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Short-run and Long-run Dynamics of Stock Prices and Exchange Rates in Developing Economies: Evidence from Malawi.

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Abstract

The study investigates the short-run and long-run dynamic relationship between stock prices and exchange rate in Malawi from January 1999 to January 2010. The study also considers the effect of internal and external macroeconomic structural shocks on the stock and foreign exchange markets. The data series consisted of the MSE stock price index, the nominal exchange rate, interest rate and JSE stock price index. The analysis used Johansen procedure for testing possibility of cointegration among the time series data. The results reveal no evidence of long-run relationship between the variables. We then employed standard Granger causality approach for testing the direction of causality. The Granger causality results show that stock prices and exchange rates do not cause each other during the period of the analysis. Our results further indicate that internal and external macroeconomic shocks do not have immediate influence on the stock and foreign exchange markets.

Keywords: Stock prices, Exchange rates, Granger causality, Cointegration test, Malawi

1. Introduction

In recent years, the relationship between stock prices and exchange rate has become key in predicting the future trends for each of these two variables and also as an input in decision making for hedging plans and portfolio diversification by investors. Moreover, their respective markets have become interdependent following the liberalization of foreign capital controls and adoption of floating exchange rates in most developing and emerging economies. Thus, changes in one market create both investment opportunities and risks in the other market (Levinson, 2009). In view of this, investigation of the relationship between stock prices and exchange rate has received considerable attention by researchers and policymakers in both developed and emerging economies for the past few years. This study, therefore, investigates the nature of the relationship that exists between stock prices and exchange rate in the developing economy of Malawi.

Investigating and understanding this interaction for a developing economy such as Malawi is not only important but also interesting for a number of reasons. First, the Malawian economy is highly vulnerable to many internally and externally generated macroeconomic shocks propelled by rapid integration of world markets. These internal and external macroeconomic shocks enhance volatility of the stock prices and exchange rate leading to high financial risk in the wealth and assets of investors (Ali and Afzal, 2012). This study analyzes these macroeconomic effects on the stock market and foreign exchange market by capturing the contagion effects of interest rate changes and trading on the Johannesburg Stock Exchange (JSE) on the two Malawian markets during the analysis period. Secondly, the financial sector in the country is still underdeveloped, with the Malawi Stock Exchange (MSE) being relatively young, small in size, with low volume of trade, and lacks high quality accounting data and market information. This makes trading on MSE more risky than other markets within and outside Southern Africa Development Community (SADC). Thirdly, the study will contribute to literature on short-run and long-run dynamic analysis of stock prices and exchange rate with evidence from a developing country like Malawi. These peculiar conditions provide the essence for investigating the nature of relationship between stock prices and exchange rate in Malawi.

Most empirical studies regarding the interaction between stock prices and exchange rates are built on the traditional and portfolio balance economic theories (Aydemir and Demirhan, 2009). The traditional approach suggests that exchange rate is expected to lead stock prices (Dornbusch and Fisher, 1980). According to this theory, devaluation or depreciation could either raise or lower a firm's stock price depending on whether that firm is an exporting firm or heavy user of imported inputs. For exporters, devaluation or depreciation creates price advantages against other trading partners of the importing country. This may increase firms' sales and profits, which in turn raises their stock prices. Thus, devaluation or depreciation will positively affect exporting firms and increase their income, consequently, boosting the level of stock prices (Aggarwal, 1981; Wu, 2000).

The portfolio balance approach postulates negative relationship as changes in stock prices may influence movements in exchange rate. The underlying argument is that the increase in stock prices increases domestic wealth, which in turn stimulates appreciation of the domestic currency. Muhammad and Rasheed (2002) further argued that an increase in domestic wealth due to a rise in domestic asset prices also leads investors to increase their demand for money, which in turn raises domestic interest rate. This again leads to appreciation of domestic currency as high interest rate attracts more foreign capital. Thus, according to portfolio balance approach, stock prices and exchange rate have an inverse relationship. On the other hand, the asset market approach to exchange rate determination provides a weak or no association between stock prices and exchange rate and treats exchange rate to be the price of an asset. That is, expected future exchange rate determines the current exchange rate such that factors affecting exchange rates and stock prices may be different (See Aydemir and Demirhan, 2009; Muhammad and Rasheed, 2002).

Although, there is more empirical evidence supporting both traditional and portfolio approaches, the direction of causality between stock prices and exchange rate remain inconclusive (Issam and Murinde, 1997; Granger, et al., 2000; Pan et al., 2007; Rahman and Uddin, 2009; Sifunjo and Mwasaru, 2012). Moreover, most of the researches in this area focus on developed economies with very little work done on developing economies (Zia and Rahman, 2011). There is, therefore, a need to establish the direction and magnitude of interaction between stock prices and exchange rate for less developed and emerging economies such as Malawi with smaller stock market size. The linkages have implications for the country like Malawi where the Stock Market is still in its infant stage while government is shifting to independently floating exchange rate regime.

2. Literature Review

Literature on the relationship between stock prices and exchange rate is enormous for both developed and developing countries; however, there is limited number of studies investigating this relationship in Sub Saharan Africa (SSA). The existing literature provides a very diverse outlook on the relationship between stock prices and exchange rate at both microeconomic and macroeconomic level.

The early pioneers, Frank and Young (1972) investigated the stock prices and exchange rate dynamics and found no significant relationship between the two variables. Later, Aggarwal (1981) examined the influence of exchange rate changes on U.S. stock prices using monthly data over period from 1974 to 1978. His findings revealed a positive correlation between the variables. Aggarwal (1981) findings received support from the study of Giovannini and Jorion (1987) but were in sharp contrast with Soenen and Hennigar (1988) findings after investigating the same market for different time periods and found that U.S. stock exchange and exchange rate have negative relationship.

Following this, there have been a growing number of empirical studies for both developed and developing economies examining the stock prices-exchange rate nexus. Bahmani and Sohrabian (1992) investigated the relationship between U.S. stock prices and exchange rates. The study used data for the time span from July 1973 to December 1988 whereas Granger causality and cointegration tests were employed for the analysis. Their study findings shows that stock prices measured by S&P 500 index and the effective exchange rate of the dollar have bidirectional causality at least in the short run. Ajayi and Mougoue (1996) also examined the intertemporal relation between stock price indices and exchange rates for 8 developed countries: Canada, France, Germany, Italy, Japan, Netherlands, United Kingdom, and US. The study used daily data over the period from 1985 to 1991. The findings revealed significant short- and long- run feedback relationship between the two financial markets. Specifically, an increase in aggregate domestic stock price has a negative short run effect on domestic currency value. In the long run, however, increase in the stock prices has a positive effect on domestic currency value. On the other hand, currency depreciation has a negative short- and long- run effect on the stock market.

In 2001, Nieh and Lee examined the relationship between stock prices and exchange rate for G-7 countries using daily closing stock market indices and foreign exchange rates for the period from October 1, 1993 to February 15, 1996. The study findings showed no long-run equilibrium relationship between the two variables. However, the results revealed one day short-run relation in six countries except United States. The authors concluded that the differences in the one day short-run results could be explained by differences in each country's economic stage, government policy and expectations pattern among others.

Hatemi-J and Irandoust (2002) investigated the causal relationship between stock prices and exchange rate in Sweden. Monthly stock prices and nominal effective exchange rate over the period from 1993 to 1998 was used for the analysis. The results indicated unidirectional causal effect from stock prices to exchange rate.

Kurihara (2006) investigated the relationship between the two variables using daily stock prices and exchange rate in Japan for March 2001 to September 2005 period. The study takes Japanese stock prices; US stock prices; Yen/US dollar exchange rate and Japanese interest rate. The empirical evidence from the study revealed that exchange rate and U.S. stock prices affect Japanese stock prices whereas interest rate does not have an influence on the stock prices.

On the emerging economies perspective, Issam and Murinde (1997) investigated interaction between stock prices and exchange rate for India, Korea, Pakistan and Philippines. The study employed bivariate vector autogressive model to analyze monthly observations for International Finance Corporation (IFC) stocks and real effective exchange rate for time period from January 1985 to July 1994. The findings showed unidirectional causality from exchange rate to stock prices in all sample countries except the Philippines. Doong et al. (2005) examined the dynamic relationship between stock prices and exchange rate for Indonesia, Malaysia, Philippines and Taiwan over the period 1989 to 2003. The study results show that the variables are not co-integrated as such classic Granger causality method was employed to detect causal effects between the variables. The findings provide evidence that in Indonesia, Korea, Malaysia and Thailand, the two variables affect each other.

Morales (2007) analyzes the relationship between stock prices and exchange rate for four Eastern European emerging economies: Czech Republic, Hungary, Poland and Slovakia using daily observations covering seven years (1999-2006) for stock prices and exchange rate and also considers stock prices for the United States, Germany and United Kingdom. The results provide evidence that exchange rate Granger causes stock prices in Hungary, Poland and Czech Republic except in Slovakia where relationship could not be established. The results further showed that stock prices and exchange rate for these economies interact with stock prices of United Kingdom and United States.

Aydemir and Demirhan (2009) examined the causal relationship between exchange rates and stock prices for Turkey; where the national 100, services, financial, industrial, and technology indices were taken as stock price indices. The study analyzed monthly data for period from February 2001 to January 2008 using Toda-Yamamoto Granger causality. The findings indicate that there is bidirectional causal relationship between exchange rates and all stock market indices. The negative causality exists from national 100, services, financial, and industrial indices to the exchange rates; while technology index reveal a positive causal relationship to the exchange rate.

More recently, Mbutor (2010) investigated the nature of the relationship between exchange rate volatilities, equity price fluctuations and the loan behaviour of banks in Nigeria following the global financial crisis of 2007. The study applied vector autoregressive (VAR) methodology for analyzing monthly data over the period from January, 2003 to December, 2008. The findings show that stock prices Granger causes Naira to depreciate without the reverse effect.

In 2011, Parsva and Lean investigated the interactions between stock returns and exchange rate for six Middle East economies: Egypt, Iran, Jordan, Kuwait, Oman and Saudi Arabia before and during 2007 global financial crisis. The analysis applied Johansen-Juselius procedure for cointegration testing and vector error correction model (VECM) for Granger causality for data period from January, 2004 to September 2010. The results showed bidirectional causality between the variable in both short-run and long-run for Egypt, Iran, and Oman before the crisis, while in Kuwait exchange rate has effect on stock prices; whereas in Jordan and Saudi Arabia, the variables have no causal effect on each other in the short-run. Surprisingly, the results showed that the interactions were robust indicating no distinction before and during the crisis period.

Zia and Rahman (2011) analyzed the dynamic relationship between stock market index and exchange rate in Pakistan for period over January 1995 to January 2010. The study employed Johansen procedure for cointegration test. The cointegration test results show that the variables do not influence each other in the long-run; consequently, standard Granger causality method was used to analyze direction of causality. The results provide no evidence of causality in either direction indicating that variables are independent of each other.

Sifunjo and Mwasaru (2012) also analyzed the causal relationship between Kenyan Nairobi Stock Exchange (NSE) stock prices and foreign exchange rate using monthly data from November 1993 to May 1999. Johansen cointegration procedure and error correction model were used for analysis. The empirical results indicate that, in Kenya, nominal exchange rate of shillings per U.S. dollar Granger-causes stock price.

Thus, the existing literature on the stock prices-exchange rate nexus do not provide consensus on the causal direction. Moreover, many of the empirical studies concentrate on developed economies with relatively few for emerging economies.

3. Data and Methodology

The study used monthly data of Malawi stock exchange indices (MSE); average nominal exchange rate (ER) (Malawi Kwacha per US Dollar); real interest rate (IR) and Johannesburg Stock Exchange (JSE) share price index. Malawi Stock Price Index data was collected from Malawi Stock Exchange, while average nominal exchange rate, real interest and Johannesburg Stock Exchange share prices index were taken from the International Financial Statistics (IFS). The period spanned from January 1999 to January 2010. The data in this analysis is expressed in natural logarithms in order to include the proliferate effect of time series and to reduce the problem of heteroskedasticity (Gujarati, 2009).

The analyses of modern time series assume that the underlying time series is stationary (Gujarati, 2009). But most time series economic variables are non-stationary and Granger and Newbold (1974) observed that the use of non-stationary time series results into a spurious regression which has a high R^2 and t-statistics that appear to be significant but the results have no economic meaning, especially beyond a particular episode. However, before analyzing time series data in an empirical study, there is a need to establishing stationarity of the data in order to get valid estimates and inferences that can be used for forecasting. Most empirical studies use Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) due to Dickey and Fuller (1979, 1981) for testing stationarity. The general forms that estimate DF and ADF regression models respectively are given as:

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \mu_t \qquad (1)$$

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta y_{t-i} + \mu_t \qquad (2)$$

where y is a time series, Δ is difference operator, β is a constant, t is time or trend variable, μ_t is white noise error term and *m* optimum lag length. In each case, the null hypothesis is that $\delta = 0$ against the alternative hypothesis that $\delta < 0$. If null hypothesis is rejected, it means that y_t is stationary time series with mean zero and constant variance.

However, it has been proved, using Monte Carlo simulations that the power of the ADF test is very low and fails to discriminate clearly between non-stationary and stationary series for the series with higher degree of autocorrelation (Newey and West, 1987). To overcome this problem, Phillips-Perron (1988) applied semi-parametric method to control higher order serial correlation in error terms without adding lagged difference terms. The Phillips-Perron (PP) unit root test provides robust estimates when the series have serial correlation and time-dependent heteroskedasticity. The Phillips-Perron (PP) unit root test is the AR (1) process and expressed as:

$$\Delta y_t = \beta + \delta y_{t-1} + \mu_t \qquad (3)$$

The variables and parameters are described as in the DF and ADF tests.

This study will employ both ADF and PP unit root tests for the analysis of the stationarity of the data series. If the two time series variables are found to be integrated of the same order, the cointegration test procedure as suggested by Johansen (1988, 1995) and Johansen and Juselius (1990) for establishing the possibility of the long-run relationship between the variables will be used. Johansen method applies maximum likelihood procedure to determine the presence of cointegrating vectors in non-stationary time series as a vector autogressive (VAR):

$$\Delta Y_t = C + \sum_{i=1}^{k} \Gamma_i \Delta Y_{t-1} + \Pi Y_{t-1} + \varepsilon_t \qquad (4)$$

where Y_t is a vector of non-stationary variables, *k is* optimum lag length and C is the constant term.

The Johansen cointegration test is based on examination of coefficient matrix Π, which contains an error correction term that has information about a long-run relationship. If the matrix has a reduced rank $r < k$, then there exists *k* x *r* matrices of α and *ß* each with rank *r* such that $\Pi = \alpha\beta'$ where *α* is the matrix of error correction parameters that measures the speed of adjustments in ΔY_t and β' is column of cointegrating vectors and r is cointegrating rank. If the rank of matrix Π equals zero, the matrix is a null matrix and the equation remains a traditional first difference VAR.

Johansen (1988, 1995) and Johansen and Juselius (1990) provide two likelihood ratio statistics to test for the number of cointegrating vectors: *trace (λ-trace) statistic* and *maximum eigenvalue (L-max) statistic* ratios. *Trace statistic* tests the null hypothesis of at most r cointegrating vectors against the alternative and *maximum eigenvalue (L-max) statistic* tests a null hypothesis of exactly r cointegrating vectors against the alternative r+1 vectors.

If the two series are found to be co-integrated, then error correction model is appropriate to investigate causality relationship. The error correction model (ECM) involving two co-integrated time series is set as:

$$\Delta SP_t = \phi_0 + \sum_{j=1}^{p} \phi_{1j}\Delta SP_{t-j} + \sum_{j=1}^{p} \phi_{2j}\Delta ER_{t-j} + \phi_5 Z_{t-1} + \varepsilon_{1t} \qquad (5)$$

$$\Delta ER_t = \lambda_0 + \sum_{j=1}^{q} \lambda_{1j}\Delta ER_{t-j} + \sum_{j=1}^{q} \lambda_{2j}\Delta SP_{t-j} + \lambda_5 Z_{t-1} + \varepsilon_{2t} \qquad (6)$$

where Z_{t-1} is the error correction term obtained from the cointegrating equation. The error correction coefficients ϕ_5 and λ_5 are expected to capture the adjustment of ΔSP_t and ΔER_t towards the long-run equilibrium whereas coefficients of ΔSP_{t-i} and ΔER_{t-i} are expected to capture the short-run dynamics of the model.

In the absence of any cointegration relationship between the two time series variables, the standard Granger causality test based on Granger (1988) method is applied. The Granger method is estimated as:

$$\Delta SP_t = \phi_0 + \sum_{j=1}^{p} \phi_{1j}\Delta SP_{t-j} + \sum_{j=1}^{p} \phi_{2j}\Delta ER_{t-j} + \varepsilon_{1t} \qquad (7)$$

$$\Delta ER_t = \lambda_0 + \sum_{j=1}^{q} \lambda_{1j}\Delta ER_{t-j} + \sum_{j=1}^{q} \lambda_{2j}\Delta SP_{t-j} + \varepsilon_{2t} \qquad (8)$$

in which SP_t and ER_t represent stock prices and exchange rates. ε_{1t} and ε_{2t} are uncorrelated stationary random process, and t denotes the time period. Failing to reject: $H_{0:}\ \phi_{21} = \phi_{22} = \ldots = \phi_{2p} = 0$ implies that exchange rates do not Granger cause stock prices. On the other hand, failing to reject: $H_{0:}\ \lambda_{21} = \lambda_{22} = \ldots = \lambda_{2q} = 0$ implies that stock prices do not Granger cause exchange rates.

4. Empirical Results

4.1 Stationarity Tests Results

The stationarity test was performed first in levels and then in first difference to establish the presence of unit roots and the order of integration in all variables. We used ADF and PP test with intercept and intercept plus trend as suggested by Engle and Granger (1987). The results of the ADF and PP stationarity tests for each variable are presented in Table 1. The results show that both tests fail to reject the presence of unit root for the data series in levels, indicating that the variables are non-stationary. The first difference results reveal that the variables are stationary at 1% significance level. Thus, the examined time series variables are integrated of order one, I(1).

4.2 Co-integration Results

We performed Johansen cointegration test after determining stationarity of the data series. *Trace statistic* test and *Maximum eigenvalue statistic* test results of the cointegration fail to reject the null hypothesis of no cointegration at 5% significance level (see Table 2). The results indicating that there is no long-term relationship between the stock prices and the exchange rate suggesting that none of the variables is predictable on the basis of the past values of the other variable.

4.3 Granger Causality Results

In the absence of cointegrating relationship between the variables, we employed standard Granger causality test to establish the direction of causality between stock prices and exchange rate. Oxley and Greasley (1998) show that Granger causality tests are misspecified if they are applied to non-stationary and non-cointegrated data series without transforming the data into stationary series. Miller and Russek (1990) further show that Granger causality tests are well specified if they are applied in standard vector autoregressive form to first difference data and the inferences of F-statistics are not spurious as the test will have standard distributions. We, therefore, differenced all data series since they were non-stationary in levels, and we performed the standard Granger causality tests. The Granger causality results reported in Table 3 shows that stock prices and exchange rate have no causal relationship in the short-term. These results provide evidence that in Malawi, the relationship of the two variables support neither traditional nor portfolio balance approach during the period of analysis. Thus, the past values of the stock prices cannot be used to improve the forecast of the future exchange rate or vise versa. This supports the results obtained by Frank and Young (1972), Nieh and Lee (2001) but is in sharp contrast to results obtained from most developed countries and equally few from some developing countries, notably Mbutor (2010) and Sifunjo and Mwasaru (2012). However, these results can be attributed to MSE small capitalization with its limited number and types of securities traded on this market.

On the macroeconomic effects, the results show that interest rate changes and South African (JSE) stock prices fluctuations do not equally influence stock market prices and the foreign exchange rate in Malawi. These results do suggest the weak link or non-existence of any link between the MSE and other major stock markets in Africa, like JSE. In addition, it suggest that there is poor response of capital in-flow or out-flow due change in interest rates and changes in price indexes of other major stock markets in Africa as stipulated by the portfolio balance approach.

Since Granger causality is sensitive to the number of lags; the study performed Granger causality for optimal lag length determined by Akaike Information Criterion (AIC). The Granger causality results from this test show that stock prices and exchange rate do not cause each other in the short-term. The results indicates that the sharp fluctuation in the stock prices arising from fluctuations in foreign exchange rates might not be expected to cause panic among portfolio investors and managers immediately. On the macroeconomic shocks, the results indicate that interest rate changes and South African (JSE) stock prices fluctuations do not influence stock prices or foreign exchange at 1% or 5% level (see Table 4). Again, emphasizing the lack of any significant linkages between the MSE and other major stock markets in Africa.

5. Conclusion

This study examines the short and long-term dynamic linkages between stock prices and exchange rates taking into consideration the internal and external macroeconomic structural shocks (interest rate changes and South African stock prices) on the Malawi stock market and foreign exchange market. Johansen cointegration approach was employed to establish the existence of long-run relationship after the series were found to be non-stationary.

The cointegration results show that there is no cointegration relationship indicating that the variables have no long-term relationship. In the absence of cointegration, standard Granger causality approach was carried out with one optimal lag length selected by Schwarz Information Criterion (SIC) and Akaike Information Criterion (AIC).The Granger causality results suggest that stock prices do not Granger cause exchange rate; conversely exchange rate do not Granger cause stock prices. Further, our results indicate that internal and external macroeconomic shocks do not have immediate effect on the stock market and foreign exchange market.

The common belief among investors that stock prices and exchange rate relationship are predictable on the basis of the past values of the other variable is not supported by results from this study during the period under analysis. The lack of short-run and long-run relationship has countered this belief. Therefore, investment decisions in both the stock market securities or the foreign exchange market should depend on past information provided generated from their respective markets and not the other market.. It is also important that as the Malawi Government attempts to further develop these two sectors of the economy, it should not use the information from one sector to make policies for the other sector as the cross-asset spillovers, specifically from foreign exchange market to the stock market were not robust enough in this study. The lack of international stock market influence from the JSE on Malawi stock market and foreign exchange market indicates that these two markets are not deeply integrated with world financial markets and thus domestic policy decisions should not be heavily influenced by activities of world financial markets.

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Table 1: Unit Root tests

Variable	Augmented Dickey-Fuller (ADF)				Phillips-Perron (PP)			
	Levels		First Difference		Levels		First Difference	
	Intercept	Intercept and trend	Intercept	Intercept and trend	Intercept	Intercept and trend	Intercept	Intercept and trend
MSE	-0.2685	-1.3525	-12.2235*	-12.1861*	-0.2804	-1.3857	-12.1977*	-12.1629*
ER	-1.8237	-2.1357	-6.0182*	-6.1332*	-1.8464	-1.6728	-6.0230*	-6.1238*
IR	-2.8181	-3.1999	-12.0629*	-12.1178*	-2.7400		-12.1323*	-12.2323*
JSE	-1.6810	-0.6690	-9.4930*	-9.5971*	-1.6918	-3.1113	-9.4931*	-9.6131*
						-0.9667		

Notes: * and ** denote stationary at 1% and 5% levels.

Table 2: Cointegration Test Results

Null hypothesis	Trace statistic				Maximum Eigenvalue statistic			
	Alternative hypothesis	Statistic	0.05 Critical Value	Probability Value	Alternative hypothesis	Statistic	0.05 Critical Value	Probability Value
r = 0	r ≤ 1	51.8941	63.8761	0.3336	r = 1	25.7982	32.1183	0.2423
r ≥ 1	r ≤ 2	26.0961	42.9153	0.7322	r = 2	12.6960	25.8232	0.8262
r ≥ 2	r ≤ 3	13.4000	25.8721	0.7065	r = 3	8.8939	19.3870	0.7353
r ≥ 3	r ≤ 4	4.5062	12.5180	0.6682	r = 4	4.5062	12.5180	0.6682

Notes: ** denotes rejection of the null hypothesis at the 0.05 critical values.

P-values are based on MacKinnon-Haug-Michelis (1999)

Table 3: Granger causality results

Null Hypothesis	Observations	F-Statistic	Probability
DMSE does not Granger Cause DER	131	0.4395	0.5086
DER does not Granger Cause DMSE		1.0558	0.3061
DMSE does not Granger Cause DIR	131	0.0873	0.3472
DIR does not Granger Cause DMSE		0.0198	0.2498
DER does not Granger Cause DIR	131	0.0521	0.8198
DIR does not Granger Cause DER		0.1250	0.7242
DMSE does not Granger Cause DJSE	131	0.8904	0.3472
DJSE does not Granger Cause DMSE		1.3367	–0.2498
DER does not Granger Cause DJSE	131	0.4183	0.5189
DJSE does not Granger Cause DER		0.0328	0.8566

Notes: * and ** indicate significance at 1% and 5% levels.
Appropriate lag length was determined by Schwarz Information Criterion (SIC).

Table 4: Granger causality results

Null Hypothesis	Observations	F-Statistic	Probability
DMSE does not Granger Cause DER	130	1.8141	0.1672
DER does not Granger Cause DMSE		0.3450	0.7089
DMSE does not Granger Cause DIR	130	0.0532	0.9482
DIR does not Granger Cause DMSE		0.1101	0.8958
DER does not Granger Cause DIR	130	1.2520	0.2895
DIR does not Granger Cause DER		0.4516	0.6376
DMSE does not Granger Cause DJSE	130	0.4794	0.6203
DJSE does not Granger Cause DMSE		0.6173	0.5410
DER does not Granger Cause DJSE	130	0.2461	0.7822
DJSE does not Granger Cause DER		0.0290	0.9714

Notes: * and ** indicate significance at 1% and 5% levels.
Appropriate lag length was determined by Akaike Information Criterion (AIC).