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THE CAUSAL RELATIONSHIP BETWEEN STOCK PRICES AND EXCHANGE RATES: PANEL GRANGER CAUSALITY EVIDENCE FROM EMERGING AND DEVELOPED MARKETS [1]

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ABSTRACT

The financial literature has paid increasing attention to the relationship between stock prices and exchange rates. This study examines the relationship between these variables using a newly developed heterogeneous panel Granger causality test robust to cross-sectional dependency for 21 emerging and 22 developed markets. Panel results show a unidirectional causality relationship between the variables for both emerging and developed markets, running from stock prices to exchange rates. Additionally, in most cases, country-specific results also support the panel results, indicating the same unidirectional causality for 13 emerging markets (approximately 62 %) and 15 developed markets (approximately 68 %). The opposite link is found for only one emerging market. As such, we conclude that the stock-oriented model is valid for most of emerging and developed markets. That is, in both emerging and developed markets, a change in stock markets causes a change in exchange rate markets in most cases. These findings have important policy implications.

1. INTRODUCTION

The relationship between stock prices and exchange rates has important implications for both financial managers and policy makers. Generally, the literature presents two approaches to explain this relationship: (1) flow-oriented and (2) stock-oriented models. In the flow-oriented model, changes in exchange rates affect firms' domestic and international sales, which in turn affect the firms' stock prices. Therefore, there is a positive relationship between stock prices and exchange rates, with the causality relationship running from exchange rates to stock prices (Dornbusch and Fischer, 1980). In the stock-oriented model, on the other hand, increasing stock prices increase the demand for money, which in turn causes an increase in interest rates that will attract corresponding capital inflows, appreciating the local currency (Frankel, 1983; Krueger, 1983). Therefore, according to the stock-oriented model, there is a negative relationship between stock prices and exchange rates, with the causality relationship running from stock prices to exchange rates.

Despite numerous studies in the extant literature examining this relationship, there is no consensus regarding the linkage between these stock prices and exchange rates. While certain studies have found that the flow-oriented model is valid (Aggarwal, 1981; Chiang et al., 2000; Liu and Wan, 2012; Pan et al., 2007; Yau and Nieh, 2009), others have supported the stock-oriented model (Gavin,1989; Hatemi and Irandoust, 2002; Liang et al., 2013; Tsai, 2012). Moreover, some studies have found no significant relationship between the variables (Fernandez, 2006; Solnik, 1987), while others have shown a bidirectional causality relationship between them (Caporale et al., 2014; Nieh and Lee, 2001; Zhao, 2010).

However, most studies in literature have used conventional co-integration and / or Granger casualty tests. In this regard, the aim of this study is to investigate the relationship between stock prices and exchange rates for 21 emerging and 22 developed markets using a panel Granger causality test, by Emirmahmutoglu and Kose (2011), that takes into account both heterogeneity and cross-sectional dependency.

[1] A previous version of this paper was presented at the Eurasia Business and Economics Society Congress, held in Turkey in May 2016. We thank the participants for the instructive and helpful comments.

The contribution of this study to the literature are as follows. First, the relationship between stock prices and exchange rates in literature is based on time series analysis. Therefore, contrary to the general literature, this study uses panel data analysis, which is more reliable and efficient than time series analysis (Baltagi, 2009). Second, in order to take into account the impact of different levels of financial development, countries are categorized into emerging and developed markets. Third, though a large portion of literature examines the relationship between the variables, it is difficult to compare their results, since they employ various methodologies and investigate different samples with diverse data frequencies. This paper, however, examines 21 emerging and 22 developed markets, using the same methodology, samples, and frequency. Fourth and more importantly, this paper applies a newly developed panel causality test by Emirmahmutoglu and Kose (2011), which takes into account both heterogeneity and cross-section dependency [2]. As pointed out by Romero-Avila (2008), failure to properly characterise the time series properties of data may cause fragility in the analysis. Therefore, if cross-sectional dependency and heterogeneity are present in the data, they should be considered not to cause any misleading inference (Pesaran, 2006; Wolde-Rufael, 2014). Additionally, Emirmahmutoglu and Kose's (2011) panel causality test has other advantages. For example, this test does not require pre-tests for stationarity and / or cointegration, thereby avoiding the associated pre-test bias and size distribution, at least asymptotically. The only prior information needed for the test is the maximum order integration of the process (Emirmahmutoglu and Kose, 2011; Yamada and Toda, 1998). We believe that this is an important point, since the different unit root and cointegration tests may indicate different results, as generally reported in the literature. Moreover, the test is valid for mixed panels involving integrated of order one I(1) and zero I(0) series. Furthermore, this test also allows the lag length used in causality analysis to vary across cross-sectional units. To the best knowledge of the author, the relationship between stock prices and exchange rates has not been previously examined using this test.

The remainder of the paper is organized as follows: section 2 describes the data and the methodology, section 3 presents the results, and the conclusion and policy implications can be found in section 4.

2. DATA AND METHODOLOGY

The study uses monthly stock indices and nominal exchange rates from January 2003 to January 2016, consisting of 157 observations for each emerging and developed market. Countries are classified into emerging and developed markets based on the Morgan Stanley Capital International (MSCI) classification as of 2016.[3] All stock indices are from the MSCI database and denominated in local currency. The exchange rates data are from the Oanda database and express foreign currencies in terms of USD, meaning that an increase in the exchange rate implies an appreciation of the USD. All the series are transformed into the natural logarithm form.

This paper employs the panel Granger causality test developed by Emirmahmutoglu and Kose (2011). They propose a simple procedure for the Granger causality test with lag augmented vector autoregressive (LA-VAR) procedure by Toda and Yamamoto (1995) in heterogonous mixed panels applying meta-analysis (Emirmahmutoglu and Kose, 2011). This test has the null hypothesis of 'no Granger causality'. This study considers the following level VAR model with $k_i + d\,max_i$ lags in heterogeneous mixed panels:

$$LNFX_{it} = \varphi_i^{LNFX} + \sum_{k=1}^{k_i+d\,max_i} A_{11,ik}\, LNFX_{i,t-k} + \sum_{k=1}^{k_i+d\,max_i} A_{12,ik}\, LNS_{i,t-k} + \mu_{i,t}^{LNFX} \quad (1)$$

$$LNS_{it} = \varphi_i^{LNS} + \sum_{k=1}^{k_i+d\,max_i} A_{21,ik}\, LNFX_{i,t-k} + \sum_{k=1}^{k_i+d\,max_i} A_{22,ik}\, LNS_{i,t-k} + \mu_{i,t}^{LNS} \quad (2)$$

Where *LNFX* and *LNS* denote the logs of exchange rates and stock prices, respectively. i denotes the cross-sectional dimension and t is the time period. φ_i^{LNFX} and φ_i^{LNS} are vectors of fixed effects; $A_{11,ik}$, $A_{12,ik}$, $A_{21,ik}$, and $A_{22,ik}$ are fixed matrices of parameters allowed to change across cross-sectional units; $\mu_{i,t}^{LNFX}$ and $\mu_{i,t}^{LNS}$ are column vectors of the error terms; k_i is the lag length, which can differ across cross-sectional units; and $d\,max_i$ is the maximum order of integration in the system for each i.

[2] Among others, Chang et al. (2015) also use this test.

[3] The emerging markets investigated in this study are Brazil, Chile, Colombia, Mexico, Peru, Czech Republic, Egypt, Greece, Hungary, Poland, Russia, South Africa, Turkey, China, India, Indonesia, Korea, Malaysia, Philippines, Thailand, and Taiwan, whereas the developed markets are Canada, Denmark, Israel, Norway, Sweden, Switzerland, United Kingdom (UK), Australia, Hong Kong, Japan, New Zealand, Singapore, Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, and Spain.

In this regard, rejecting the null hypothesis that all $A_{12,ik}$ are equal to zero means that there is a causal relationship from stock prices to exchange rates, while rejecting the null hypothesis that all $A_{21,ik}$ are zero leads us to conclude that there is causality from exchange rates to stock prices.
Following Emirmahmutoglu and Kose (2011), we use Fisher test statistics (Fisher, 1932) to test the null hypothesis in a heterogeneous panel, defined as follows:

$$\lambda = -2\sum_{i=1}^{N} \ln(p_i), \quad i = 1,2, \dots N, \tag{3}$$

Where p_i is the p-value corresponding to the Wald statistics of the ith individual cross-section.This test statistic has a chi-square distribution with $2N$ degrees of freedom.
However, as Emirmahmutoglu and Kose (2011) state, the limit distribution of the Fisher test statistic is invalid if the cross-sectional units exhibit cross-sectional dependency. To overcome this problem, Emirmahmutoglu and Kose (2011) use a bootstrap methodology, which can be summarized in six steps:[4]

Step1: Determine the maximum order integration of the variables in the system for each cross-sectional unit. Subsequently, estimate equation (2) for each cross-sectional unit using the ordinary least square (OLS) method, and select the lag lengths (k_i).
Step2: Based on the k_i and $dmax_i$ obtained in step1, re-estimate equation (2) by OLS under the null hypothesis of 'no Granger causality' and obtain the residuals for each cross-section unit.

$$\mu_{i,t}^{LNS} = LNS_{it} - \hat{\varphi}_i^{LNS} - \sum_{k=k_i+1}^{k_i+d\,max_i} \hat{A}_{21,ik}\, LNFX_{i,t-k} - \sum_{k=1}^{k_i+d\,max_i} \hat{A}_{22,ik}\, LNS_{i,t-k} \tag{4}$$

Step3: In order to obtain centred residuals, use Stine's (1987) methodology, i.e.,

$$\tilde{\mu}_t = \hat{\mu}_t - (T-k-l-2)^{-1} \sum_{t=k+l+2}^{T} \hat{\mu}_t, \tag{5}$$

Where $\hat{\mu}_t = (\hat{\mu}_{1t}, \hat{\mu}_{2t}, \dots, \hat{\mu}_{Nt})'$, $k = \max(k_i)$, and $l = \max(dmax_i)$. Subsequently, $[\tilde{\mu}_{it}]_{NxT}$ is generated from these residuals, and a full column at a time with replacement from the matrix to preserve the cross covariance structure of the errors is selected randomly. The bootstrap residuals are denoted as $\tilde{\mu}_t^{*}$, where $t = 1,2 \dots, T$.
Step4: Generate the bootstrap sample of LS under the null hypothesis:

$$LNS_{it}^{*} = \hat{\varphi}_i^{LNS} + \sum_{k=k_i+1}^{k_i+d\,max_i} \hat{A}_{21,ik}\, LNFX_{i,t-k} + \sum_{k=1}^{k_i+d\,max_i} \hat{A}_{22,ik}\, LNS_{it_{i,t-k}}^{*} + \tilde{\mu}_{it}^{*}, \tag{6}$$

Where $\hat{\varphi}_i^{LNS}$, $\hat{A}_{21,ik}$ and $\hat{A}_{22,ik}$ are the estimations from step2.
Step5: Substitute LNS_{it}^{*} for LNS and estimate equation (2) without imposing any restrictions on parameters to obtain the Wald statistics for the null hypothesis of 'no Granger causality' for each cross-sectional unit.

Step6: Using individual probability values of individual Wald statistics for each cross-sectional unit, calculate the Fisher test statistic as shown in equation (3). Subsequently, in order to produce the bootstrap empirical distribution of the Fisher test statistics, repeat steps 3–5 for at least 1,000 times and, finally, specify bootstrap critical values by choosing the suitable percentiles of these sampling distributions.

However, before employing the causality test, the cross-sectional dependency assumption of the test must first be tested as a prerequisite. Different tests are employed in literature for this purpose. Generally, the main differences among them concern the relationship between the time dimension (T) and cross-sectional dimension (N) of panel data. If T is large and N is small (as is the case in our study), Breusch and Pagan's (1980) Lagrange multiplier test statistic (BP LM) is a more appropriate choice. However, different tests can be used together to obtain robust results. Accordingly, we employe both the Lagrange multiplier statistic developed by Pesaran (2004), the Pesaran CDLM, which is valid when both T and N are large, and the cross-sectional dependency test statistic also proposed by Pesaran (2004), the Pesaran CD, which is valid when N is large and T is small. All three test statistics are applied separately to equation (1), in which stock prices are the dependent variables, and to equation (2), in which exchange rates are the dependent variable for both emerging and developed markets. All three test statistics have the null hypothesis of cross-sectional independence'.

The next step is to examine the slope heterogeneity assumption of the test. We use the slope homogeneity test developed by Pesaran and Yamagata (2008), which is a standardized version of Swamy's (1970) test. This slope homogeneity test has two test statistics, Δ and Δ_{adj}. Both have the null

[4] For more details about the bootstrap procedure, see the original paper by Emirmahmutoglu and Kose (2011).

hypothesis of 'slope homogeneity', while the Δ_{adj} statistic is an improved version of Δ. As with the cross-sectional dependency tests, the slope homogeneity test is also employed on equation (1), in which stock prices are the dependent variables, and on equation (2), in which the exchange rates are the dependent variables for both emerging and developed markets.

3. RESULTS

The results of the cross-sectional dependency test, presented in Table 1, show that all three test statistics (BP LM, Pesaran CDLM, and Pesaran CD) reject the null hypothesis of 'cross-sectional independence' at the 1% significance level for both emerging and developed markets and for both stock price and exchange rate as dependent variables. This means that, for example, a shock to the stock market (exchange rate market) in one of the emerging markets (developed markets) can also influence the stock markets (exchange rate markets) of other emerging markets (developed markets).

Table 1: Cross-Sectional Dependency Tests Results

	Dependent variable: lns		Dependent variable: lnfx	
CD tests	DM	EM	DM	EM
BP LM test	954.256*(0.000)	566.63*(0.000)	11716.05*(0.000)	1327.06*(0.000)
Pesaran CDLM test	33.649*(0.000)	17.402*(0.000)	534.336*(0.000)	54.507*(0.000)
Pesaran CD test	-7.894*(0.000)	-7.775*(0.000)	13.754*(0.000)	-7.329*(0.000)

Note: The figures are test statistics. Between parentheses are the probability values. *, denotes the 5% significance level. DM and EM represent developed and emerging markets, respectively.

The results of the slope homogeneity test are shown in Table2. Both Δ and Δadj test statistics reject the null hypothesis of 'slope homogeneity' in all cases at the 1 % significance level. This means that country-specific characteristics should be considered (Chang et al., 2015).

Table 2: Pesaran and Yamagata's (2008) Slope Homogeneity Test Results

	Dependent variable: lns		Dependent variable: lnfx	
Test statistics	DM	EM	DM	EM
Δ	46.136*(0.000)	146.562*(0.000)	63.735*(0.000)	134.649*(0.000)
Δ_{adj}	46.580*(0.000)	147.974*(0.000)	64.349*(0.000)	135.946*(0.000)

Note: The figures are relevant test statistics. Between parentheses are the probability values. *, denotes the 5% significance level. DM and EM represent developed and emerging markets, respectively.

Having established that cross-sectional dependency and slope heterogeneity exist across countries, the next step is to apply the causality test. First, however, the maximum order of integration of the VAR system should be determined, as indicated earlier; this is the only prior information needed for the test. Consequently, we use two conventional unit root tests, namely the augmented Dickey Fuller (1981) (ADF) and the Phillips and Perron (1988) (PP) unit root tests.

The results of the ADF unit root test are presented in Appendix A. Both exchange rates and stock prices have a unit in their level form, whereas first differences of the series are found to be stationary in all cases at the 5 % significance level, except for Hong Kong's exchange rate, which is found to be stationary. However, the maximum order of integration is an important characteristic in the VAR system. Therefore, since Hong Kong stock prices are found to be integrated of order one at the 5% significance level, the *dmax* that should be used in the VAR system for Hong Kong is also 1. Moreover, as previously mentioned, Emirmahmutoglu and Kose's (2011) test is also valid for mixed panels involving integrated series of the order one I (1) and zero I (0). As for the PP unit root test, the results (presented in Appendix B) are similar. In this regard, we determine that in all cases the *dmax* to use in VAR systems is 1.

The results of Emirmahmutoglu and Kose's (2011) Granger causality test are reported in Tables 3 and 4 for developed and emerging markets, respectively. The panel results for developed markets show a clear, unidirectional Granger causality relationship running from stock prices to exchange rates at the 10% or better significance level. In most cases, the country-specific results also support these panel results, with causality unidirectional from stock prices to exchange rates for 15 developed markets out of 22 (nearly 68%). For the relevant countries, this means that a change in stock markets causes changes in exchange-rate markets. Conversely, in no developed market is causality found running from exchange rates to stock prices. Moreover, bidirectional causality is found in only one country (the UK), while no causality relationship is found for the remaining six developed markets (Denmark, Israel, Switzerland, Hong Kong, New Zealand, and Ireland). In these countries, the findings suggest that movements in stock prices and exchange rates are independent of each other.

Table 3: Emirmahmutoglu and Kose's (2011) Panel Granger Causality Test Results for Developed Markets

Developed Markets	dmax	Δ	Ho: lns ≠ lnfx		Ho: lnfx ≠ lns		Results
			Wald stat.	p-value	Wald stat.	p-value	
Country specific results							
Canada	1	2	40.590*	0.000	0.9350	0.626	lns → lnfx
Denmark	1	2	4.0910	0.129	1.8050	0.406	(-)
Israel	1	1	2.6320	0.105	0.8520	0.356	(-)
Norway	1	2	16.643*	0.000	4.5400	0.103	lns → lnfx
Sweden	1	2	8.6100*	0.014	0.9570	0.620	lns → lnfx
Switzerland	1	1	0.0340	0.855	2.0380	0.153	(-)
UK	1	2	17.606*	0.000	6.5920*	0.037	lns ↔ lnfx
Australia	1	2	14.873*	0.001	2.6460	0.266	lns → lnfx
Hong Kong	1	1	2.0630	0.151	1.0540	0.305	(-)
Japan	1	2	17.483*	0.000	3.2300	0.199	lns → lnfx
New Zealand	1	2	1.4410	0.487	3.2080	0.201	(-)
Singapore	1	2	16.364*	0.000	0.9850	0.611	lns → lnfx
Austria	1	2	5.2930**	0.071	0.3920	0.822	lns → lnfx
Belgium	1	2	5.7640**	0.056	3.7900	0.150	lns → lnfx
Finland	1	1	3.6320**	0.057	0.7140	0.398	lns → lnfx
France	1	2	5.8770**	0.053	0.4810	0.786	lns → lnfx
Germany	1	2	5.3970**	0.067	0.3350	0.846	lns → lnfx
Ireland	1	2	0.1450	0.930	0.8280	0.661	(-)
Italy	1	1	7.8780*	0.005	0.0640	0.801	lns → lnfx
Netherlands	1	2	4.6210**	0.099	0.7280	0.695	lns → lnfx
Portugal	1	2	4.6700**	0.097	0.0730	0.964	lns → lnfx
Spain	1	1	5.6770*	0.017	0.0200	0.887	lns → lnfx
Panel result							
Fisher test statistic			202.537*		42.245		lns → lnfx
Bootstrap critical values			5%	10%	5%	10%	
			80.428	68.382	103.659	79.66	

Note: The symbol '≠' means does not Granger cause. Δ shows optimal lag length, selected by SBC with a maximum lag length of 12. '→' shows the direction of causality. Symbol (-) means that there is no causality between the variables. * and **, denote the 5% and 10% significance level, respectively. Critical values are obtained through 1,000 bootstrap replications.

For emerging markets, the panel results clearly show a unidirectional Granger causality relationship running from stock prices to exchange rates at the 10% or better significance level. Additionally, in most cases, the country-specific results also support the panel results, showing unidirectional causality from stock prices to exchange rates for 13 emerging markets out of 21 (nearly 62%). In only Chile is causality found from exchange rates to stock prices. Moreover, bidirectional causality is found only in three countries (Colombia, Mexico, and Indonesia), with no causality relationship found for the remaining four emerging markets on the panel (Egypt, South Africa, China, and Korea).

In summary, we conclude that the stock-oriented model is valid for most developed and emerging markets. Generally, these results also imply that differences in the levels of financial development between developed and emerging markets have no noticeable different impact on the relationship between the relevant variables, since similar results are found for both types of market.

Table 4. Emirmahmutoglu and Kose's (2011) Panel Granger Causality Test Results for Emerging Markets

Emerging Markets	dmax	Δ	Ho: lns≠ lnfx		Ho: lnfx ≠lns		Results
			Wald stat.	p-value	Wald stat.	p-value	
Country specific results							
Brazil	1	2	10.097*	0.006	0.1120	0.946	lns → lnfx
Chile	1	2	1.1660	0.558	4.6880**	0.096	lnfx → lns
Colombia	1	2	5.6940**	0.058	8.5420*	0.014	lns ↔ lnfx
Mexico	1	2	7.4410*	0.024	7.1730*	0.028	lns ↔ lnfx
Peru	1	2	5.2570**	0.072	4.2030	0.122	lns → lnfx
Czech Republic	1	1	3.3370**	0.068	0.7290	0.393	lns → lnfx
Egypt	1	2	1.0420	0.594	3.0670	0.216	(-)
Greece	1	1	3.0980**	0.078	1.0030	0.316	lns → lnfx
Hungary	1	2	11.914*	0.003	0.3360	0.845	lns → lnfx
Poland	1	2	9.6730*	0.008	1.8740	0.392	lns → lnfx
Russia	1	4	18.612*	0.001	4.0280	0.402	lns → lnfx
South Africa	1	2	4.5890	0.101	3.9530	0.139	(-)
Turkey	1	3	12.249*	0.007	1.2780	0.734	lns → lnfx
China	1	1	1.8150	0.178	0.4090	0.523	(-)
India	1	1	5.1430*	0.023	1.3610	0.243	lns → lnfx
Indonesia	1	2	48.011*	0.000	5.8790**	0.053	lns ↔ lnfx
Korea	1	2	4.2590	0.119	0.2250	0.894	(-)
Malaysia	1	2	10.395*	0.006	0.6210	0.733	lns → lnfx
Philippines	1	2	5.1820**	0.075	0.4370	0.804	lns → lnfx
Taiwan	1	2	23.350*	0.000	0.6030	0.740	lns → lnfx
Thailand	1	2	6.6010*	0.037	2.4470	0.294	lns → lnfx
Panel result							
Fisher test statistic			200.111*		54.885		lns → lnfx
Bootstrap critical values			5%	10%	5%	10%	
			63.653	57.929	65.586	58.008	

Note: The symbol '≠' means does not Granger cause. Δ shows optimal lag length, selected by SBC with a maximum lag length of 12. '→' shows the direction of causality. Symbol (-) means that there is no causality between the variables. * and ** denote the 5% and 10% significance level, respectively. Critical values are obtained through 1,000 bootstrap replications.

However, not withstanding that the stock-oriented model is validated for most developed and emerging markets, it remains important to explain why the relationship between exchange rates and stock prices varies in some cases across countries. First, results may be related to each country's differences in the size of the equity and exchange rates markets, as well as the differences in the trade size, structure, and monetary policy framework (Abouwafia and Chambers, 2015; Nieh and Lee, 2001). Second, whether or not exchange rate risk is hedged may also affect the relationship between exchange rates and stock prices. Third, the utilization rate of the local currency in foreign trade may also play a role in the relationship between the two examined variables (Pan et al., 2007). Lastly, differences in exchange rate arrangements among countries may be another important influencing factor.[5]

[5] For example, based on the International Monetary Fund's (IMF) Annual Report on Exchange Arrangements and Exchange Restrictions from 2014, the latest available as of June 2016, there are different exchange rate arrangements, ranging from hard pegs to free floating regimes. Although most of the developed and emerging markets investigated in this study have floating or free floating exchange rate regimes, there are also some countries (e.g., China, Hong Kong, Egypt, Singapore, Switzerland) that have exchange rate regimes not allowing prices to be determined by markets based on the IMF approach. In other words, movements in these countries' exchange rate markets can be affected by official actions (IMF, Annual Report on Exchange Arrangements and Exchange Restrictions, 2014). Therefore, examining the stock price-exchange rate relationship for these countries may be criticized. However, there are also studies examining the stock price-exchange rate relationship for those countries where exchange rate arrangements are not free floating or floating regimes (e.g., Abouwafia and Chambers, 2015; Diamandis and Drakos, 2011; Pan et al., 2007;Wu, 2000; Zhao, 2010). Additionally, the aim of this study is to investigate the causality relationship between the relevant variables employing a newly developed panel causality test which takes into account both the cross-sectional dependency and heterogeneity. Therefore, the effect of different exchange rate arrangements on the stock price-exchange rate relationship is beyond the scope of this study. However, such an issue can also be examined in future studies.

4. POLICY IMPLICATIONS AND CONCLUSION

This study examines the relationship between stock prices and exchange rates for 21 emerging and 22 developed markets using a newly developed heterogeneous panel Granger causality test by Emirmahmutoglu and Kose (2011), which is also robust for cross-sectional dependency. Results indicate that the causality relationship is unidirectional, running from stock prices to exchange rates for both emerging and developed markets. Besides, in most cases, country-specific results also support the panel results and indicate that causality is unidirectional, running from stock prices to exchange rates for 13 emerging markets out of 21 and 15 developed markets out of 22. Moreover, whereas causality from exchange rates to stock prices is found for only one emerging market (Chile), a bidirectional causality relationship is found for one developed (UK) and three emerging markets (Colombia, Mexico, and Indonesia). Furthermore, no causality relationship is found for the remaining six developed (Denmark, Israel, Switzerland, Honk Kong, New Zealand, and Ireland) and four emerging (Egypt, South Africa, China, and Korea) markets. As such, we conclude that the stock-oriented model is valid for most of emerging and developed markets. That is, in both emerging and developed markets, a change in stock markets causes a change in exchange rate markets in most cases.

These findings have important policy implications. First, for international investors, results indicate that movement in stock markets can be used to better predict the movements in exchange rate markets for the countries where it is reported that the stock-oriented model is valid. However, for the countries where no causality is found, it means that neither the fluctuations in stock markets nor the fluctuations in exchange rate markets can be used to better predict the direction of the other market. Therefore, investors can benefit from the different causality relationship reported in this study to develop better investment and hedging strategies. Second, as reported in the relevant literature, volatility in exchange rate markets can adversely affect a country's trade performance. As such, the fluctuations of exchange rates are a source of concern for policy makers. Therefore, policy makers in the countries where it is found that stock markets lead to exchange rate markets should pay more attention to stock market fluctuations. In this regard, especially policy makers in emerging markets should try to implement policies that aim to construct a more diversified, broader, and deeper stock markets, whereas policy makers in developed countries should implement policies that will ensure to build more robust stock markets which, in turn, may help reduce the fluctuations in exchange rate markets. Besides, in order to forecast exchange rates more accurately, these countries' exchange rate models should also consider their stock market movements. Finally, policy makers in the countries where the bidirectional causality relationship is found should recognize that a shock originating in any of these markets can easily spillover into the other market.

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Appendix A: ADF Unit Root Test Results

	ADF lnfx p-value		ADF lns p-value		dmax
	Level	First difference	Level	First difference	
Developed markets					
Canada	0.9532(1)	0.0000*(0)	0.3281(1)	0.0000*(0)	1
Denmark	0.4847(1)	0.0000*(0)	0.4644(1)	0.0000*(0)	1
Israel	0.387(1)	0.0000*(0)	0.0928(0)	0.0000*(0)	1
Norway	0.8944(1)	0.0000*(0)	0.1664(1)	0.0000*(0)	1
Sweden	0.3345(1)	0.0000*(0)	0.4160(0)	0.0000*(0)	1
Switzerland	0.6454(0)	0.0000*(0)	0.4460(1)	0.0000*(0)	1
UK	0.1811(1)	0.0000*(0)	0.3631(0)	0.0000*(0)	1
Australia	0.6675(1)	0.0000*(0)	0.6781(0)	0.0000*(0)	1
Hong Kong	0.029*(2)	-	0.3510(0)	0.0000*(0)	1
Japan	0.9575(1)	0.0000*(0)	0.7229(1)	0.0000*(0)	1
New Zealand	0.3586(1)	0.0000*(0)	0.7802(0)	0.0000*(0)	1
Singapore	0.9829(1)	0.0000*(0)	0.3238(1)	0.0000*(0)	1
Austria	0.4730(1)	0.0000*(0)	0.3285(1)	0.0000*(0)	1
Belgium	0.4730(1)	0.0000*(0)	0.5358(4)	0.0200*(3)	1
Finland	0.4730(1)	0.0000*(0)	0.6265(1)	0.0000*(0)	1
France	0.4730(1)	0.0000*(0)	0.6306(0)	0.0000*(0)	1
Germany	0.4730(1)	0.0000*(0)	0.2267(1)	0.0000*(0)	1
Ireland	0.4730(1)	0.0000*(0)	0.8520(3)	0.0017*(2)	1
Italy	0.4730(1)	0.0000*(0)	0.6065(0)	0.0000*(0)	1
Netherlands	0.4730(1)	0.0000*(0)	0.8114(0)	0.0000*(0)	1
Portugal	0.4730(1)	0.0000*(0)	0.2486(1)	0.0000*(0)	1
Spain	0.4730(1)	0.0000*(0)	0.4437(0)	0.0000*(0)	1
Emerging markets					
Brazil	0.9720(1)	0.0000*(0)	0.7793(0)	0.0000*(0)	1
Chile	0.7270(1)	0.0000*(0)	0.7223(0)	0.0000*(0)	1
Colombia	0.9974(2)	0.0000*(1)	0.8685(0)	0.0000*(0)	1
Mexico	0.4243(1)	0.0000*(0)	0.5792(0)	0.0000*(0)	1

Peru	0.9992(1)	0.0000*(0)	0.9296(0)	0.0000*(0)	1
Czech Republic	0.7817(1)	0.0000*(0)	0.4738(0)	0.0000*(0)	1
Egypt	0.9786(1)	0.0000*(0)	0.3658(0)	0.0000*(0)	1
Greece	0.4730(1)	0.0000*(0)	0.7989(0)	0.0000*(0)	1
Hungary	0.2931(1)	0.0000*(0)	0.2098(1)	0.0000*(0)	1
Poland	0.5497(1)	0.0000*(0)	0.4705(0)	0.0000*(0)	1
Russia	0.9959(2)	0.0000*(1)	0.2476(1)	0.0000*(0)	1
South Africa	0.8814(2)	0.0000*(1)	0.6900(0)	0.0000*(0)	1
Turkey	0.5807(2)	0.0000*(1)	0.2854(0)	0.0000*(0)	1
China	0.9998(1)	0.0000*(0)	0.7125(0)	0.0000*(0)	1
India	0.5246(1)	0.0000*(0)	0.5028(0)	0.0000*(0)	1
Indonesia	0.8254(1)	0.0000*(0)	0.2693(1)	0.0000*(0)	1
Korea	0.3627(3)	0.0000*(2)	0.4792(0)	0.0000*(0)	1
Malaysia	0.9996(5)	0.0000*(4)	0.4581(1)	0.0000*(0)	1
Philippines	0.8617(1)	0.0000*(0)	0.4488(0)	0.0000*(0)	1
Taiwan	0.5672(1)	0.0000*(0)	0.3175(0)	0.0000*(0)	1
Thailand	0.9375(1)	0.0000*(0)	0.3315(0)	0.0000*(0)	1

Note: Figures for ADF test show the probability values. * denotes the 5%significance level. The unit root tests are employed in a form with constant and trend. Figures in parentheses are lag lengths. The lag length for ADF is selected using the Schwartz information criteria.

Appendix B. PP Unit Root Test Results

	PP lnfx p-value		PP lns p-value		dmax
	Level	First difference	Level	First difference	
Developed markets					
Canada	0.9603(5)	0.0000*(2)	0.3412(6)	0.0000*(5)	1
Denmark	0.5634(5)	0.0000*(2)	0.4978(6)	0.0000*(5)	1
Israel	0.4043(6)	0.0000*(5)	0.0835(4)	0.0000*(3)	1
Norway	0.9598(4)	0.0000*(2)	0.3447(3)	0.0000*(3)	1
Sweden	0.4235(6)	0.0000*(4)	0.2993(6)	0.0000*(6)	1
Switzerland	0.4530(4)	0.0000*(1)	0.5606(6)	0.0000*(6)	1
UK	0.2474(6)	0.0000*(5)	0.2736(7)	0.0000*(7)	1
Australia	0.7766(5)	0.0000*(0)	0.5397(6)	0.0000*(6)	1
Hong Kong	0.0212*(4)	-	0.1899(4)	0.0000*(0)	1
Japan	0.9652(4)	0.0000*(2)	0.7530(6)	0.0000*(4)	1
New Zealand	0.3512(6)	0.0000*(2)	0.7413(5)	0.0000*(4)	1
Singapore	0.9955(2)	0.0000*(6)	0.3265(6)	0.0000*(5)	1
Austria	0.5552(5)	0.0000*(2)	0.3637(6)	0.0000*(5)	1
Belgium	0.5552(5)	0.0000*(2)	0.8136(8)	0.0200*(7)	1
Finland	0.5552(5)	0.0000*(2)	0.6494(6)	0.0000*(5)	1
France	0.5552(5)	0.0000*(2)	0.5113(7)	0.0000*(7)	1
Germany	0.5552(5)	0.0000*(2)	0.3688(6)	0.0000*(6)	1
Ireland	0.5552(5)	0.0000*(2)	0.9130(8)	0.0000*(7)	1
Italy	0.5552(5)	0.0000*(2)	0.5069(7)	0.0000*(6)	1
Netherlands	0.5552(5)	0.0000*(2)	0.6332(7)	0.0000*(7)	1
Portugal	0.5552(5)	0.0000*(2)	0.4343(6)	0.0000*(6)	1
Spain	0.5552(5)	0.0000*(2)	0.3912(5)	0.0000*(5)	1
Emerging markets					
Brazil	0.9955(2)	0.0000*(8)	0.7431(2)	0.0000*(0)	1
Chile	0.9391(1)	0.0000*(8)	0.6984(2)	0.0000*(0)	1
Colombia	0.9989(4)	0.0000*(10)	0.8548(4)	0.0000*(6)	1
Mexico	0.6524(3)	0.0000*(1)	0.5238(7)	0.0000*(7)	1
Peru	0.9995(5)	0.0000*(3)	0.9019(6)	0.0000*(6)	1

Czech Republic	0.8415(4)	0.0000*(1)	0.4736(3)	0.0000*(2)	1
Egypt	0.6425(6)	0.0000*(2)	0.3678(5)	0.0000*(5)	1
Greece	0.5552(5)	0.0000*(2)	0.7631(4)	0.0000*(4)	1
Hungary	0.4312(4)	0.0000*(1)	0.2860(5)	0.0000*(4)	1
Poland	0.6660(6)	0.0000*(5)	0.4136(6)	0.0000*(6)	1
Russia	0.9995(11)	0.0000*(100)	0.1934(6)	0.0000*(5)	1
South Africa	0.7502(4)	0.0000*(2)	0.6893(4)	0.0000*(3)	1
Turkey	0.6497(4)	0.0000*(10)	0.2856(2)	0.0000*(1)	1
China	0.9991(8)	0.0000*(6)	0.6062(3)	0.0000*(1)	1
India	0.6283(2)	0.0000*(10)	0.3765(6)	0.0000*(6)	1
Indonesia	0.8434(6)	0.0000*(4)	0.3001(6)	0.0000*(5)	1
Korea	0.5145(5)	0.0000*(0)	0.3938(5)	0.0000*(4)	1
Malaysia	0.9998(6)	0.0000*(12)	0.3465(6)	0.0000*(5)	1
Philippines	0.9300(4)	0.0000*(7)	0.3120(7)	0.0000*(7)	1
Taiwan	0.7848(3)	0.0000*(1)	0.1144(5)	0.0000*(4)	1
Thailand	0.9651(5)	0.0000*(0)	0.1703(6)	0.0000*(6)	1

Note: Figures for PP test show the probability values.* denotes the 5%significance level. Figures in parentheses are lag lengths. The unit root tests are employed in a form with constant and trend. The lag length for PP is chosen by applying the Bartlett kernel spectral estimation method and the Newey West criteria.