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Dynamic heterogeneous panel analysis of the correlation between stock prices and exchange rates

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This article uses quarterly data from 29 countries, during the period from the first quarter of 2000 to the second quarter of 2011, and the Pooled Mean Group (PMG) method to estimate the dynamic heterogeneous panel data model and to verify the correlation between stock prices and exchange rates. According to empirical results, the stock market and the foreign exchange market have a long-run co-integration relationship. In the short-run, the stock market and the foreign exchange market are negatively correlated, supporting the viewpoints of the portfolio approach. However, using the error-correction adjustment process, the long-run relationship between the two is positive, supporting the results of the traditional approach. This study suggests that the viewpoints of both the portfolio approach and the traditional approach can co-exist through long- and short-run adjustments.

Keywords: stock price; exchange rate; pooled mean group (PMG) method; dynamic heterogeneous panel data model

JEL classification: C33; D51; F31; G15

1. Introduction

Globalisation and expansion of trade investment liberalisation, international financial market integration, and the rapid flow of capital have increased the linkages between global stock and foreign exchange markets, thereby strengthening the relationship between exchange rate changes and stock market fluctuations. This phenomenon has been the topic of study by scholars during various financial crises, such as the 1997 Asian financial crisis, the sub-prime mortgage crisis, and the recent European debt crisis. Therefore, a thorough understanding of the long- and short-run interactions between the global stock markets and foreign exchange markets can be effective in enabling governments in various countries to develop relevant financial policies and investment portfolios, and to reduce any possible adverse impacts on a country's economy.[1]

The stock market and the foreign exchange market are usually regarded as important indicators of the state of a country's financial markets. Regarding the dynamic correlation between exchange rates and stock prices, there are two theoretical perspectives: the traditional approach (also known as the goods market approach) and the portfolio

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approach. The traditional approach argues that when a country's currency depreciates, the exports of the domestic manufacturers would become more competitive, enhancing the stock prices of manufacturing firms; hence, the depreciation of a country's currency can enhance the stock prices in that country. The viewpoints of the portfolio approach are opposite to that of the traditional approach, arguing that rising stock prices imply increasing investor demands on a country's assets. Consequently, demand for the domestic currency would increase, leading to the appreciation of the domestic currency against foreign currencies. Rising stock prices in a country can lead to currency appreciation. When the exchange rate is represented as a measure of foreign currencies with respect to the domestic currency, the traditional approach argues that stock prices and exchange rates are positively correlated, whereas the portfolio approach argues that the two are negatively correlated.

Dornbusch and Fisher (1980) conducted an empirical study on the relationship between the stock price and the exchange rate. They argued that the foreign exchange rate has a positive impact on the stock price. This contradicts Branson (1983), who noted that the stock price has a negative impact on the foreign exchange rate. Curiously, subsequent studies (e.g. Abdalla & Murinde, 1997; Ajayi & Mougoue, 1996; Alagidede, Panagiotidis, & Zhang, 2011; Bahmani-Oskooee & Sohrabian, 1992; Bartov & Bodnar, 1994; Chkili, Aloui, & Nguyen, 2012; Doong, Yang, & Wang, 2005; Fernandez, 2006; Granger, Huang, & Yang, 2000; Mok, 1993; Nieh & Lee, 2001; Tsagkanos & Siriopoulos, 2013; Walid, Chaker, Masood, & Fry, 2011; Yau & Nieh, 2009) have supported both views. Although the research subject was expanded from a single country to multiple countries, the studies only displayed the more diversified results of individual countries in order to explain the coexistence of negative and positive relationships. For example, Granger et al. (2000) argued that South Korea follows the traditional approach, and the Philippines, the portfolio approach. The empirical study of these relationships has also been extended to volatility relevance, from first-order moments to second-order moments (e.g. Chkili et al., 2012).

Other literature suggests that only short-run relationships exist between the stock price and the exchange rate, while long-run relationships are non-existent (e.g. Nieh & Lee, 2001). However, Ajayi and Mougoue (1996) and Tsagkanos and Siriopoulos (2013) argued that both long- and short-run relationships exist. Hence, the debate on the correlation between the stock price and the exchange rate is not conclusive; in fact, it has even triggered a new controversy regarding the existence of long-run relationships. Thus, previous studies do not offer a simple and convincing argument to explain the coexistence of negative and positive relationships between the stock price and the exchange rate. The controversy over the existence of the long-run relationship between the stock price and the exchange rate is the main motivation of this study. As shown in Kim and Lin (2010), Kim, Lin and Suen (2010a, 2010b), and Iwata, Okada, and Samreth (2011), the empirical results using Pooled Mean Group (PMG) can display the long- and short-run relationships of the variables, thus explaining the contradictions among the above-mentioned studies.

If long-run relationships can be found between the stock price and the exchange rate, and the directions of the long- and short-run relationships are opposite, the result can be used to explain the controversy over the coexistence of the negative and positive relationships between the stock price and the exchange rate. The PMG model is constructed using panel data. It can incorporate cross-sectional information and tolerate data heterogeneity, and thus, it is conducive to empirical study. Hence, in this study, we use panel data to construct the PMG model. By changing our focus from a single country to a group of countries, we discuss the relationship between the stock price and the exchange rate from the transnational perspective. The advantage provides reasonable conviction to explain the coexistence of the negative and positive relationships between the stock price and the exchange rate, which is the primary purpose and the major contribution of this study.

Regardless of empirical studies or theoretical models, results from many studies demonstrate a significant correlation between exchange rates and stock prices. However, the direction of impact and causality of the correlation between exchange rates and stock prices may be inconsistent or contradictory (e.g. Bahmani-Oskooee & Sohrabian, 1992; Bartov & Bodnar, 1994; Fernandez, 2006; Mok, 1993; Nieh & Lee, 2001). Most previous studies have used time-series data for empirical research on the impact of and the causality relationship between stock prices and exchange rates. With the exception of a few articles arguing that there is no correlation between the two variables, most empirical results have proved the causal correlation of the different impacts between the two variables (see Table 1). Regarding international financial integration, using time-series data for estimation purposes cannot fully reflect the impact of international financial integration. Hence, this study uses panel data from 29 countries and the PMG method proposed by Pesaran, Shin, and Smith (1999) to review the relationship between the stock market and the foreign exchange market. This approach uses the Autoregressive distributed lag model (ARDL) as the basic structure and the PMG estimation method to conduct the model estimation procedure. The advantage of using these methods is that it can detect the long-run equilibrium relationship and the long- and short-run results. In addition, this approach has statistical advantages such as low co-linearity, greater degrees of freedom, and higher estimation efficiency.[2]

This article is organised into five sections. Section 1 presents the introduction. Section 2 presents the literature review and section 3 describes the empirical methods and data analysis. Section 4 discusses the empirical results and section 5 offers conclusions.

2. Literature review

Some theoretical models are applied to analyse the correlation between the stock market and the foreign exchange market. The traditional approach (e.g. Dornbusch & Fisher,1980) argues that there is a significant causal relationship between the foreign exchange market and stock prices. The main viewpoint is that changes in foreign exchange rates would affect the international competitiveness of manufacturers. Consequently, the real income, output and stock price of manufacturers would be affected. The investment portfolio analysis approach (e.g. Branson, 1983) argues that expected changes in financial asset prices would consequently affect changes in foreign exchange rates. This can be used to illustrate the causality between stock price and exchange rate.

There are numerous articles on topics relating to the correlation between the stock market and the foreign exchange market. For example, Mok (1993) determined a weak mutual causality between foreign exchange and stock price. Bartov and Bodnar (1994) and Fernandez (2006) only determined the existence of either weak or no correlation between stock price and exchange rate. Bahmani-Oskooee and Sohrabian (1992) discussed the correlation between the stock market and foreign exchange market in the US, and empirical results suggested that stock prices and exchange rates have two-way causal relationships in the short-run. Smith (1992) determined that the stock market, excluded as an explanatory variable in previous literature, has a significant impact on

Table 1. Summary of literature on the relationship between stock price and exchange rate.

Author(s)	Method or approach	Sample Countries	Period	Traditional Approach (E→S the positive relationship between the exchange rate and the stock price)	Portfolio Approach (S→E the negative relationship between the exchange rate and the stock price)
Bahmani-Oskooee and Sohrabian (1992)	causality tests	Unite State	1973M7–1988M12	none	The bi-directional causality between stock prices and the exchange rate in short-run
Smith (1992)	optimising inter-temporal model of asset choice	Germany and Japan	1974Q1–1989Q3	none	Germany (The negative impact of the stock prices on the exchange rate) Japan (The positive impact of the stock prices on the exchange rate)
Mok (1993)	ARIMA causality tests	Hong Kong	1986/04/2–1991/06/30	Hong Kong: short-run. (sub-period)	Hong Kong: short-run. (sub-period)
Ajayi and Mougoue (1996)	ECM model	Canada, France, US, UK, Italy, Japan, Germany and Netherlands	1985M04–1991M07	The positive impact of the stock prices on the exchange rate in long- run	The negative impact of the stock prices on the exchange rate in short-run
Abdalla and Murinde (1997)	VECM model	India, Pakistan, Philippines, and South Korea	1985/1/1–1994/7/31	India, Pakistan, and South Korea	Philippines: in the short-run
Wu (2000)	VECM model	Singapore	1980M01–1996M12	none	Singapore: short-run
Granger et al. (2000)	VAR model Granger causality test	Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, and Taiwan	1986/1/3–1998/6/16	South Korea: in the short-run	Hong Kong, Malaysia, Philippines, Singapore, Thailand, and Taiwan: in the short-run
Nieh and Lee (2001)	VECM model	G-7 countries	1993/10/1–1996/2/15	None	None
Doong et al. (2005)	Vector GARCH-M	Indonesia, Korea, Malaysia, Philippines, Thailand, and Taiwan	1989/01/6–2003/01/3	Indonesia, Malaysia, Philippines, Thailand, (in the short-run)	Indonesia, Malaysia, Philippines, Thailand: in the short-run
Phylaktis and Ravazzolo (2005)	Co-integration test Granger causality tests	Hong Kong, Malaysia, Singapore, Thailand and Philippines	1980M01–1998M12	All countries: in the short-run	None

(*Continued*)

Table 1. (*Continued*).

Author(s)	Method or approach	Sample Countries	Period	Traditional Approach (E→S the positive relationship between the exchange rate and the stock price)	Portfolio Approach (S→E the negative relationship between the exchange rate and the stock price)
Fernandez (2006)	Tail -dependence test	US, Japan, the Czech Republic, Poland, Switzerland, and the UK	1999M1–2002M12	None	None
Yau and Nieh (2006)	Co-integration test Granger causality tests	Taiwan and Japan	19991M01–2005M07	Taiwan: in the long-run	Taiwan and Japan: in the short-run
Pan et al. (2007)	VAR model Granger causality tests	Hong Kong, Japan, Korea, Malaysia, Singapore, Taiwan, and Thailand,	1988M1–1998M10	Hong Kong, Japan, Malaysia, and Thailand: in the short-run	Hong Kong, Korea, and Singapore: in the short-run
Yau and Nieh (2009)	Threshold ECM model Granger causality tests	Taiwan and Japan	1991M01–2008M03	Taiwan: in the long-run	None
Chen and Chen (2011)	VECM model, Bounds test, and linear and nonlinear Causality	G-7 countries	1974M01–2007M09	US, Canada, Italy, Germany, and the UK (in nonlinear causality). Germany and Japan (in nonlinear causality)	US, Canada, Italy, Germany, and the UK (in nonlinear causality). US, Canada, Italy, Germany, and the UK. (in linear causality)
Walid et al. (2011)	Markov-Switching EGARCH	Hong Kong, Singapore, Malaysia and Mexico	1994M12–2009M3	All countries, in the high mean-low variance regime. The stock price volatility reacts asymmetrically to events in the FX market	

Source: Authors' compilation.

the German Mark–US Dollar and the Japanese Yen–US Dollar exchange rates (equation). Ajayi and Mougoue (1996) studied eight developed countries, namely Canada, France, the US, Britain, Italy, Japan, Germany, and Holland. They found that the exchange rates and stock prices were inversely correlated, either in the long- or the short-run.

Wu (2000) discussed the correlation between the Singapore Dollar–US Dollar exchange rate and the Singapore stock market. The empirical results suggested that the exchange rate and the Singapore stock market depict Granger causality. Granger et al. (2000) verified the Granger causality between stock prices and exchange rates in Asian countries. In South Korea, the exchange rate leads the stock price, supporting the results of the traditional approach; in the Philippines, the stock price (negative) leads the exchange rate, supporting the results of the portfolio approach. Two-way causality has been observed in the case of Hong Kong, Malaysia, Singapore, Thailand, and Taiwan.

Nieh and Lee (2001) discussed the dynamic correlation between stock prices and exchange rates in seven major industrialised nations. The empirical results suggested that the stock prices and exchange rates in these countries have no long-run equilibrium relationships. When the German exchange rate depreciates, stock price returns would be affected before influencing Canada and the UK, whereas rising stock prices would result in the depreciation of exchange rates in Italy and Japan. Phylaktis and Ravazzolo (2005) discussed the long- and short-run relationships between stock prices and exchange rates, as well as impulse responses in the following six Asian countries (or regions): Hong Kong, Malaysia, Philippines, Indonesia, Singapore, and Thailand. They determined that there is no long-run equilibrium relationship. Yau and Nieh (2006) studied the relationship between the NTD/Yen exchange rate and stock prices in Taiwan and Japan. The empirical results suggested that the portfolio approach is applicable to the short-run relationship between stock prices and exchange rates in Japan and Taiwan. In the long-run, the traditional approach is applicable in Taiwan; however, the asset analysis method is not applicable in Japan.

Pan, Fok, and Liu (2007) discussed the relationship between exchange rates and stock prices in the following seven Asian countries or regions: Japan, South Korea, Hong Kong, Malaysia, Singapore, Thailand, and Taiwan. The empirical findings suggested diversified correlations that are inconsistent with the viewpoints of either the traditional or the portfolio approach. Yau and Nieh (2009) discussed the relationships between stock prices and exchange rates in Japan and Taiwan under the nonlinear structure. With the threshold error correction model as the main architecture, it is found that a long-run equilibrium relationship between Japan and Taiwan exists. Chen and Chen (2011) discussed the long- and short-run causal relationships between stock prices and exchange rates in seven industrialised nations. The empirical results found that a co-integration relationship exists in France and UK. However, the single-way causality of stock prices against exchange rates exists in the US, Canada, Italy, Germany, and the UK. Regarding nonlinear causality, two-way feedback nonlinear causality exists in the US, Canada, Italy, Germany, France, and the UK. The exchange rates have a single-way nonlinear causality with stock prices in Germany and Japan.

As discussed above, most studies use time-series data for empirical research on the direction and causality between stock prices and exchange rates with two different findings regarding causality and direction. Such contradictory results have no complete and integrated explanations. If the omissions such as the negligence of cross-sectional data can be integrated, the cross-sectional information may be lost. In addition, empirical models in some studies do not consider the differences in the mutual influence of long- and short-run variables. Hence, the two contradictory results of the previous literature may either be owing to the estimation results of the long- or short-run framework or be caused by the omitted cross-sectional information. For example, regarding the variable correlation, Lin (2009) and Russell (2011) conducted necessary verifications in the long- and short-run frameworks, and found that differences in the long- and short-run can affect the correlation between variables. Hence, this article uses the PMG approach, because it infers that the relationships between stock prices and exchange rates are diversified. Therefore, pending further verification of this key point, the long- and short-run results may be in different directions.

Some follow-up studies on other topics have also applied the PMG approach. For example, Loayza and Ranciere (2006) used panel data for the period from 1960 to 2000 for 75 countries to discuss the relationship between financial development and economic growth. They employed the PMG estimation model for relevant empirical study, and found that the two variables have a positive relationship in the long-run. However, in the short-run, the two variables have a negative relationship. The contradictory results identified in the previous studies may arise either from the long- or short-run case. Goswami and Junayed (2006) used multiple estimation methods, including PMG, mean group (MG), and ARDL, to discuss the bilateral trade equations for the US with 19 trading partners. The research period and data pertain to quarterly data in the period from the first quarter of 1973 to the fourth quarter of 2004. The results suggested that the performance of PMG estimation method is the best. It can eliminate the limitations posed by other estimation methods, and present diversified results. Kim and Lin (2010) discussed the relationship between inflation and financial development in 87 countries under the PMG approach architecture for empirical study. They concluded that inflation has a negative impact on financial development in the long-run; however, it has a positive impact in the short-run. Moreover, Kim et al. (2010a, 2010b), and Iwata et al. (2011) used the PMG estimation empirical model, and found that in both the short- and the long-run, the directions of influence in between the variables are significantly different. As discussed above, the PMG estimation method is a very useful tool for processing topics pertaining to the correlation between the long- and short-run. The comparison of the literature review is shown in Table 1.

3. Empirical approach and data

3.1 Research method

Using panel data model to examine the relationship between the stock price and the exchange rate has many advantages in empirical research. For example, we can consider the cross-sectional characteristics between countries simultaneously, and capture the dynamic interaction between the stock price and exchange rate. In addition, as a large number of observations increases the degrees of freedom, the estimation would become more efficient.

This study used the PMG method proposed by Pesaran et al. (1999) to consider a lower degree of heterogeneity, as it imposes homogeneity in the long-run coefficients while still allowing for heterogeneity in the short-run coefficients and error variances. The basic assumptions of the PMG estimator are as follows: first, the error terms are serially uncorrelated and are distributed independently of the regressors, that is, the explanatory variables can be treated as exogenous; second, there is a long-run relationship between the dependent and explanatory variables; and third, the long-run parameters are the same across countries. This estimator is also flexible enough to allow for long-run coefficient homogeneity over a single subset of regressors and/or countries. Through this estimation approach, we can present the multiplicity between the stock and foreign exchange markets and solve for the traditional panel model estimation problem. Pesaran et al. (1999) use the ARDL (p, q, q,…, q) model as the empirical structure:

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij} y_{i,t-j} + \sum_{j=0}^{q} \delta'_{ij} x_{i,t-j} + \mu_i + \varepsilon_{it}, \quad (1)$$

where y_{it} denotes the dependent variables for group i and x_{ij} (k × 1) is the vector explanatory variables for group i, δ_{ij} are (k × 1) coefficient vectors, groups are denoted by i = 1, 2,…, N, time periods by t = 1, 2,…, T, whereas μ_i represents the fixed effects. It is convenient to work with the following re-parameterisation of equation (1). It can structure the long- and short-run co-integration dynamic panel model.

$$\Delta y_{it} = (\varphi_i y_{i,t-1} + \beta'_i x_{it}) + \sum_{j=1}^{p-1} \lambda^*_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta^{*\prime}_{ij} \Delta x_{i,t-j} + \mu_i + \varepsilon_{it}, \quad (2)$$

where $\Delta y_{it} = y_{it} - y_{i,t-1}$, $\varphi_i = -(1 - \sum_{j=1}^{p} \lambda_{ij})$, $\beta_i = \sum_{j=o}^{q} \delta_{ij}$, $\lambda^*_{ij} = -\sum_{m=j+1}^{p} \lambda_{im}$, and $\delta^*_{ij} = -\sum_{m=j+1}^{q} \delta_{im}$.

Regarding the PMG estimation method and related statistical theory of inference process, please refer to Pesaran et al. (1999).

Furthermore, Pesaran et al. (1999) suggest two different estimators, which are consistent when both T and N are large. The difference between these two estimators is that the MG estimator seems to be more consistent under the assumption that both the slope and intercepts are allowed to vary across countries, whereas the PMG estimator is consistent under the assumption of long-run slope homogeneity. An alternative estimator is set up under the assumption of homogeneous slope is dynamic fixed effects (DFE), wherein the slopes are fixed and the intercepts are allowed to vary across countries. The MG estimator derives the long-run parameters for the panel from an average of the long-run parameters from ARDL models for individual countries.

In this article, we compare the MG, PMG, and DFE estimation results. It is also possible to test for the suitability of the PMG estimator relative to the MG estimator based on the consistency and efficiency properties of the two estimators, using a likelihood ratio test or a Hausman test.

This study follows Pesaran et al. (1999) to construct the empirical model. The base model between stock price and exchange rate as ARDL (1, 1) is

$$\ln st_{it} = \mu_i + \lambda_i \ln st_{i,t-1} + \delta_{10i} \ln ex_{it} + \delta_{11i} \ln ex_{i,t-1} + \varepsilon_{it} \quad (3)$$

In equation (3), ln st_{it} is the logarithm of stock price index, and ln ex_{it} is the logarithm of exchange rate.

Through the translation of equation (3), the short-run model between stock price and exchange rate is as follows:[3]

$$\Delta \ln st_{it} = \varphi_i (\ln st_{i,t-1} - \theta_{1i} \ln ex_{it}) - \delta_{11i} \Delta \ln ex_{it} + \mu_i + \varepsilon_{it} \quad (4)$$

The notation Δ implies the first-difference term, Δ ln st_{it} = ln st_{it} − ln $st_{i,t-1}$ is the stock return, and Δ ln ex_{it} = ln ex_{it} − ln $ex_{i,t\text{-}1}$ is the exchange rate return. Additionally, $\varphi_i = -(1 - \lambda_i)$ is the coefficient of error correction. When ϕ_i is significant and negative, it implies that co-integration exists. $\theta_{1i} = \frac{\delta_{10i} + \delta_{11i}}{(1-\lambda_i)}$ is a long-run parameter. When θ_{1i} is significant and positive, the long-run relationship between stock price and exchange rate supports the results of the traditional approach; however, when θ_{1i} is significant and negative, the long-run relationship supports the viewpoints of the portfolio approach. In addition, when $-\ \delta_{11i}$ is significant and positive, the short-run relationship supports the traditional approach, whereas a negative relationship supports the portfolio approach.

3.2 Data

This article uses quarterly data from 29 countries or regions, including four major industrialised countries (Canada, Japan, German, and the UK),[4] 10 emerging industrialised countries or regions in Asia (Taiwan, Singapore, Hong Kong, South Korea, Philippines, Malaysia, Thailand, India, Indonesia, and China), as well as Australia, Czech Republic, Denmark, Hungary, Poland, Russia, Norway, Sweden, Switzerland, Argentina, Brazil, Chile, Mexico, Israel, and South Africa. The data for the two major variables of the empirical studies in this paper, that is, the US Dollar exchange rate against the local currency (ex) and large-cap share prices at major stock exchanges in various countries (st),[5] has been sourced from the IFS database of the International Money Fund (IMF) and the 'AREMOS Economic Statistics Database System' of the Taiwan Economic Data Centre. The most complete data by country of homogeneous nature has been obtained for the period from the first quarter of 2000 to the second quarter of 2011 (for detailed contents of data by country, please refer to Appendix 1).

4. Empirical results

4.1 Analysis of the main empirical results

The empirical analysis uses the natural logarithms of the stock price and exchange rate. Figure 1 illustrates the trends in stock prices and exchange rates of 29 countries. As shown in Figure 1, the stock price and exchange rate show positive and negative correlations during different periods. From 2007 to 2008, the negative trend was more obvious, and after 2009, the positive trend was more obvious. In other periods, although the correlation can be negative or positive, it is mostly positive. This seems to imply that the two variables might have a positive co-integration. In addition, the relationship between the stock price and exchange rate in OECD countries is more similar. The differences between Mexico and Sweden are more obvious. The differences in the relationships between the stock prices and exchange rates in non-OECD countries are relatively large. According to Figures 1, the long- and short-run relationships between the stock market and the foreign exchange market are not distinct, thereby necessitating further empirical verifications. Table 2 shows the pooling basic statistics of the stock price and exchange rate in 29 countries. The average rate of change and the average risk level for the stock market are greater than that for the foreign exchange market. However, stock returns are left-skewed, whereas the rates of change in exchange rate are right-skewed.

In order to clarify whether the correlation between the stock market and the foreign exchange market varies both in the long- and short-run, following the empirical procedure of Pesaran et al. (1999), this article uses Equation (4) as the empirical model to obtain three estimates using the PMG, MG, and DFE estimation methods. All samples are incorporated in the empirical estimation. The results are as shown in Table 3.[6] As shown, the results using PMG estimation method suggest that the error correction coefficients are significantly negative, indicating the existence of a stable and converging long-run relationship between exchange rate and stock price. Since the long-run coefficient θ_{1i} is significantly positive, the long-run relationship between exchange rate and stock price is positive, indicating that rising exchange rate (depreciation of domestic currency and appreciation of USD) is conducive to domestic exports. With rising profits of domestic exporters, domestic stock market will be bullish with an upward trend, and the long-run results are closer to that of the traditional approach. However, in the short-run,

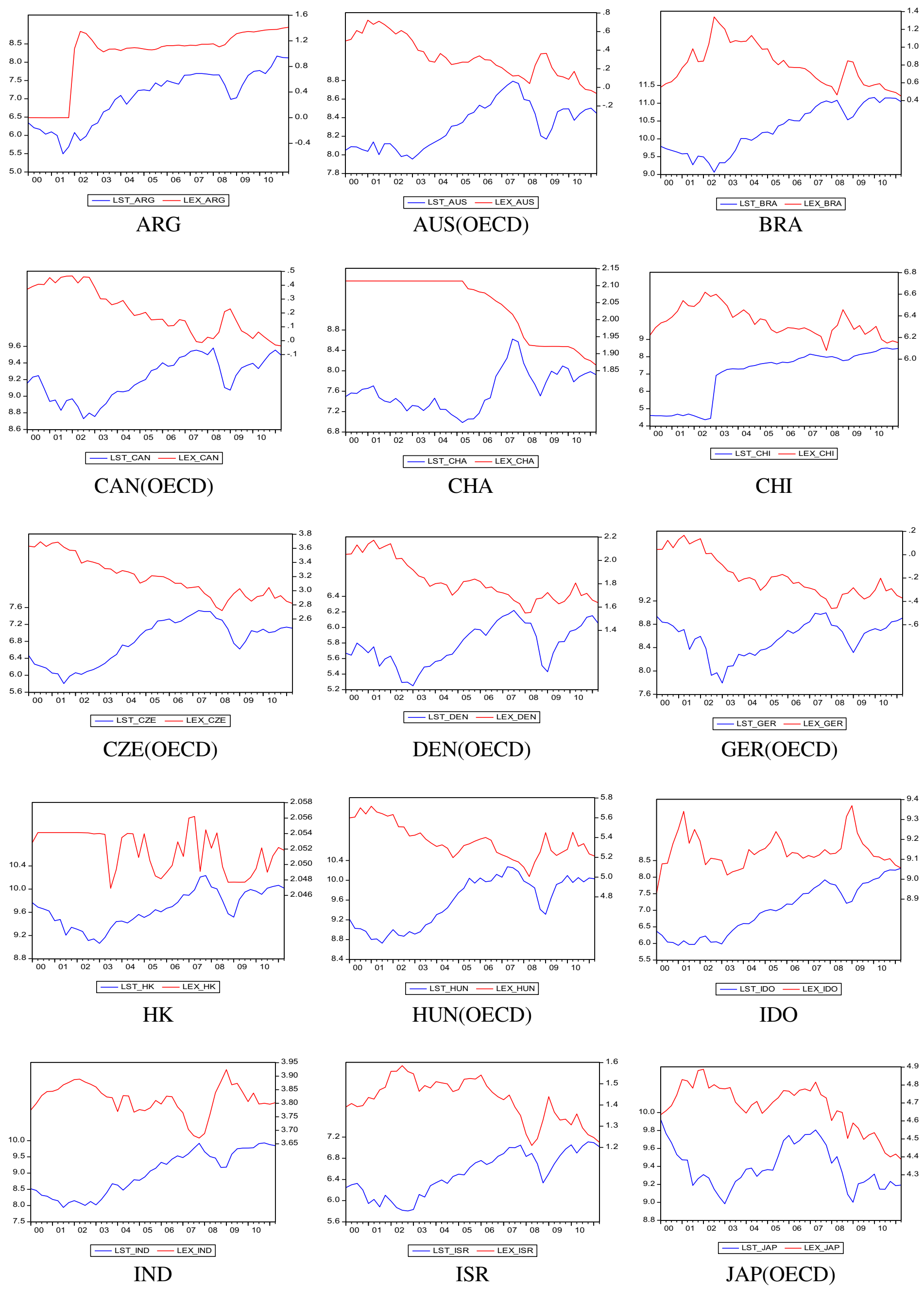

Figure 1. The time trends in stock prices and exchange rates of 29 countries.
Note: The horizontal-axle as the time trend. The vertical-axle of the right hand side as the value of exchange rates (red line), and the left hand side as the stock price (blue line).

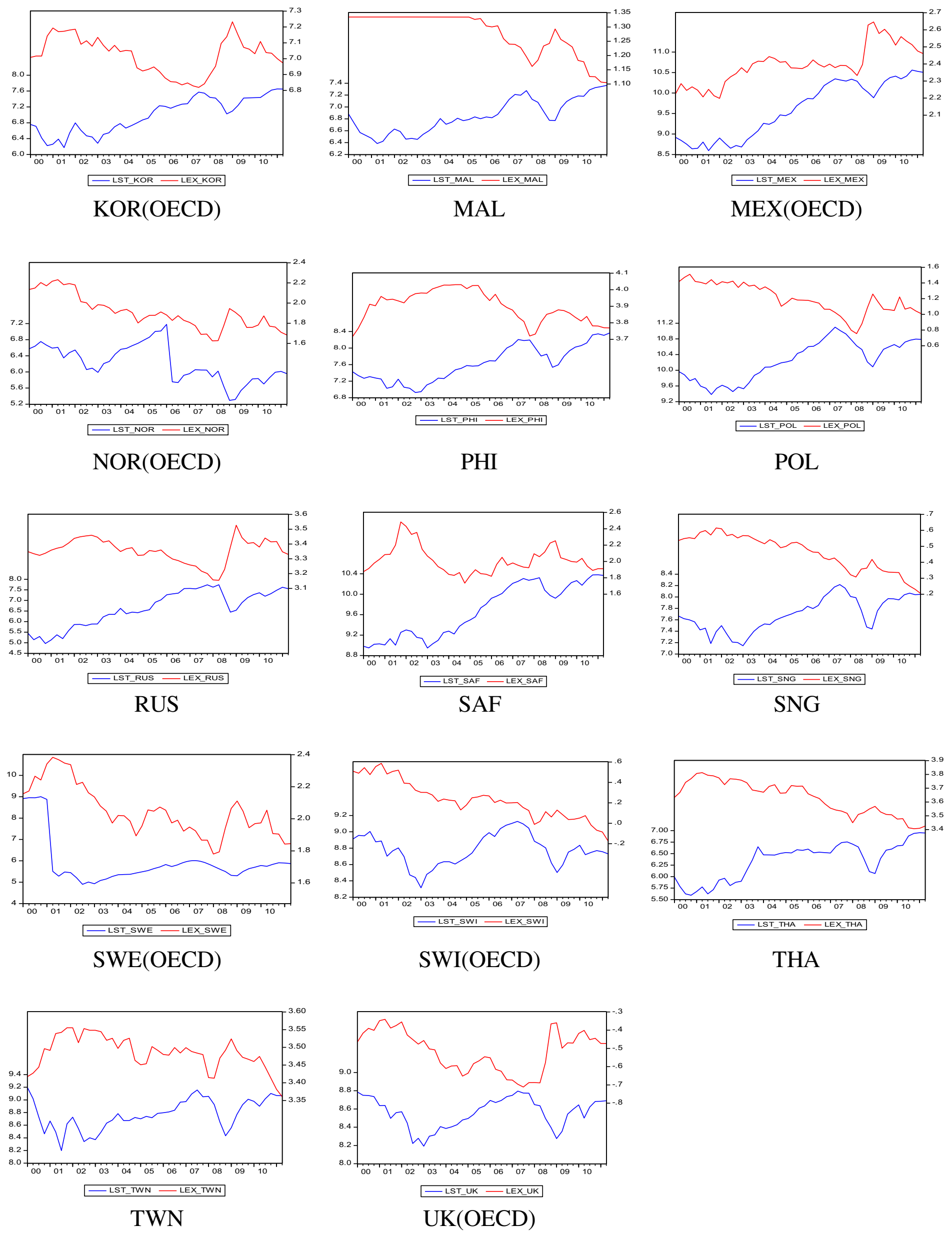

Figure 1. (*Continued*).

since the coefficient (- δ_{11i}) is significantly negative, the correlation between changes in exchange rate and stock returns is negative. In other words, it is expected that investors are increasingly willing to invest in the domestic stock market in anticipation of increasing returns in the future, causing increased demand and appreciation of the domestic currency. Owing to future expectations, domestic stock market depicts an upward trend.

Table 2. The pooling results of the basic statistics of the stock price and exchange rate.

Variable	ln st_{it}	ln ex_{it}	Δ ln st_{it}	Δ ln ex_{it}
Mean	7.99	2.57	0.01	0.00
Maximum	11.16	9.37	2.48	1.08
Minimum	4.36	−0.71	−3.37	−0.21
Standard deviation	1.47	2.25	0.18	0.06
Skewness	−0.09	1.06	−3.82	4.32
Kurtosis	2.15	3.83	132.87	71.74
Observation	1,334	1,334	1,305	1,305

Notes: the notation 'Δ' denotes the first-difference term.
Source: Authors' analysis

Table 3. Estimation results of the dynamic panel model.

Methods	PMG	MG	Hausman test	DFE
Dependent variable Δ ln st_{it}				
Error-correction effect (coefficient)			H_0: PMG	
ϕ_i	−0.054***	−0.094***	H_1: MG	−0.063***
	(0.011)	(0.014)	Chi-square statistic	(0.009)
Long-run effect (coefficient)			0.100	
-θ_{1i}	1.241***	−1.690	[0.758]	−0.246
	(0.369)	(9.020)		(0.474)
Short-run effect (coefficient)				
-δ_{11i}	−1.028***	−0.708***		−0.503***
	(0.223)	(0.203)		(0.078)
Constant (μ_i)	0.254***	1.586		0.554***
	(0.046)	(1.108)		(0.113)
Country number	29	29		29
Observation	1,305	1,305		1,305

Notes: The parenthesis (.) is the standard deviation, [.] is the P-value; and ***denotes significance at the 1% level. The model is $\Delta \ln st_{it} = \phi_i(\ln st_{i,t\text{-}1} - \theta_{1i} \ln ex_{it}) - \delta_{11i}\Delta \ln ex_{i\text{-}t} + \mu_i + \varepsilon_{it}$.
Source: Authors' analysis.

Therefore, the short-run results are closely related to the arguments of the portfolio approach.[7]

The MG estimation results as shown in Table 3 provide another long-run result (heterogeneous groups). The error correction coefficient is still significantly negative, confirming the long-run relationship. In addition, because the long-run coefficient is negative and insignificant, it implies that the long-run impact of exchange rate on stock price seems to be unstable. This article applies the Hausman test to distinguish the PMG and MG estimation methods to determine the long-run settings that are more suitable for the panel data of this study. According to the test results, the null hypothesis of long-run heterogeneity cannot be rejected; in other words, PMG estimation method is more suitable. Therefore, regarding the long-run impact of exchange rate on stock price, the PMG results should be adopted, and the exchange rate would have a long-run positive and homogeneous impact on stock price. In addition, according to the MG short-run estimation results, the change in exchange rate is negatively correlated with stock returns. This is consistent with the PMG results and is very reasonable as both estimation methods argue that short-run coefficients should be different in various countries. Hence, in the short-run, the average effect of a change in exchange rate on stock returns should be in the range of −0.708 to −1.028.

To provide complete estimation results, Table 3 shows the estimation results by DFE estimation method for comparison and reference purposes. DFE estimation method is the opposite extreme of the MG estimation method, which restricts both the long- and the short-run coefficients. In other words, DFE estimation method assumes that the data for multiple countries is pooled as a single entity. Therefore, each explanatory variable has a common coefficient without the coefficients of individual countries. Such settings, in particular the restrictions on short-run effects, are not consistent with economic intuition. As shown in the DFE estimation results listed in Table 3, exchange rate and stock price have a long-run correlation and the long-run coefficient is insignificantly negative. Hence, the long-run effect is not stable, possibly owing to the DFE estimation restrictions. The short-run coefficient is significantly negative. The above findings are closely related to the conclusions of Pan et al. (2007).

4.2 Sensitivity analyses

In order to determine whether the empirical results of this article are robust, we make the following changes:

(1) The German DAX stock index, which represents the stock market in the eurozone, is replaced with the pan-European Dow Jones STOXX 600 index in order to verify whether the German stock market can adequately represent the eurozone stock markets. If the German stock market is not representative of the changes in the stock markets in the eurozone, the findings of this article may change. Therefore, the pan-European Dow Jones STOXX 600 index is used to replace the German DAX index for a second empirical verification, coupled with the euro exchange rate, to verify whether the findings of this article are robust. The estimation results are as shown in Table 4.

(2) The basic model architecture is changed from ARDL (1, 1) to ARDL (2, 2). The model setting of this paper, ARDL (1, 1), is the most appropriate model architecture for an overall evaluation. If the major arguments of this article are valid when the model setting parameters are slightly adjusted, it can better support the conclusions of this article. Therefore, the ARDL model setting parameters are relaxed to ARDL (2, 2). The results are as shown in Table 5.

(3) After removing the data for four countries (Czech, Denmark, Hungary, and Poland) from the data for the 29 countries, the panel data for 25 countries are used for conducting the empirical study to estimate the ARDL (1, 1) and ARDL (2, 2) models. Since different research subjects often result in differences in statistics or causality, this article randomly removes the data for four countries. Except for Denmark, the other three countries are emerging Eastern European economies. As compared with the industrially advanced Western European countries, the characteristics and sizes of the stock market and the foreign exchange market are significantly different. This article verifies whether the removal of data for these countries changes the conclusions of this paper. The results are as shown in Tables 6 and 7.

(4) Since the sub-prime mortgage crisis occurred during the research period, to test whether the crisis has any impact on the relationship between the stock market and the foreign exchange market, the samples are divided into two sub-periods of 2002Q3–2006Q4 (pre-crisis) and 2007Q1–2011Q2 (post-crisis) for estimation purposes. The results are as shown in Tables 8 and 9.

(5) The results of the stock price and the effective exchange rate index, as measured by TWI, to replace the nominal exchange rate. Because Argentina, Indonesia, India, Thailand, and Taiwan do not have an effective exchange rate index in the IFS database, we deleted the data for these five countries from this estimation. Table 10 shows that the positive long-run equilibrium relationship between stock prices and exchange rates still exist. The PMG model remains the most appropriate framework for this study. In general, these results agree with our original findings.

According to the estimation results shown in Tables 4 to 10, PMG is the most appropriate estimation method, and the correlation between the stock market and the foreign exchange market still exists both in the long- and the short-run; these results are consistent with those shown in Table 3. Hence, it can be concluded that the empirical results of this article demonstrate a certain level of robustness, and are not significantly different from the original results when some observations are adjusted or some model conditions changed. On the other hand, according to the PMG results shown in Tables 8 and 9, the occurrence of financial crisis cannot affect the integrated structure. However, according to the error correction coefficient ϕ, after the breakout of the financial crisis, the speed of adjustment from short- to long-run equilibrium is accelerated (from −0.063 to −0.154). Meanwhile, the long-run coefficient suggests that the mutual impact of the stock market and the foreign exchange market becomes smaller (coefficient reduces from 3.529 to 2.491), whereas the short-run coefficient impact increases (from −1.155 to −1.472). This indicates that when financial crises occur, negative information will have an immediate impact in the short-run. In order to prevent bad news from entering the domestic market to reduce the long-run impact, countries usually take control measures to isolate the information exchange and flow, resulting in slowdown of the error correction mechanism.

Table 4. Estimation results of the dynamic panel model (the pan-European Dow Jones STOXX 600 index is used to replace the German DAX index).

Methods	PMG	MG	Hausman test	DFE
Dependent variable Δ ln st_{it}				
Error-correction effect (coefficient)			H_0: PMG	
ϕ_i	-0.054^{***}	-0.094^{***}	H_1: MG	-0.063^{***}
	(0.011)	(0.014)	Chi-square statistic	(0.009)
Long-run effect (coefficient)			0.10	
$-\theta_{1i}$	1.241^{***}	−1.688	[0.758]	−0.246
	(0.369)	(9.020)		(0.474)
Short-run effect (coefficient)				
$-\delta_{11i}$	-1.028^{***}	-0.707^{***}		-0.503^{***}
	(0.224)	(0.203)		(0.078)
Constant (μ_i)	0.254^{***}	1.586		0.553^{***}
	(0.046)	(1.108)		(0.113)
Country number	29	29		29
Observation	1,305	1,305		1,305

Notes: In this table, the pan-European Dow Jones STOXX 600 index is used to replace the German DAX index for a second empirical verification, coupled with the euro exchange rate, to verify whether the findings of this paper are robust. The parenthesis (.) is the standard deviation, [.] is the *P*-value; and ***denotes significance at the 1% level. The model is $\Delta \ln st_{it} = \phi_i(\ln st_{i,t-1} - \theta_{1i} \ln ex_{it}) - \delta_{11i}\Delta \ln ex_{it} + \mu_i + \varepsilon_{it}$.
Source: Authors' analysis.

Table 5. Estimation results of the dynamic panel model – ARDL (2,2) model.

Methods	PMG	MG	Hausman test	DFE
Dependent variable Δ ln st_{it}				
Error-correction effect (coefficient)			H_0: PMG	
ϕ_i	-0.073^{***}	-0.138^{***}	H_1: MG	-0.077^{***}
	(0.013)	(0.024)	Chi-square statistic	(0.009)
Long-run effect (coefficient)			0.05	
$-\theta_{1i}$	1.221^{***}	0.205	[0.824]	−0.010
	(0.284)	(4.360)		(0.410)
Short-run effect (coefficient)				
$-\delta^{*\prime}_{11i}$	-1.011^{***}	-0.742^{***}		-0.452^{***}
	(0.274)	(0.162)		(0.784)
$-\delta^{*\prime}_{12i}$	−0.110	0.039		-0.164^{**}
	(0.761)	(0.147)		(0.796)
$-\lambda^{*\prime}_{i}$	0.157^{***}	0.169^{***}		0.132^{***}
	(0.234)	(0.032)		(0.028)
Constant (μ_i)	0.364^{***}	1.605^{**}		0.630^{***}
	(0.066)	(0.764)		(0.118)
Country number	29	29		29
Observation	1,249	1,249		1,249

Notes: The parenthesis (.) is the standard deviation, [.] is the *P*-value; **, and ***denotes significance at the 5%, and 1% level, respectively. The model is ARDL(2, 2): $\Delta \ln st_{it} = \varphi_i(\ln st_{i,t-1} - \theta_i' \ln ex_{it}) - \delta^{*\prime}_{11i} \Delta \ln ex_{i,t} - \delta^{*\prime}_{12i}\Delta \ln ex_{i,t-1} - \lambda^{*\prime}_i \Delta \ln st_{i,t-1} + \mu_i + \varepsilon_{ij}$.
Source: Authors' analysis.

4.3 Comparison with the OECD and non-OECD countries

In Section 4.2, by randomly changing models and slightly changing the samples to re-verify estimation results, the results remain unchanged. However, it is not clear whether other setting methods can change the results. Hence, for test purposes, this article further classifies the samples by degree of openness of countries into OECD member countries and non-OECD member countries. Of the 29 countries, 13 are OECD members and 16 are non-members; most of the non-members are either developing countries or the so-called emerging industrialised countries. The PMG and MG estimation methods are used to estimate the two types of countries to confirm the existence of differences. Table 11 illustrates the estimation results of the 13 OECD countries and Table 12 illustrates the estimation results of the 16 non-OECD countries.

As the PMG estimation method results shown in Table 11 suggest, the error correction coefficient of OECD countries is significantly negative, indicating the existence of a long-run correlation between exchange rate and stock price. Both the short- and long-run coefficients are negative, confirming the arguments of the portfolio approach. Unlike the results shown in Table 3, the empirical results of the OECD countries are relatively close to the conclusions of Ajayi and Mougoue (1996) and Yau and Nieh (2009). This article applies the Hausman test to distinguish the fitness of the PMG and MG estimation methods, and finds that the PMG estimation method is better.

Table 12 shows the PMG estimation method results for the non-OECD countries. The error correction coefficient is significantly negative, suggesting the existence of the long-run equilibrium relationship. The long- and short-run coefficients of the 16 non-OECD countries are positive, which is consistent with the estimation results indicated in Table 3. Hausman test finds that the PMG estimation method is better than the MG method. Apparently, in non-OECD countries, the exchange rate and stock price are

Table 6. Estimation results of the dynamic panel model for 25 countries – ARDL (1, 1) model.

Methods	PMG	MG	Hausman test	DFE
Dependent variable Δ ln st_{it}				
Error-correction effect (coefficient)			H_0: PMG	
ϕ_i	-0.059^{***}	-0.097^{***}	H_1: MG	-0.065^{***}
	(0.012)	(0.016)	Chi-square statistic	(0.009)
Long-run effect (coefficient)			0.06	
$-\theta_{1i}$	1.356^{***}	−1.441	[0.800]	0.150
	(0.372)	(10.491)		(0.541)
Short-run effect (coefficient)				
$-\delta_{11i}$	-1.120^{***}	-0.759^{***}		-0.509^{***}
	(0.254)	(0.232)		(0.893)
Constant (μ_i)	0.254^{***}	1.679		0.505^{***}
	(0.048)	(1.285)		(0.120)
Country number	25	25		25
Observation	1,125	1,125		1,125

Notes: The parenthesis (.) is the standard deviation, [.] is the *P*-value; ***denotes significance at the 1% level. The model is ARDL (1, 1). This table removes the data of four countries from the data of the 29 countries (Czech, Denmark, Hungary and Poland).
Source: Authors' analysis.

Table 7. Estimation results of the dynamic panel model for 25 countries – ARDL (2, 2) model.

Methods	PMG	MG	Hausman test	DFE
Dependent variable Δ ln st_{it}				
Error-correction effect (coefficient)			H_0: PMG	
ϕ_i	-0.071^{***}	-0.127^{***}	H_1: MG	-0.079^{***}
	(0.014)	(0.021)	Chi-square statistic	(0.010)
Long-run effect (coefficient)			0.21	
$-\theta_{1i}$	1.291^{***}	-2.144	[0.645]	-0.087
	(0.302)	(7.102)		(0.463)
Short-run effect (coefficient)				
$-\delta^{*\prime}_{11i}$	-1.087^{***}	-0.637^{***}		-0.443^{***}
	(0.303)	(0.238)		(0.898)
$-\delta^{*\prime}_{12i}$	−0.142	0.129		-0.184^{**}
	(0.875)	(0.217)		(0.911)
$-\lambda^{*\prime}_i$	0.129^{***}	0.132^{***}		0.123^{***}
	(0.214)	(0.030)		(0.030)
Constant (μ_i)	0.317^{***}	1.979		0.624^{***}
	(0.059)	(1.293)		(0.125)
Country number	25	25		25
Observation	1,100	1,100		1,100

Notes: The parenthesis (.) is the standard deviation, [.] is the *P*-value; ***denotes significance at the 1% level. The model is ARDL (2, 2): $\Delta st_{it} = \varphi_i(st_{i,t-1} - \theta_i' ex_{it}) - \delta^{*\prime}_{11i}\ \Delta ex_{i,t} - \delta^{*\prime}_{12i}\Delta ex_{i,t-1} - \lambda^{*\prime}_i \Delta st_{i,t-1} + \mu_i + \varepsilon_{ij}$. This table removes the data of four countries from the data of the 29 countries (Czech, Denmark, Hungary and Poland).
Source: Authors' analysis.

positively correlated in the long-run, which is closely related to the arguments of the traditional approach. The empirical results of this section are closely related to that of Pan et al. (2007).

Table 8. Estimation results of the dynamic panel model during 2002Q3–2006Q4 (pre-crisis).

Methods	PMG	MG	Hausman test	DFE
Dependent variable Δ ln st_{it}				
Error-correction effect (coefficient)			H_0: PMG	
ϕ_i	-0.063^{***}	-0.164^{***}	H_1: MG	-0.072^{***}
	(0.020)	(0.038)	Chi-square statistic	(0.016)
Long-run effect (coefficient)			0.98	
$-\theta_{1i}$	3.529^{***}	1.004	[0.323]	−0.955
	(0.673)	(2.642)		(1.000)
Short-run effect (coefficient)				
$-\delta_{11i}$	-1.155^{**}	−0.402		−0.088
	(0.515)	(0.600)		(0.134)
Constant (μ_i)	−0.042	2.338^{***}		0.811^{***}
	(0.119)	(0.764)		(0.289)
Country number	29	29		29
Observation	493	493		493

Notes: The parenthesis (.) is the standard deviation, [.] is the *P*-value; **, and ***denotes significance at the 5%, and 1% level, respectively.
Source: Authors' analysis.

Table 9. Estimation results of the dynamic panel model during 2007Q1–2011Q2 (post-crisis).

Methods	PMG	MG	Hausman test	DFE
Dependent variable Δ ln st_{it}				
Error-correction effect (coefficient)			H_0: PMG	
ϕ_i	-0.154^{***}	-0.253^{***}	H_1: MG	-0.191^{***}
	(0.022)	(0.026)	Chi-square statistic	(0.026)
Long-run effect (coefficient)			0.76	
$-\theta_{1i}$	2.491^{***}	0.008	[0.384]	0.859^{**}
	(0.481)	(2.892)		(0.426)
Short-run effect (coefficient)				
$-\delta_{11i}$	-1.472^{***}	-1.334^{***}		-1.126^{***}
	(0.246)	(0.258)		(0.091)
Constant (μ_i)	0.422^{***}	1.001		1.179^{***}
	(0.140)	(0.835)		(0.340)
Country number	29	29		29
Observation	493	493		493

Notes: The parenthesis (.) is the standard deviation, [.] is the *P*-value;
**, and
***denotes significance at the 5%, and 1% level, respectively.
Source: Authors' analysis.

According to the estimation results of Tables 11 and 12, as compared to the MG estimation method, the PMG estimation method is more suitable for the data characteristics of this study. In the long-run, in OECD countries, exchange rate and stock price have a negative long-run correlation, and this is closely related to the arguments of the portfolio approach. However, in non-OECD countries, exchange rate and stock price have a positive long-run correlation, and this is closely related to the arguments of the traditional approach. The correlation between the stock market and the foreign exchange market in the two types of countries varies in the long-run. Why? Does this result imply that the results of the 29 countries as shown in Table 3 are erroneous? In fact, no. This

Table 10. Estimation results of the dynamic panel model with ex is the NEER (measure by TWI).

Methods	PMG	MG	Hausman test	DFE
Dependent variable Δ ln st_{it}				
Error-correction effect (coefficient)			H_0: PMG	
ϕ_i	−0.064***	−0.085***	H_1: MG	−0.069***
	(0.014)	(0.017)	Chi-square statistic	(0.010)
Long-run effect (coefficient)			2.04	
$-\theta_{1i}$	1.666***	−3.237	[0.154]	−1.579
	(0.266)	(3.242)		(0.887)
Short-run effect (coefficient)				
$-\delta_{11i}$	−0.084	0.049		−0.577***
	(0.313)	(0.308)		(0.153)
Constant (μ_i)	0.023	1.292		1.078***
	(0.030)	(0.686)		(0.279)
Country number	24	24		24
Observation	1,080	1,080		1,305

Notes: The parenthesis (.) is the standard deviation, [.] is the *P*-value; ***denotes significance at the 1% level. The effective exchange rate index (NEER) that measure by TWI are taken from the IFS database of IMF. The model is $\Delta \ln st_{it} = \phi_i(\ln st_{i,t-1} - \theta_{1i} \ln ex_{it}) - \delta_{11i}\Delta \ln ex_{it} + \mu_i + \varepsilon_{it}$.
Source: Authors' analysis.

Table 11. Estimation results of the dynamic panel model sub-periods for the 13 OECD countries.

Methods	PMG	MG	Hausman test
Dependent variable Δ ln st_{it}			
Error-correction effect (coefficient)			H_0: PMG
ϕ_i	−0.099***	−0.125***	H_1: MG
	(0.017)	(0.152)	Chi-square statistic
Long-run effect (coefficient)			0.99
$-\theta_{1i}$	−1.360***	−0.602	[0.319]
	(0.225)	(0.772)	
Short-run effect (coefficient)			
$-\delta_{11i}$	−0.295**	−0.321**	
	(0.149)	(0.151)	
Constant (μ_i)	0.982***	1.146***	
	(0.145)	(0.200)	
Country number	13	13	
Observation	585	585	

Notes: The parenthesis (.) is the standard deviation, [.] is the *P*-value; **, and ***denotes significance at the 5%, and 1% level, respectively. The 13 OECD countries are Australia, Canada, Czech, Denmark, Germany, Hungary, Japan, South Korea, Mexico, Norway, Sweden, Switzerland, and England, respectively.
Source: Authors' analysis.

article argues that the differences in results of OECD countries and non-OECD countries are caused by differences in the regional country economic integrated information. Table 3 presents the performances of the stock markets and foreign exchange markets of the 29 countries in economic integration, which are definitely different from the performances of the stock markets and foreign exchange markets in terms of economic integration of either OECD countries or non-OECD countries.

Table 12. Estimation results of the dynamic panel model sub-periods for the 16 non-OECD countries.

Methods	PMG	MG	Hausman test
Dependent variable Δ ln st_{it}			
Error-correction effect (coefficient)			H_0: PMG
ϕ_i	-0.047^{***}	-0.069^{***}	H_1: MG
	(0.117)	(0.211)	Chi-square statistic
Long-run effect (coefficient)			0.08
$-\theta_{1i}$	2.146^{***}	−2.571	[0.783]
	(0.696)	(16.576)	
Short-run effect (coefficient)			
$-\delta_{11i}$	-1.497^{***}	-1.022^{***}	
	(0.360)	(0.332)	
Constant (μ_i)	0.124^{***}	1.943	
	(0.047)	(2.027)	
Country number	16	16	
Observation	720	720	

Notes: The parenthesis (.) is the standard deviation, [.] is the *P*-value; **, and ***denotes significance at the 5%, and 1% level, respectively. The 16 non-OECD countries is Argentina, Brazil, China, Chile, Hong Kong, Indonesia, India, Israel, Malaysia, the Philippines, Poland, Russia, South Africa, Singapore, Thailand, and Taiwan, respectively.
Source: Authors' analysis.

The main reasons for the better performance of the panel estimation method are its low co-linearity, higher degrees of freedom, and higher statistical estimation efficiency. Regardless of the results of Tables 3–12, Hausman tests have suggested that PMG estimation method is better than the MG and DFE methods. On the other hand, the empirical results of the OECD and non-OECD countries show that, differences in the level of development of countries can affect the long-run relationship between the stock market and the foreign exchange market, even though the short-run effect may still be consistent. At an early stage of economic development, the performance of the stock market and the foreign exchange market are closely related to the arguments of the portfolio approach. However, differences in the long-run development levels may result in situations similar to the conclusions of the traditional approach or the portfolio approach. Moreover, if the economic integration conditions are the same, the long-run relationship between the stock market and the foreign exchange market is closely related to the conclusions of the traditional analysis approach.

5. Conclusion

Stock market and foreign exchange rate are generally regarded as the major financial indicators of the financial market in a country. In the globalisation framework, the stock market and the foreign exchange market are vulnerable to the impacts of external and internal factors, making mutual influences more complex and diversified. Previous studies on the relationship between stock market and exchange rate in various countries mostly use time-series data for empirical analysis, and the empirical results may be significantly different. For example, the empirical results may lead to different causal directions, negative or positive relationships, and weak (or none) correlation. Some empirical results can be classified as conclusions of either the traditional or the portfolio approach. The issue of determining the most accurate method is often argued in literature.

This article applies the PMG approach for estimation purposes as proposed by Pesaran et al. (1999) to verify the correlation between stock price and exchange rate. The empirical results suggest that a long-run co-integration relationship exists between the stock market and the foreign exchange market. In the short-run, the stock market and the foreign exchange market are negatively correlated, supporting the arguments of the portfolio approach. However, through the error-correction adjustment process, the long-run relationship between the two is positive, supporting the results of the traditional approach. This article confirms that the viewpoints/arguments of the portfolio approach and the traditional approach exist through long- and short-run adjustments. It is also observed that when financial crises occur, negative information will have an immediate impact in the short-run. In order to prevent bad news from entering the domestic market to reduce the long-run impact, countries usually take control measures to isolate the information exchange and flow, resulting in the slowdown of the error-correction mechanism. The above findings have not been discussed in previous literature and hence are the major contributions of this study.

Finally, this article argues that previous studies which analyse data for either a single country or multiple countries in the time-series data framework often neglect significant information contained in the cross-sectional data. On the other hand, previous studies often focus on the short-run effects, while neglecting the long-run effects, making it impossible to obtain new information in the event of changes over time. This article applies the PMG estimation method to establish dynamic heterogeneous panel data models of the long- and short-run coefficients. The resulting empirical findings with diversified characteristics can explain the differences in the conclusions of previous studies.

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Notes

1. In the case of Thailand during the 1997 Asian financial crisis, when the 'hot money' was pulled out of the economy, both the stock market and the foreign exchange market collapsed simultaneously, causing considerable damage to the country's financial markets.
2. Pesaran, Shin, and Smith (2001) proposed the structure of the ARDL model. The ARDL model can be used to solve the problem of series inconsistency and is also applied to small-sized sample data. Before the co-integration test, no unit root test is required.
3. The detailed deductive process of the ARDL(1,1) model as.

$$\ln st_{it} = \sum_{j=1}^{1} \lambda_{ij} \ln st_{i,t-1} + \sum_{j=0}^{1} \delta'_{ij} \ln ex_{i,t-j} + \mu_i + \varepsilon_{it}$$

$$\ln st_{it} = \lambda_i \ln st_{i,t-1} + \delta_{10i} \ln ex_{it} + \delta_{11i} \ln ex_{i,t-1} + \mu_i + \varepsilon_{it}$$

$$\ln st_{it} - \ln st_{i,t-1} = -(1-\lambda_i) \ln st_{i,t-1} + (\delta_{10i} + \delta_{11i}) \ln ex_{it} - \delta_{11i}(\ln ex_{it} - \ln ex_{i,t-1}) + \mu_i + \varepsilon_{it}$$

$$\Delta \ln st_{it} = -(1-\lambda_i)[\mathrm{lnst}_{i,t-1} - (\tfrac{\delta_{10i}+\delta_{11i}}{1-\lambda_i})\mathrm{lnex}_{it}] - \delta_{11i}\Delta \ln ex_{it} + \mu_i + \varepsilon_{it}$$

$$\Delta \ln st_{it} = \varphi_i(\mathrm{lnst}_{i,t-1} - \theta_{1i}\mathrm{lnex}_{it}) - \delta_{11i}\Delta \ln ex_{it} + \mu_i + \varepsilon_{it}$$

4. Eurozone countries include Austria, Belgium, Finland, France, German, Greece, Italy, Ireland, Luxembourg, Netherlands, Portugal, Slovenia, Spain, Malta, Cyprus, Slovakia and Estonia. As the subject of this study is the relationship between exchange rate and stock price, German stock market is selected as the representative with respect to the US Dollar–euro exchange rate.
5. The exchange rate in this paper is measured as the conversion of USD 1 into units of local currency. Therefore, when the exchange rate rises (declines), it represents a depreciation (appreciation) of the local currency.
6. Since the empirical architecture is based on the ARDL model, it is not necessary to confirm the integration order of variables as either I(1) or I(0) in advance.
7. Capital account convertibility (CAC) is a feature of a nation's financial regime that centres on the ability to conduct transactions of local financial assets into foreign financial assets freely and at country determined exchange rates. It is sometimes referred to as capital asset liberation. The Appendix 2 provides more explanation for the liberalisation dates and Openness Index to experience a follow through effect of 'portfolio' approach.

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Appendix 1. Detailed contents of data by country.

Periods: 2000Q1–2011Q2

No	Code	Nation	Stock price index (st)	Exchange rate (ex)
1	ARG	Argentina	Merval Argentina Index	1. The exchange rate in this paper is measured by the conversion of USD 1 into units of local currency. Therefore, when ex value rises (declines), it represents the depreciation (appreciation) of the local currency
2	AUS	Australia (OECD)	Sydney All Ords Stock Index	
3	BRA	Brazil	Brazil BOYESPA Index	
4	CAN	Canada (OECD)	Toronto Stock Exchange Venture Composite Index	2. The exchange rate regimes of the sample countries are:
5	CHA	China	Shanghai Stock Exchange Composite Index	A. Managed floating with no predetermined path for the exchange rate: *Argentina, Czech, India, Malaysia, Russian, Singapore, Thailand, and Taiwan*
6	CHI	Chile	IPSA Index	B. Independently floating: *Australia, Brazil, Canada, Indonesia, Israel, Japan, South Korea, Mexico, Norway, the Philippines, Poland, South Africa, Sweden, Switzerland, and the UK*
7	CZE	Czech (OECD)	PRAGUE SE PX	
8	DEN	Denmark (OECD)	OMX COPENHAGEN 20 Index	
9	GER	Germany (OECD)	German DAX IndexDow Jones STOXX 600 index	
10	HK	Hong Kong	HK Hange Seng Index	C. Other conventional fixed peg arrangements: *China and Chile*
11	HUN	Hungary (OECD)	BUDAPEST (BUX) index	
12	IDO	Indonesia	Indonesia JSX index	D. Pegged exchange rates within horizontal bands: *Denmark and Hungary*
13	IND	India	BSE SENSEX 30 Index	E. Exchange arrangements with no separate legal tender: *Germany*
14	ISR	Israel	TA100 index	
15	JAP	Japan (OECD)	NK-225 Index (Tokyo)	
16	KOR	South Korea (OECD)	South Korea Stock Index	F. Currency board arrangements: *Hong Kong*
17	MAL	Malaysia	Kuala Lumpur Stock Index	
18	MEX	Mexico (OECD)	Mexico IPC Index	
19	NOR	Norway (OECD)	Oslo OBX Stock Indexes	
20	PHI	The Philippines	Manila Stock Index	
21	POL	Poland	Warsaw GENERAL Index	
22	RUS	Russian	RTS Stock Index	
23	SAF	South Africa	Johannesburg Stock Index	
24	SNG	Singapore	Singapal Strait Times Index	
25	SWE	Sweden (OECD)	Stockholm Affa. Sto Index	
26	SWL	Switzerland (OECD)	Zurich Market Index	
27	THA	Thailand	Bangkok Set Stock Index	
28	TWN	Taiwan	Taiwan TSE Index	
29	UK	United Kingdom (OECD)	London FTSE 100 Index	

Notes: The sources of the exchange rate regimes of the sample countries: IMF staff reports; Recent Economic Developments; and International Financial Statistics.

Appendix 2. Capital account liberalisation dates.

Nation	The Chinn-Ito index (*KAOPEN*) (Note 1)											
year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Argentina	1.38	−1.17	−1.17									
				−0.11			−0.8					
Australia	1.12											
Brazil	−1.17	−1.17	−0.11			0.15	0.41				0.15	−0.11
Canada	2.44, most financially open											
China	−1.17											
Chile	−1.17	1.38	1.65	1.91	2.18	2.44			2.18	1.91	1.65	1.38
Czech	0.15	1.65	1.91	2.18	2.44, most financially open							
Denmark	2.44, most financially open											
Germany	2.44, most financially open											
Hong Kong	2.44, most financially open											
Hungary	−0.11	1.38	1.65	1.91	2.18	2.44, most financially open						
Indonesia	1.12											−0.11
India	−1.17											
Israel	1.38	1.38	1.65	1.65	1.91	2.18	2.44, most financially open					
Japan	2.44, most financially open											
South Korea	−0.11									0.15	0.41	0.68
Malaysia	−0.11								1.12	−0.11	−1.17	−1.17
Mexico	1.12	1.12	0.06	0.06	1.12							
Norway	2.44, most financially open											
Philippines	0.06										−1.17	−1.17
Poland	−1.17		0.06									
Russian	−0.81	−1.86	−0.11							0.15	0.41	0.68
South Africa	−1.16											
Singapore	2.44, most financially open											
Sweden	2.44, most financially open											
Switzerland	2.44, most financially open											
Thailand	−0.11							−1.17	−0.11	−1.17		
Taiwan	NA (financially open started date at 1987 in Taiwan, Note 2)											
United Kingdom	2.44, most financially open											

Notes: 1. From Ito and Chinn (2013) "Notes on the Chinn-Ito Financial Openness Index 2011 Update". http://web.pdx.edu/~ito/Chinn-Ito_website.htm. The score the "most financially open" value of 2.44, whereas the "least financial open" score of −1.86. The Chinn-Ito index (KAOPEN) is based on the binary dummy variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER).* 2. Taiwan data resource: http://www.npf.org.tw/post/2/3,627.