the UK at the 10% level. The

| | Malaysia | | The Philippines | |
	Long run	Short run	Long run	Short run
Constant	–	−0.3815** (−2.6078)	–	−1.2294*** (−4.3392)
log Y	0.5477 (1.3159)	−0.1328 (−0.6789)	−0.6279*** (−3.3784)	−0.2376 (−0.9434)
i	0.0586 (0.8140)	−0.0462@@@ (8.7604)	−0.0499 (−1.6159)	−0.0072 (0.2811)
log E	0.5364 (0.3580)	1.3405@@@ (8.3980)	2.1660*** (3.4830)	1.0729@ (3.4396)
log P_{t-i}	–	0.0881 (0.9474)	–	0.2199@@ (4.7854)
$D_{1,t}$	−1.0508 (−1.5551)	−0.0499 (−1.0196)	−0.3087 (−0.7270)	−0.0230 (−0.3396)
$D_{2,t}$	−1.3175* (−1.8893)	−0.0658 (−1.1763)	−0.9988*** (−3.9706)	−0.0503 (−1.2719)
ec_{t-1}	–	−0.0772*** (−2.7733)	–	−0.1803*** (−4.3682)

Diagnostic tests

F-statistic	4.0010@@@	–	9.1439@@@	–
Adj. R^2	–	0.3325	–	0.3615
LM	–	1.2795	–	11.6591***
Hetero	–	0.5871	–	11.8916***
Reset	–	1.0997	–	1.3806
CUSUM	–	S	–	U
CUSUMSQ	–	U	–	S

| | Singapore | | Japan | |
	Long run	Short run	Long run	Short run
Constant	–	0.1474*** (3.1143)	–	1.5212*** (2.7498)
log Y	0.3776* (1.7019)	−0.1650 (−0.8546)	−15.0859 (−0.7788)	0.4203* (1.9233)
i	−0.0484 (−0.6687)	−0.0174 (−1.2011)	−0.2804 (−0.6037)	0.0003 (0.0296)
log E	−0.6058 (−0.6884)	−0.3121@@@ (0.1909)	−0.4592 (−0.2081)	−0.3229 (−1.3292)
log P_{t-i}	–	0.1354 (1.5963)	–	–
$D_{1,t}$	−0.1745 (−0.6354)	−0.0251 (−0.6017)	−1.6374 (−0.8459)	−0.0130 (−1.0196)
$D_{2,t}$	−0.9129* (−1.8676)	−0.0811 (−1.3839)	−3.2630 (−0.7980)	−0.0318 (−0.7965)
ec_{t-1}	–	−0.1289*** (−2.8008)	–	−0.0210*** (−2.7483)

Diagnostic tests

F-statistic	2.9056	–	4.1002@	–
Adj. R^2	–	0.3070	–	0.2382
LM	–	0.1147	–	7.3439@@@
Hetero	–	1.0018	–	1.5367
Reset	–	3.7110@	–	0.0157
CUSUM	–	S	–	S
CUSUMSQ	–	U	–	U

| | Korea | | The UK | |
	Long run	Short run	Long run	Short run
Constant	–	0.1301*** (2.9465)	–	−0.0847* (−1.8184)
log Y	−0.2479 (−0.6585)	0.4682 (0.7343)	1.2129 (0.8308)	−0.0047 (−0.0106)
i	−0.0762 (−0.8604)	−0.0218** (−2.4900)	−0.0535 (−1.6456)	−0.0009 (−0.1618)
log E	−0.0328 (−0.0321)	−1.1558@@@ (9.2596)	−0.6563 (−0.5567)	−0.2688 (−1.4996)
log P_{t-i}	–	–	–	0.2197** (2.4692)
$D_{1,t}$	−0.2987 (−0.3887)	−0.0241 (−0.6926)	0.6004 (1.3213)	0.0091 (0.4040)
$D_{2,t}$	−0.2426 (−0.3827)	−0.0062 (−0.1808)	−1.6034 (−1.5198)	−0.0734* (−1.8777)
ec_{t-1}	–	−0.0935*** (−3.3569)	–	−0.0402** (−2.0413)

(continued)

Table 1.
The long-run and
short-run coefficients
of the real stock price
model with real
exchange rate

Diagnostic tests

F-statistic	4.3364[@]	–	3.9756[@@@]	–
Adj. R^2	–	0.3956	–	0.1968
LM	–	3.9226[@@]	–	0.0278
Hetero	–	1.9655[@@]	–	0.7383
Reset	–	0.2766	–	3.7165[@]
CUSUM	–	U	–	S
CUSUMSQ	–	U	–	U

	Germany		Hong Kong	
	Long run	Short run	Long run	Short run
Constant	–	−0.4082*** (−3.1640)	–	0.1408*** (4.3183)
$\log Y$	0.4930 (0.5593)	0.4199 (1.1853)	2.2153 (0.9422)	0.4419 (1.4292)
i	−0.0877 (−1.2947)	0.0026 (0.1572)	0.0513 (0.4520)	−0.0091 (−0.8288)
$\log E$	0.4941 (0.3303)	−1.3690** (−2.5446)	−2.6109 (−1.4090)	−1.8184*** (−4.3361)
$\log P_{t-i}$	–	0.1730** (2.0147)	–	–
$D_{1,t}$	0.5047* (1.8407)	0.0170 (0.5007)	−0.7828 (−0.9093)	−0.0107 (−0.2807)
$D_{2,t}$	−0.9141* (−1.9145)	−0.0636 (−1.3129)	−2.4002 (−1.4215)	−0.0719 (−1.3517)
ec_{t-1}	–	−0.0985*** (−3.2276)	–	−0.0624*** (−3.7879)

Diagnostic tests

F-statistic	4.5986[@@@]	–	3.6749	–
Adj. R^2	–	0.2349	–	0.3822
LM	–	0.0803	–	0.2055
Hetero	–	0.1593	–	1.6356
Reset	–	0.8839	–	0.1990
CUSUM	–	S	–	S
CUSUMSQ	–	S	–	S

	Indonesia	
	Long run	Short run
Constant	–	1.0312*** (3.4598)
$\log Y$	1.9394*** (3.5748)	0.3515 (0.7463)
i	0.0084 (0.3276)	−0.0101*** (−2.9123)
$\log E$	−1.9213*** (−4.8745)	−0.5719*** (−4.3366)
$D_{1,t}$	0.2607 (0.4978)	−0.0241 (−0.4239)
$D_{2,t}$	−1.2805* (−1.6792)	−0.0796 (−1.2841)
ec_{t-1}	–	−0.1175*** (−3.3996)

Diagnostic tests

F-statistic	3.4665	–
Adj. R^2	–	0.4939
LM	–	0.8047
Hetero	–	1.1456
Reset	–	0.0003
CUSUM	–	S
CUSUMSQ	–	U

Note(s): ec_{t-1} is an error correction term. F-statistic is the Pesaran *et al.* (2001) bounds testing statistic for cointegration. The critical values of the bounds testing approach can be obtained from Pesaran *et al.* (2001). Adj. R^2 is the adjusted R^2. LM is the Lagrange multiplier test of disturbance serial correlation. Hetero is the test of heteroscedasticity. Reset is the test of functional form. CUSUM denotes the cumulative sum test of stability. CUSUMSQ denotes the cumulative sum of squares test of stability. S denotes stable. U denotes unstable. (F) denotes coefficient of normalised restriction. Values in the parentheses are the t-statistics or the F-statistics. *** (**, *) denotes significance of the t-statistic or the F-statistic at the 1% (5%, 10%) level. [@@@] ([@@], [@]) denotes significance of the F-statistic at the 1% (5%, 10%) level
Source(s): Own estimations

Table 1.

| | Malaysia | | The Philippines | |
	Long run	Short run	Long run	Short run
Constant	–	−0.1939* (−1.9654)	–	0.9219*** (3.4097)
$\log Y$	1.2290* (1.8833)	−0.1587 (−0.7766)	−2.4983** (−2.4445)	−0.3067 (−1.0221)
i	0.0771 (0.8206)	−0.0604@@@ (16.5233)	−0.1150** (−2.3917)	0.0019 (0.1621)
$\log E^+$	−1.5227 (−1.0209)	−0.1071 (−0.8857)	2.5702** (2.0992)	−0.1390 (−1.1807)
$\log E^-$	0.7911 (1.0568)	0.0585 (0.9541)	−1.6499* (−1.9805)	0.1365 (1.4715)
$D_{1,t}$	−2.4899** (−2.3768)	−0.0950* (−1.9250)	−0.5663 (−1.5961)	−0.0138 (−0.1304)
$D_{2,t}$	−1.8336* (−1.8230)	−0.0900* (−1.6603)	−1.9835*** (−4.4291)	−0.0538 (−0.7197)
ec_{t-1}	–	−0.0438** (−2.1858)	–	−0.1014*** (−3.4017)

Diagnostic tests

F-statistic	1.3177	–	8.0977@@@	–
Wald LR	−2.3137 (1.0847)	–	4.2201 (2.2962)	–
Wald SR	–	−0.1656 (0.8317)	–	−0.2754 (1.7220)
Adj. R^2	–	0.2613	–	0.2940
LM	–	1.4713	–	0.5838
Hetero	–	0.8911	–	5.4399@@@
Reset	–	0.3163	–	4.2991@@
CUSUM	–	S	–	S
CUSUMSQ	–	S	–	S

| | Singapore | | Japan | |
	Long run	Short run	Long run	Short run
Constant	–	−0.3873** (−2.2246)	–	0.7470*** (3.3802)
$\log Y$	0.7211*** (3.1348)	−0.0432 (−0.1937)	−2.7535 (−1.1533)	0.2491 (0.9113)
i	−0.0208 (−0.3653)	−0.0994@@@ (15.7460)	−0.0998 (−0.7463)	0.0026 (0.2702)
$\log E^+$	−1.1687* (−1.7340)	−0.2750 (−1.2959)	−0.5621** (−2.1324)	0.0616 (1.5641)
$\log E^-$	1.1485** (2.1326)	0.2767 (1.4975)	0.3362 (1.5013)	−0.0990** (−2.2086)
$\log P_{t-i}$	–	–	–	0.3103*** (3.8428)
$D_{1,t}$	−0.2643 (−1.1448)	−0.0223 (−0.3606)	−0.6565 (−1.6091)	−0.0155 (−0.8340)
$D_{2,t}$	−0.7571** (−2.1638)	−0.0912 (−1.0492)	−1.0728 (−0.9710)	−0.0368 (−0.5425)
ec_{t-1}	–	−0.1500** (−2.3193)	–	−0.0542*** (−3.3704)

Diagnostic tests

F-statistic	2.2320	–	3.2712	–
Wald LR	−2.3172@ (3.7374)	–	−0.8984@ (3.5999)	–
Wald SR	–	−0.5517@@ (5.6307)	–	0.1606@ (3.0273)
Adj. R^2	–	0.2768	–	0.3428
LM	–	0.3690	–	0.3966
Hetero	–	1.8966@	–	3.0594@@@
Reset	–	2.8238@	–	9.4111@@@
CUSUM	–	S	–	S
CUSUMSQ	–	U	–	U

| | Korea | | The UK | |
	Long run	Short run	Long run	Short run
Constant	–	0.4169*** (3.2758)	–	−0.6680*** (−2.8725)
$\log Y$	−1.6419* (−1.9075)	0.5805 (1.4617)	1.3193* (1.8847)	0.0305 (0.0694)
i	−0.0675 (−0.6359)	−0.0198(F) (0.6169)	0.0246 (0.7761)	0.0005 (0.0971)
$\log E^+$	1.5520* (1.8980)	0.1345 (1.6838)	0.5575** (2.4750)	0.0077 (0.1027)
$\log E^-$	−1.6115** (−2.0055)	−0.1404* (−1.8632)	−0.7277*** (−2.6738)	−0.0179 (−0.2065)

(*continued*)

Table 2.
The long- and short-run coefficients of the real stock price model with the asymmetric real exchange rate

| | Korea | | The UK | |
	Long run	Short run	Long run	Short run
$\log P_{t-i}$	–	0.1551(F) (1.7456)	–	0.2325*** (2.6301)
$D_{1,t}$	−1.2629 (−1.2073)	−0.0188 (−0.2987)	0.0878 (0.3477)	0.0030 (0.1321)
$D_{2,t}$	−0.4825 (−0.8225)	−0.0117 (−0.2412)	−0.8764** (−2.1107)	−0.0469 (−1.2826)
ec_{t-1}	–	−0.0797*** (−3.3631)	–	−0.0997*** (−2.9161)

Diagnostic tests

| | Korea | | The UK | |
	Long run	Short run	Long run	Short run
F-statistic	3.4513	–	2.1832	–
Wald LR	3.1635@ (3.5155)	–	1.2852@@@ (7.0042)	–
Wald SR	–	0.2749 (2.6825)	–	0.0255 (0.0252)
Adj. R^2	–	0.4795	–	0.2074
LM	–	0.7903	–	0.4249
Hetero	–	2.4131@@@	–	0.9999
Reset	–	0.0137	–	4.9632@@
CUSUM	–	S	–	S
CUSUMSQ	–	U	–	U

| | Germany | | Hong Kong | |
	Long run	Short run	Long run	Short run
Constant	–	−0.1255** (−2.6749)	–	−3.1987*** (−6.9822)
$\log Y$	0.4108 (0.3086)	0.5719 (1.6122)	1.0634*** (4.0614)	1.5560@@@ (8.6060)
i	−0.1029 (−1.2206)	−0.0004 (−0.0215)	−0.0036 (−0.2086)	−0.0181* (−1.7316)
$\log E^+$	−0.2522 (−0.2328)	−0.0245 (0.0262)	0.6080*** (5.2256)	0.2403*** (2.7660)
$\log E^-$	−0.0330 (−0.0279)	0.0226 (0.1389)	−1.4820*** (−6.7509)	0.9193@@@ (11.9487)
$\log P_{t-i}$	–	0.2010** (2.2745)	–	0.7715@@@ (20.085)
$D_{1,t}$	0.5274* (1.7566)	0.0168 (0.4844)	−0.3159* (−1.8587)	−0.0358 (−0.9883)
$D_{2,t}$	−0.7993 (−1.6255)	−0.0560 (−1.1136)	−0.3099** (−2.4248)	−0.0344 (−0.7307)
ec_{t-1}	–	−0.0904*** (−2.8517)	–	−0.5639*** (−7.0147)

Diagnostic tests

| | Germany | | Hong Kong | |
	Long run	Short run	Long run	Short run
F-statistic	3.3168@@@	–	5.0144@@	–
Wald LR	−0.2192 (0.0097)	–	2.0900@@@ (37.8481)	–
Wald SR	–	−0.0471 (0.0232)	–	−0.6790@@ (5.2098)
Adj. R^2	–	0.2141	–	0.5010
LM	–	0.3378	–	0.2379
Hetero	–	0.0801	–	0.9193
Reset	–	0.1736	–	0.2525
CUSUM	–	S	–	S
CUSUMSQ	–	S	–	S

| | Indonesia | |
	Long Run	Short Run
Constant	–	−0.4298*** (−5.5938)
$\log Y$	0.6770 (0.4410)	6.2761@@@ (14.3233)
i	−0.0602 (−1.1197)	0.1486@@@ (27.6380)
$\log E^+$	−0.4298 (−0.9337)	1.9411@@@ (17.4439)
$\log E^-$	−0.5022 (−0.9045)	−1.7816@@@ (11.3427)
$\log P_{t-i}$	–	−0.1027(F) (0.2498)
$D_{1,t}$	−0.6052 (−0.7228)	−0.0602 (−0.9091)
$D_{2,t}$	−1.8046* (−1.9788)	−0.0456 (−0.8733)
ec_{t-1}	–	−0.1290*** (−5.8293)

Table 2.

(*continued*)

Diagnostic tests		
F-statistic	6.3126$^{@@@}$	–
Wald LR	0.0723 (0.0061)	–
Wald SR	–	3.7227$^{@@@}$ (14.2243)
Adj. R^2	–	0.6600
LM	–	1.3139
Hetero	–	1.3576
Reset	–	1.7227
CUSUM	–	S
CUSUMSQ	–	U

Note(s): (F) denotes coefficient of normalised restriction. Wald LR denotes the long-run asymmetric effect. Wald SR denotes the short-run asymmetric effect
Source(s): Own estimations

Table 2.

coefficients of the error correction models are all found to be negative and statistically significant, and their values are found to be less than one. For Malaysia, Germany, Hong Kong and Indonesia, the estimated models fulfil the conditions of no autocorrelation, homoscedasticity of disturbance terms and no-functional form, and the estimated models are mostly found to be stable. For the Philippines, Singapore, Japan, Korea and the UK, the estimated models fulfil the conditions of no-autocorrelation and are mostly found to be stable.

For Malaysia, an increase in real output will lead to an increase in real stock prices in the long run. The Asian financial crisis and the global financial crisis decrease the real stock price in the short run and long run. An increase in the real interest rate will lead to a decrease in real stock prices in the short run. There is no asymmetric effect of real exchange rate found in the short run and long run. For the Philippines, real output, real interest rate, negative real exchange rate or the global financial crisis decrease the real stock price in the long run whereas an increase in the positive real exchange rate will lead to an increase in the real stock price in the long run. For Singapore, an increase in the real output or the negative real exchange rate will lead to an increase in real stock prices in the long run. Conversely, a positive real exchange rate or the global financial crisis decreases the real stock price in the long run. An increase in the real interest rate will lead to a decrease in real stock prices in the short run. For Japan, an increase in a positive real exchange rate will lead to a decrease in real stock prices in the long run while an increase in the negative real exchange rate will lead to a decrease in real stock prices in the short run. For Korea, an increase in real output or a negative real exchange rate will lead to a decrease in real stock prices in the long run. An increase in the positive real exchange rate will lead to an increase in real stock prices in long run. In the short run, an increase in the positive exchange rate will lead to an increase in the real stock price, and an increase in the negative real exchange rate will lead to a decrease in real stock prices. For the UK, an increase in the real output or a positive real exchange rate will lead to an increase in real stock prices in the long run. A negative real exchange rate or the global financial crisis decreases the real stock price in the long run. Economic variables are important for the real stock price in the long run but not in the short run. For Germany, the Asian financial crisis increases the real stock price in the long run. Generally, economic variables are not important to influence the real stock price in the short run and long run. For Hong Kong, an increase in the real output or a positive real exchange rate will lead to an increase in the real stock price in the long run. A negative real exchange rate, the Asian financial crisis or the global financial crisis decrease the real stock price in the long run. An increase in the real output, a positive real exchange rate or a negative real exchange rate will lead to an increase in the real stock price in the short run. An increase in the real interest rate will lead to a decrease in real stock prices in the short run. Economic variables are important in influencing real stock price in the short run and long run. Finally, in Indonesia, the global financial crisis decreases the

real stock price in the long run. An increase in the real output, real interest rate or a positive real exchange rate will lead to an increase in real stock prices. An increase in the negative exchange rate will lead to a decrease in the real stock price in the short run. Generally, economic variables are more found to be important in influencing the real stock price in the short run.

There is no short-run and long-run asymmetric real exchange rate in Malaysia, the Philippines and Germany. There is short-run and long-run asymmetric real exchange rate in Japan and Hong Kong. There is a long-run asymmetric real exchange rate but no short-run asymmetric real exchange rate in Singapore, Korea and the UK. There is a short-run asymmetric real exchange rate but no long-run asymmetric real exchange rate in Indonesia. The asymmetric real exchange rate is found in some real exchange rates either in the short run, long run or both (see Table 2).

5. Discussions
Overall, the results of the Johansen likelihood ratio test statistics mostly show that there is a long-run relationship between real stock price and its determinants. The results of the NARDL approach show more economic variables to be statistically significant compared with the results of the ARDL approach. This features the importance of estimating the NARDL model. Generally, an increase in real output will lead to an increase in real stock price. An increase in real interest rate will lead to a decrease in real stock prices. An increase in the real exchange rate will lead to an increase or a decrease in real stock prices. A positive real exchange rate or negative real exchange rate will lead to an increase or a decrease in real stock prices. The Asian financial crisis or the global financial crisis decreases the real stock price in some economies. Economic variables could influence real stock prices in the short and long run. There is some evidence of the significant impact of asymmetric real exchange rates on real stock prices. Moreover, the impact of asymmetric real exchange rate on real stock price can be happened either in the short run, long run or both. This finding is not limited to developing economies but also to developed economies.

5.1 Policy implication
The policy implication of those economies with asymmetric real exchange rates shall not be the same with those economies without asymmetric real exchange rates. For example, firms shall adopt an asymmetric hedging in the real exchange rate if there is an asymmetric effect of the real exchange rate on the real stock price. Also, the hedging strategy of firms can be more complicated and shall be actively monitored. On the other hand, symmetric hedging is still appropriate for firms if there is no asymmetric effect of real exchange rate on the real stock price. Investors shall not assess the impact of real exchange rate on real stock price if is the same for all economies. The real exchange rate could be used as a policy variable to influence the economy through real stock prices. For economies that there is evidence of the link between real exchange rate and real stock price can be due to inefficiency link between stock market and exchange rate market. Hence, the efficiency in both markets shall be improved. For economies that there is no evidence of asymmetric real exchange rate impact on real stock price, which may imply the appreciation of real exchange rate can improve the welfare of the economy. Generally, there is no single policy that is good for all economies all the time either in the short run or long run. In other words, a good policy in the short run may not be good for the long run, and a policy that is good for an economy may not be good for another economy, or a policy that is good for one time may not be effective in another time.

5.2 Future research agenda
It is recommended to use the real exchange rate undervaluation/overvaluation instead of the real exchange rate in future studies to examine its impact on the real stock price. The real exchange rate undervaluation/overvaluation is not common for an economy that adopts a

floating exchange rate regime, such as Japan, the UK and Germany. Also, the impact of real exchange rate on real stock price shall be considered in a panel data analysis based on a group of homogenous exchange rate regimes with the use of a panel ARDL and a panel NARDL. Moreover, the impact of the real exchange rate on real stock price can be evaluated in an artificial neural network (Moghaddam *et al.*, 2016). Another possible future direction is to test the Granger causality between real exchange rate and real stock price.

6. Conclusions

This study has examined the impact of real exchange rates and asymmetric real exchange rates on real stock prices, in Malaysia, the Philippines, Singapore, Korea, Japan, the UK, Germany, Hong Kong and Indonesia. The ADF and the PP unit root test statistics show no evidence of I(2) variable. The Johansen likelihood ratio test statistics and F-statistic for bounds testing mainly imply a long-run relationship between the real stock price and its determinants. The results of the NARDL approach show more economic variables to be statistically significant compared to the results of the ARDL approach. Economic variables, namely asymmetric real exchange rate, real interest rate and real output, could influence real stock price in the short and long run. The financial crisis adversely affects the stock market in some economies. Economic variables could affect real stock prices in some economies more than other economies. The asymmetric real exchange rate is found to influence real stock price in some economies either in the short run, long run or both. Investors shall not assess the impact of economic variables to be the same for all stock markets in all economies. A different policy of exchange rate shall be adopted in an economy. The use of the real exchange rate undervaluation instead of the real exchange rate is recommended in future studies.

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