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Temporal Causality between the Malaysian Stock Price and Stock-indexed Futures Market amid the Selective Capital Controls Regime

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The article examines the temporal causal relationships between Malaysian stock prices measured by the composite index (MSCI) and stock-indexed futures prices (KLFI), with the aid of cointegration and error correction modelling. The empirical regressions from standard Granger causality and Hsiao's sequential approach (HSM) suggest a bi-directional (feedback) causality for the short-run period; while the error correction method (ECM) provides the evidence that the stock index futures (KLFI) leads the market stock (composite) index (MSCI). The selective capital controls policy does have a positive influence on the stock-indexed futures market.

I. Introduction

A voluminous number of causal studies on the stock market between spot and futures prices have been investigated. A cursory survey indicates that the major trend of empirical results for the causality relationship between the spot and futures markets tends to fall into three different categories, namely, (1) unidirectional causality, (2) bi-directional (or feedback) causality, and (3) no causal relationship between the variables.

An early study by Lim (1992) found no evidence of cross correlation that futures prices led spot prices, or spot prices led futures prices in the Nikkei stock index futures market. On the other hand, Wahab and Lashgari (1993) who used the error correction model (ECM) on daily data for the S&P 500 found bi-directional causality between spot and futures markets. Similarly, using the ECM framework and daily data from the Hang Seng index, Raj (1995) found bi-directional causality between futures and spot prices. Turkington and Walsh (1999) rejected the usual result of futures leading spot, with clear bi-directional causality for the Australian futures market.

Among those who found that the futures market led the spot market were Stoll and Whaley (1990), Kutner and Sweeney (1991), Tang, Mak, and Choi (1992), Kawaller, Koch, and Koch (1993), Ghosh (1993), Puttonen (1993), and Tse (1995). De Jong and Nijman (1995) provided a comprehensive study of lead-lag relationships with high frequency data. The relationship was not completely unidirectional. Similarly, Pizzi, Economopoulos, and O'Neill (1998) studied the relationship between the S&P 500 stock index cash and futures markets. Using the Engle-Granger 2-step procedure, the 3- and 6-month futures markets led the spot market. Nieto, Fernandez, and Jesus (1998) analysed Granger causality between daily prices of Spanish stock index (IBEX 35) and its futures contract using the Johansen cointegration methodology. The empirical results proved that, in the short run, the futures caused the spot price. However, the opposite was not true. Frino and West (1999) also concluded that the futures market led the equities market, but the effect decreased over time.

This study purports to add empirically to the existing pool of empirical literature on causality between the stock (cash) price and stock index futures markets. It contributes to the empirical debate or Granger's causal hypothesis for the Malaysian stock and futures markets, both in the short and long-run periods. The distinct feature of this study is the use of a policy control variable (namely, the selective capital controls as being implemented effectively on 1 September 1998 by the Malaysian Government) in estimating the causality regressions. The dummy variable as introduced for policy changes would minimize any specification bias; which may result in spurious causality tests. It also allows for the measurement of structural break for the period studied, that is the period before and after the implementation of selective capital controls regime in Malaysia. In short, the paper analyses Granger causality between the stock market (composite) index and stock futures index of the Malaysian stock exchange and futures markets respectively, amid the implementation of the selective capital controls policy by the Malaysian Government. The standard Granger causality test using the F-statistics will be estimated for the basis of comparison with Hsiao's (1981) sequential approach and the error correction model (ECM).

The study is organized as follows. Section I provides a brief introduction. Section II presents some characteristics of the Malaysian stock and futures markets. The research methodology is discussed in Section III. In this section, the first step is to test for stationarity of the time series; whether the stock market exhibits a random walk process. Cointegration test is performed to indicate support for the economic variables as a long-run condition, and finally, vector error correction models are used to test the cointegrated relationship for dynamic adjustment of stock prices in the short-run and long-run equilibrium. Data sources and variables are also provided. Section IV details the empirical results for three subperiod financial time series. The summary and conclusion are discussed in Section V.

II. The Malaysian Stock and Futures Markets: Some Characteristics

Theoretical Underpinning

Theoretically, if the stock-indexed futures market behaves competitively, then it should exhibit a random walk process. With market perfection, information as reflected in the stock price movements will be disseminated and transmitted simultaneously in the stock and derivatives markets. This conduct can be construed as a perfectly competitive financial market model. However, with market imperfection, this link may not be consistent resulting in a lead-lag relationship. Such a lead-lag relation would imply that one market might process new information faster than the other market(s).

Recent Trend

Given its inception in December 1995, trading in stock-indexed futures is relatively new in Malaysia. The Kuala Lumpur Options and Financial Futures Exchange (KLOFFE) operates the stock index futures market on a fully automated trading system known as KATS; while the stock market is under the purview of the Kuala Lumpur Stock Exchange (KLSE). The KLSE market and the Malaysian derivatives markets (KLOFFE) have a relatively small market capitalization and turnovers (contracts) compared with other more developed financial markets such as the Chicago Mercantile Exchange (CME), New York Futures Exchange (NYFE), London International Financial Futures and Options Exchange (LIFFE), Osaka Securities Exchange, Singapore International Monetary Exchange (SIMEX), or for that matter, Hong Kong Futures Exchange (HKFE).

The Malaysian economy succumbed to a financial crisis, which occurred in early 1998, and resulted in the sharp dip of the Malaysian stock prices. However, most stock prices at the KLSE recovered steadily in early 1999, albeit very slowly. This scenario was also reflected in the derivatives market. Meanwhile, the Malaysian Government imposed selective capital controls and exchange rate pegging (U.S. dollars to ringgit) polices effectively on 1 September 1998 to stabilize the economy.

Descriptive Statistics

Table 1 reports the summary statistics for the daily closing prices of the spot (Malaysian stock composite index, abbreviated as MSCI) and futures (Kuala Lumpur futures index, abbreviated as KLFI) markets for the period from 2 January 1996 to 29 September 2000: a total of 1,174 observations. The financial time series for the undifferenced prices for both spot and futures markets show negatively skewed and leptokurtotic characteristics. In the first difference series, the spot price exhibits a positively skewed distribution; while the futures index is negatively skewed. Both data series also exhibit leptokurtic characteristics, with relatively large tails typical of financial time series. The Jarque-Bera test strongly rejects the normality assumption of all the series. The Q statistics at lags 12, 24, and 36 for the undifferenced series are found to be statistically

TABLE 1
Summary of Descriptive Statistics (2 January 1996 to 29 September 2000)

Statistics	*Undifferenced series*		*First differenced series*	
	MSCI	*KLFI*	*ΔMSCI*	*ΔKLFI*
Mean	837.65	839.07	−0.2384	−0.2413
Maximum	1271.57	1272.50	131.80	131.40
Minimum	262.70	274.90	−95.50	−169.10
Std. Dev.	257.56	256.50	14.46	17.62
Skewness	−0.1007	−0.0976	0.7107	−0.0991
Kurtosis	1.8931	1.8929	14.0246	16.2328
Jarque-Bera	1.9234*	61.8241*	6039.10*	8560.26*
Q(12)	13806*	13753*	17.240	16.237
Q(24)	26987*	26824*	32.787	33.163
Q(36)	39358*	39067*	48.937***	42.862

NOTES:
* denotes significance at the 1 per cent level.
*** denotes significance at the 10 per cent level.
$Q(q)$ denotes Ljung-Box statistic test at lag q; distributed as $\chi^2(q)$.
SOURCE: Author's estimation.

significant at the 1 per cent level. Thus, market efficiency is not evidenced as indicated by the significant linear dependency.

III. Empirical Methodology and Data

Unit Root Tests

Most time series data including stock prices exhibit random walks. As highlighted by Phillips (1986), regression analysis with nonstationary data would result in spurious and erroneous empirical results. The order of integration of the variables must be ascertained so as to provide valid inferences. To test for stationarity, the conventional unit-root test methods such as Augmented Dickey-Fuller (1981) (ADF) and Phillips-Peron (1988) (PP) are employed.

The ADF regression equation is given in the form:

$$\Delta x_t = \gamma_0 + (\gamma_1 - 1)x_{t-1} + \sum_{i=1}^{m} \beta_i \Delta x_{t-i} + \varepsilon_t \qquad (1)$$

where Δ is the first differenced operator, $\Delta x_t = x_t - x_{t-1}$; γ_0, γ_1, and β_i are the coefficients to be estimated, and ε_t is the error term. The null hypothesis is that the variable, x_t has unit root if $\gamma_1 = 1$. The null hypothesis will not be rejected if the significantly negative ADF statistic is less (in absolute value) than the MacKinnon (1991) critical value. The alternative hypothesis will be that the economic variable is integrated of order *I(0).*

The regression equation for the PP test is given as:

$$\Delta x_t = \delta_0 + (\delta_1 - 1)x_{t-1} + \varepsilon_t \qquad (2)$$

where δ_0 , and δ_1 are coefficients to be estimated. The null hypothesis of $\delta_1 = 1$ will not be rejected if the significantly negative PP value is less (in absolute value) than the MacKinnon (1991) critical value. This suggests a nonstationarity behaviour of the variable. The alternative hypothesis postulates that the data series are integrated of order *I(0).*

Cointegration Tests

If economic variables are integrated of the same order (more than one), the presence of cointegration warrants further attention. For instance, if the economic variables used are of integrated, say *I(1)*, then there exists a possible long-run relationship between the two variables. Therefore, the two variables are said to be cointegrated in an econometric sense. In this model, the Johansen procedure (1988) is used to test for cointegration. The advantage of this procedure is that it assumes all variables are endogenous. Thus, a long-run equilibrium of these variables implies that some short-run disequilibrium adjustment does exist, as pointed out by Granger (1986).

Vector Error Correction Models

Granger (1986), Phillips (1986), Engle and Granger (1987), and Johansen (1988), among others, have proposed the use of an econometric procedure, the error correction model (ECM) in the presence of unit root and cointegration. The ECM is a restricted vector autoregression (VAR) that builds in integration. Consider a two-variable system with two cointegration equations and given as:

$$x_{1,t} = \varphi_0 + \varphi_1 x_{2,t} + v_{1,t} \qquad (3)$$

$$x_{2,t} = \gamma_0 + \gamma_1 x_{1,t} + v_{2,t} \qquad (4)$$

where $x_{1,t}$ and $x_{2,t}$ are endogenous variables; φ_0, φ_1, γ_0 and γ_1 are parameters to be estimated; and $v_{1,t}$ and $v_{2,t}$ are residuals of the cointegration regressions. The ECM (with deterministic drift) equations can now be expressed as:

$$\Delta x_{1,t} = \lambda_0 + \sum_{i=1}^{m} \lambda_i \Delta x_{1,t-1} + \sum_{j=1}^{n} \theta_j \Delta x_{2,t-1} + \phi_1(v_{1,t-1}) + \xi_{1,t} \qquad (5)$$

$$\Delta x_{2,t} = \lambda_1 + \sum_{i=1}^{r} \lambda_i \Delta x_{2,t-1} + \sum_{j=1}^{s} \theta_j \Delta x_{1,t-1} + \phi_2 (\nu_{2,t-1}) + \xi_{2,t} \quad (6)$$

where $\xi_{1,t}$ and $\xi_{2,t}$ are error terms with zero mean and covariance matrix Ω. The error correction coefficients of ϕ_1 and ϕ_2 are expected to capture the long-run information in the system; while the short-run adjustments are captured by the coefficients of $\Delta x_{1,t-1}$ and $\Delta x_{2,t-1}$ in the models. It should be noted that the ECM provides an additional channel for the causal relationship between the financial variables.

The regressions for unit root, cointegration, and ECM for testing Granger causality are highly sensitive to the number of lags used in the estimations (Stock and Watson 1989). To overcome this constraint, Akaike's final prediction error (FPE) will be used to determine the optimal lags in the system. In estimating the models, Hsiao's (1981) sequential approach will be adopted due to its simplicity and robustness.

Data Sources and Variables

Daily closing stock price indices for the period from 2 January 1996 to 29 September 2000 for the MSCI were collected from the KLSE. The KLFI for the same period were retrieved from the website of the KLOFFE. The KLSE Composite Index is a capitalization-weighted index, with a component of 100 companies, most heavily traded blue-chip stocks — the so-called index-linked Malaysian stocks. This index acts as a benchmark for other Malaysian equities market, including the Malaysian stock index futures market. The observations of the stock-indexed futures (KLFI) are based on the daily closing (settlement) prices (spot month) by the end of the day. The stock index futures market opens 15 minutes earlier than the cash market; while it closes 15 minutes later.

The regressions for analysing Granger causality between the conventional stock and index futures markets will be divided into three subperiods designated as: (1) subperiod I (2 January 1996 to 28 August 1998), namely, the period before the implementation of the selective capital controls policy; (2) subperiod II (1 September 1998 to 29 September 2000), namely, the period after the implementation of the selective capital controls policy; and (3) subperiod III (2 January 1996 to 29 September 2000) encompassing financial time series data before and after the policy implementation. Note that these subperiods are based on the historical event that Malaysia succumbed to a financial crisis in 1998. The crisis resulted in the imposition of the selective capital controls policy and an exchange rate pegging (U.S. dollar/Malaysian ringgit) on 1 September 1998 (till now) by the Malaysian Government with the purpose of stabilizing the economy, at least in the short run.

For analytical purposes, the variable of the KLSE composite index is abbreviated as *MSCI*; while the variable for the futures index is given as *KLFI*.

IV. Empirical Results

The statistical results for the unit root test are reported in Table 2. These ADF and PP tests comprise: (1) no intercept or trend; (2) with intercept; and (3) with intercept and trend. The estimated statistics of the levels of the variables are less than the critical values at the 1 per cent level of significance. Thus, the null hypothesis of nonstationarity of the variables cannot be rejected.

However, nonstationarity can be rejected at the 1 per cent level of significance when the first-differenced time series data are used. The variables are integrated of order one, *I(1)*. Henceforth, the cointegration analysis will utilize the undifferenced data; while the first-differenced data will be used for estimating the ECM.

Table 3 shows the cointegration results based on Johansen (1988, 1991*a*, 1991*b*) for the data covering the period from 2 January 1996 to 29 September 2000. As analysed, the two series are

TABLE 2
Test for Unit Roots
(For the Period from 2 January 1996 to 29 September 2000)

	ADF Test Statistic[a]			*PP Test statistic*[b]		
	τ_0	τ_γ	τ_t	Z_0	Z_δ	Z_t
			Undifferenced Level			
MSCI	−0.9563	−1.1043	−1.1082	−0.8169	−1.0583	−1.1853
KLFI	−0.9442	−1.1557	−1.1676	−0.8108	−1.1335	−1.2686
			First-differenced Level (Δ)			
MSCI	−15.2059*	−15.2152*	−15.2122*	−31.4261*	−31.4208*	−31.4079*
KLFI	−16.1770*	−16.1849*	−16.1814*	−36.5161*	−36.5111*	−36.4967*

NOTES:
τ_0 and Z_0 denote without drift and trend; τ_γ and Z_δ denote with drift; τ_t and Z_t denote with drift and trend.
[a] The optimal lag length of 4 for conducting ADF statistic was selected based on Akaike's final prediction error (FPE).
[b] The truncated lag length used for the PP statistic was 6.
* denotes significance at the 1 per cent level. The critical values for rejection of the null hypothesis of unit root were based on Mackinnon (1991).
SOURCE: Author's estimations.

TABLE 3
Johansen Cointegration Test Based on Maximal Eigenvalue and Trace Statistics
(Restricted Intercept and No Trend)
(For the Period from 2 January 1996 to 29 September 2000)

	Eigenvalue test			*Trace test*		
Eigenvalue	*Null*	*Alternative*	*Statistics*	*Null*	*Alternative*	*Statistics*
Lag 4						
0.0617	$r = 0$	$r = 1$	74.5017*	$r = 0$	$r \geqslant 1$	76.3552*
0.0158	$r \leqslant 1$	$r = 2$	1.8535	$r \leqslant 1$	r = 2	1.8535
Lag 8						
0.0419	$r = 0$	$r = 1$	49.8572*	$r = 0$	$r \geqslant 1$	51.6641*
0.0155	$r \leqslant 1$	$r = 2$	1.8069	$r \leqslant 1$	$r = 2$	1.8069

NOTES:
* denotes rejection of null hypothesis at the 5 per cent significance level.
r denotes the number of cointegrating vectors.
SOURCE: Author's estimation.

cointegrated (as indicated by the maximum eigenvalue and trace statistic). These statistics reject the null hypothesis of no cointegration ($r = 0$) at the 95 per cent critical values. Only one cointegration equation must exist or equivalently the cointegration of the rank of cointegrating matrix must be one. This has been the statistical result as shown in Table 3. A linear combination of the stock market price (composite) index (MSCI) and futures price index (KLFI) can be chosen such that the result exhibits stationarity, yet is cointegrated. This condition rules out spurious correlation and non-Granger causality. The residuals of the regression equations of (3) and (4) are then tested for their stationarity; which evidently is *I(0)* or stationary. Empirical evidence from the cointegration test results with different lags suggests that both variables are stationary of the same order and exhibit a relatively stable equilibrium relationship between these two variables.

The analytical results of Granger causality for the three subperiods are described in this section. The empirical evidence depicts the regression results of standard (conventional) Granger F-statistics (using four lags of the variables), Hsiao's (1981) sequential approach (HSM), including the error correction variable for testing the short- and long-run causality when the two variables are found to be cointegrated. The two variables of MSCI and KLFI are stationary after the first differencing. The short- and long-run Granger causality tests (by using the HSM and ECM estimations) are evaluated by the standard t-statistics, R^2 and CRDW. As mentioned earlier, the addition of the lagged error terms, $\phi_1(v_{1,t-1})$ and $\phi_2(v_{2,t-1})$ in the ECM estimation provides an additional avenue for the Granger causality test.

Table 4 shows the Granger causality test results for subperiod I (with 657 observations). Notably, the two prices move fairly closely together. The F-statistic tests are statistically and significantly different from zero in both regressions. The F-statistic for causality running from KLFI to MSCI is statistically significant at the 1 per cent level; while the F-statistic for causality running from MSCI to KLFI is only statistically significant at the 10 per cent level. Thus, one could easily lend support to the weakly bi-directional (or feedback) causality between MSCI and KLFI in the short run. Alternatively, the analysis also uses the Hsiao's (1981) sequential approach (HSM), which is based on Granger's concept of causality and minimizing the Akaike's final prediction error (FPE) criterion. The empirical result suggests a unidirectional causality, running from KLFI to MSCI.

As for long-run causality, the lagged error term, $\phi_1(v_{1,t-1})$, in the ECM estimation is only statistically significant at the 10 per cent level; while the estimated coefficient for the lagged error term, $\phi_2(v_{2,t-1})$, is not significant. The results suggest weak evidence of unidirectional causality (negatively) running from KLFI to MSCI.

Table 5 depicts the statistical findings of Granger causality for subperiod II (with 517 observations). This period coincided with the imposition of the selective capital controls and exchange rate pegging (U.S. dollar/ringgit) by the Malaysian Government on 1 September 1998. The empirical evidence shows a similar pattern in the causality effects as in subperiod I. The standard short-run Granger's F-test depicts a bi-directional causality relationship between MSCI and KLFI for this period. However, this is only significant at the 10 per cent level. The statistical results, using Hsiao's (1981) and Akaike's FPE estimating criteria for short-run causality also support the evidence of bi-directional causality between MSCI and KLFI.

Meanwhile, the long-run causality test as measured by the error terms of the ECM estimations shows no causal relationship between MSCI and KLFI. As shown in Table 5, both the lagged error terms of $\phi_2(v_{2,t-1})$ and $\phi_1(v_{1,t-1})$ estimated from the ECM regressions are insignificant, respectively. One may argue that in a financial crisis with high volatility and uncertainty in the financial market (as occurred in 1998 in Malaysia), the stock index futures market would not improve "price discovery", as no new information would be provided. Secondly, a diversion of primarily based market-wide (systematic) information to company-specific (unsystematic) information during the financial turmoil would have further aggravated this phenomenon. Thirdly, the financial crisis as

TABLE 4
Temporal Granger Causality Test Results for MSCI and KLFI
(Subperiod I covering 2 January 1996 to 28 August 1998)

Direction of Causality	$KLFI(x_{2,t}) \Rightarrow MSCI(x_{1,t})$	$MSCI(x_{1,t}) \Rightarrow KLFI(x_{2,t})$
(i) Standard Granger		
F-statistics	10.5933*(4)	2.1632***(4)
(ii) HSM[a]		
FPE(p, 0)	FPE(1, 0) = 8.208828	FPE(1, 0) = 8.540399
FPE(p, q)	FPE(1, 3) = 8.173998	FPE(1, 2) = 8.542511
	{FPE(1, 0) > FPE(1, 3)}	{FPE(1, 0) < FPE(1, 2)}
(iii) ECM[b]	(m = 1, n = 3)	(r = 1, s = 2)
ϕ_i (i = 1, 2)	−0.0993***	−0.0836
t	−1.6663	−1.2094
R^2	0.0860	0.0037
CRDW	1.9975	1.9945

NOTES:
Figures in parentheses denote optimal lags based on Akaike's FPE criterion.
* indicates significance at the 1 per cent level.
*** indicates significance at the 10 per cent level.
[a] Hsiao's (1981) sequential approach (HSM) which is based on Granger's concept and Akaike's final prediction error (FPE) approach. If FPE$x_{1,t}$(p, 0) > FPE$x_{1,t}$(p, q), then $x_{2,t}$ is said to Granger-cause $x_{1,t}$. If FPE$x_{1,t}$(p, 0) < FPE$x_{1,t}$(p, q), $x_{1,t}$ would not be Granger-caused by $x_{2,t}$.
[b] ECM includes a short-run equation estimated by OLS, all the variables in the long-run equation, lagged and without restriction. The optimal lags for the ECM estimation were determined by the Akaike's FPE criterion.
Regression models for HSM and ECM estimations are given as follows:
$KLFI(x_{2,t}) \Rightarrow MSCI(x_{1,t})$

$$\Delta x_{1,t} = \lambda_0 + \sum_{i=1}^{m} \lambda_i \Delta x_{1,t-1} + \sum_{j=1}^{n} \theta_j \Delta x_{2,t-1} + \phi_1(v_{1,t-1}) + \xi_{1,t}$$

$MSCI(x_{1,t}) \Rightarrow KLFI(x_{2,t})$

$$\Delta x_{2,t} = \lambda_1 + \sum_{i=1}^{r} \lambda_i \Delta x_{2,t-1} + \sum_{j=1}^{s} \theta_j \Delta x_{1,t-1} + \phi_2(v_{2,t-1}) + \xi_{2,t}$$

SOURCE: Author's estimation.

experienced in 1998 disrupted the pricing efficiency, amid the financial volatility of prices and a flux of disparate views on the Malaysian spot and futures financial markets, thus exacerbating the distortion of the price-discovery process. Fourthly, in the wake of the Dow's fall in October 1997, the Malaysian Government precipitated "circuit-breakers" and other trading restrictions on the exchanges as stock prices plummeted drastically. All these measures led to the disruption of the price discovery process between the cash and futures markets during this period.

Table 6 depicts the empirical results for subperiod III (with 1,147 observations). This subperiod combines all the time series data (inclusive of subperiods I and II), encompassing all

TABLE 5
Temporal Granger Causality Test Results for MSCI and KLFI
(Subperiod II covering 1 September 1998 to 29 September 2000)

Direction of Causality	$KLFI(x_{2,t}) \Rightarrow MSCI(x_{1,t})$	$MSCI(x_{1,t}) \Rightarrow KLFI(x_{2,t})$
(i) Standard Granger		
F-statistics	2.0806***(4)	2.2088***(4)
(ii) HSM[a]		
FPE(p, 0)	FPE(5, 0) = 8.056021	FPE(5, 0) = 8.578594
FPE(p, q)	FPE(5, 2) = 8.052000	FPE(5, 3) = 8.577266
	{FPE(5, 0) > FPE(5, 2)}	{FPE(5, 0) > FPE(5, 3)}
(iii) ECM[b]	(m = 5, n = 2)	(r = 2, s = 5)
ϕ_i (i = 1, 2)	−0.1078	−0.1444
t	−1.6173	−1.4875
R^2	0.0518	0.0747
CRDW	1.9895	1.9931

NOTES:
Figures in parentheses denote optimal lags based on Akaike's FPE criterion.
*** indicates significance at the 10 per cent level.
[a] Hsiao's (1981) sequential approach (HSM) which is based on Granger's concept and Akaike's final prediction error (FPE) approach. If FPE$x_{1,t}$(p, 0) > FPE$x_{1,t}$(p, q), then $x_{2,t}$ is said to Granger-cause $x_{1,t}$. If FPE$x_{1,t}$(p, 0) < FPE$x_{1,t}$(p, q), $x_{1,t}$ would not be Granger-caused by $x_{2,t}$.
[b] ECM includes a short-run equation estimated by OLS, all the variables in the long-run equation, lagged and without restriction. The optimal lags for the ECM estimation were determined by the Akaike's FPE criterion.
Regression models for HSM and ECM estimations are given as follows:
$KLFI(x_{2,t}) \Rightarrow MSCI(x_{1,t})$

$$\Delta x_{1,t} = \lambda_0 + \sum_{i=1}^{m} \lambda_i \Delta x_{1,t-1} + \sum_{j=1}^{n} \theta_j \Delta x_{2,t-1} + \phi_1(v_{1,t-1}) + \xi_{1,t}$$

$MSCI(x_{1,t}) \Rightarrow KLFI(x_{2,t})$

$$\Delta x_{2,t} = \lambda_1 + \sum_{i=1}^{r} \lambda_i \Delta x_{2,t-1} + \sum_{j=1}^{s} \theta_j \Delta x_{1,t-1} + \phi_2(v_{2,t-1}) + \xi_{2,t}$$

SOURCE: Author's estimation.

the financial time series before and after the selective capital controls and currency pegging regime. It is modelled in a parsimonious manner with a dummy variable for the policy variable. Here, a one-period lag dummy variable, (DUM_{t-1}), representing the selective capital controls policy is included in the regressions so as to minimize the error from "omission bias" due to structural break. The dummy variable uses the value of zero for observations before the imposition of selective capital controls, and a value of one after its implementation on 1 September 1998.

In both standard Granger F-statistics and HSM estimations, the statistical results provide strong evidence of short-run bi-directional causality (or feedback) between the two time series data. The F-statistics for KLFI and MSCI were statistically significant at the 1 per cent level. Thus, it strongly

TABLE 6
Temporal Granger Causality Test Results for MSCI and KLFI
(Subperiod III covering 2 January 1996 to 29 September 2000)

Direction of Causality	$KLFI(x_{2,t}) \Rightarrow MSCI(x_{1,t})$	$MSCI(x_{1,t}) \Rightarrow KLFI(x_{2,t})$
(i) Standard Granger		
F-statistics	8.1015*(4)	2.9630*(4)
(ii) HSM[a]		
FPE(p, 0)	FPE(4, 0) = 8.153714	FPE(4, 0) = 8.566932
FPE(p, q)	FPE(4, 3) = 8.142459	FPE(4, 4) = 8.565214
	{FPE(4, 0) > FPE(4, 3)}	{FPE(4, 0) > FPE(4, 4)}
(iii) ECM[b]	(m = 4, n = 3)	(r = 4, s = 4)
ϕ_i (i = 1, 2)	−0.1298*	−0.0727
t	(−2.7672)	(−1.2302)
β_i (i = 1, 2)	0.7289	2.9573**
t	(0.7610)	(2.5148)
R^2	0.0499	0.0269
CRDW	1.9936	1.9937

NOTES:
Figures in parentheses denote optimal lags based on Akaike's FPE criterion.
* indicates significance at the 1 per cent level.
** indicates significance at the 5 per cent level.
[a] Hsiao's (1981) sequential approach (HSM) which is based on Granger's concept and Akaike's final prediction error (FPE) approach. If FPE$x_{1,t}$(p, 0) > FPE$x_{1,t}$(p, q), then $x_{2,t}$ is said to Granger-cause $x_{1,t}$. If FPE$x_{1,t}$(p, 0) < FPE$x_{1,t}$(p, q), $x_{1,t}$ would not be Granger-caused by $x_{2,t}$.
[b] ECM includes a short-run equation estimated by OLS, all the variables in the long-run equation, lagged and without restriction. The optimal lags for the ECM estimation were determined by the Akaike's FPE criterion.
Regression models for HSM and ECM estimations are given as follows:
$KLFI(x_{2,t}) \Rightarrow MSCI(x_{1,t})$

$$\Delta x_{1,t} = \lambda_0 + \sum_{i=1}^{m} \lambda_i \Delta x_{1,t-1} + \sum_{j=1}^{n} \theta_j \Delta x_{2,t-1} + \phi_1(v_{1,t-1}) + \beta_1 DUM_{t-1} + \xi_{1,t}$$

$MSCI(x_{1,t}) \Rightarrow KLFI(x_{2,t})$

$$\Delta x_{2,t} = \lambda_1 + \sum_{i=1}^{r} \lambda_i \Delta x_{2,t-1} + \sum_{j=1}^{s} \theta_j \Delta x_{1,t-1} + \phi_2(v_{2,t-1}) + \beta_2 DUM_{t-1} + \xi_{2,t}$$

SOURCE: Author's estimation.

supports a bi-directional (feedback) causality relationship between KLFI and MSCI in the short run.

On the other hand, the regression results from the error correction method (ECM) show a unidirectional causality in that, the stock index futures prices led the market stock prices in the long run (that is, KLFI led MSCI). This premise was based on the statistical significance of the lagged error term of $\phi_1(v_{1,t-1})$ at the 1 per cent level. Meanwhile, the lagged error term of $\phi_2(v_{2,t-1})$ was unsubstantiated from zero.

Therefore, the empirical results provide strong evidence of a bi-directional causality (or feedback) between KLFI and MSCI in the short run, but a unidirectional causality running from KLFI to MSCI in the long-run period. The empirical evidence seems more plausible as it conforms to the theoretical concepts of the role of the stock index futures market in price discovery.

Meanwhile, the lagged one-period dummy variable for the selective capital controls policy variable, (β_1) in the case for MSCI (as the dependent variable) is not significant, indicating that the regime had no significant effect (on the stock prices as measured by the composite index) on the Malaysian stock exchange market. In the other case, this dummy variable has a positive influence on the derivatives market, as indicated by the estimated coefficient (β_2) which is significant at the 5 per cent level. As a result, the derivatives market may be construed to be sensitive to the implementation of the selective capital controls regime. This seems plausible even theoretically as any changes in government policy would obviously be absorbed much faster into the derivatives market; given its role in price discovery. Hence, information translated through the derivatives market and then channelled to the stock (cash) market may have been "discounted". This link results in the lead-lag relationship between the cash and derivatives markets.

V. Summary and Conclusion

The study utilized the time series data from the KLSE composite index (MSCI) and the stock-indexed futures index (KLFI) for the period from 2 January 1996 to 29 September 2000. The empirical analysis indicates that both MSCI and KLFI series are integrated of order one, *I(1)* and cointegrated. This implies that the error correction models (ECM) and Hsiao's (1981) sequential approach (HSM) are consistent and robust for the Granger-causality study. For analytical purposes, the study period was divided into three subperiods, using the introduction of the policy of selective capital controls and exchange rate pegging as the cut-off period. Subperiod I covered the time series data before the policy implementation; subperiod II after the policy implementation and finally, subperiod III was all-inclusive.

The statistical results for Granger-causality remain consistent in the short run for the three subperiods. The empirical evidence suggests a bi-directional (feedback) causality for the KLSE composite index (MSCI) and stock futures index (KLFI), representing a short-run phenomenon. Using the Hsiao's (1981) sequential method (HSM) for all the models, the statistical results also further support this evidence.

For the long-run relationship, the empirical finding that KLFI led MSCI was evidenced from the statistical results of causality from subperiod I and subperiod III. This evidence fits the theoretical role of the derivatives market in price discovery as the futures market led the stock (spot) market.

On the contrary, for subperiod II (the period under the selective capital controls regime) the estimated ECM shows no relationship between MSCI and KLFI on a long-term basis as the lagged error terms in the ECM estimations are not substantiated. One may attribute this finding to the fact that the stock-indexed futures market did not improve price discovery during this subperiod. This phenomenon could be attributed to a diversion of primarily based market-wide (systematic risk) to company-specific (unsystematic risk) information during the financial crisis under study. The turbulent financial market with its erratic price volatility and disparate views of the financial crisis in Malaysia resulted in pricing inefficiency and illiquidity. Trading restrictions imposed by the authorities concerned, and which aimed to halt plummeting prices and smooth violent movements including heaving selling pressures also led to the disruption of the price discovery process. Moreover, the spillover from the regional contagion effect of the financial crisis at its height in October 1997 and the Dow's fall in the same period created much uncertainty in the domestic cash and futures markets. This precipitated a misalignment to asset prices, subdued investors' confidence due to market uncertainty and distorted the price discovery process of the financial markets.

For subperiod III (encompassing both subperiod I and subperiod II), both the standard Granger causality F-tests and Hsiao's (1981) sequential method using FPE criterion indicate a bi-directional relationship between the stock index futures (KLFI) and market stock composite index (MSCI). As usual, one might interpret this relationship as a short-run phenomenon. On the other hand, the use of cointegration and Hsiao's (1981) sequential approach with the error-correction model reveal a unidirectional relationship between these two variables; namely KLFI led MSCI. Similarly, this empirical evidence may be construed as the long-run effect. The latter seems more rational as the futures markets are characterized by the flexibility of trading including easy short-selling, low transaction costs, high leverage and liquidity as well as longer trading hours. Given any new information, it may well be reflected in the futures prices much earlier than spot (cash) prices. This fits the important role of the stock index futures market on "price discovery", which is in tandem with the financial theory of a lead-lag relationship between the spot and futures markets. Meanwhile, the statistical analysis supports the view that the selective capital controls policy had a positive impact on the Malaysian stock-indexed futures market; while there is no statistical evidence of its effect on the stock market. Therefore, this study supports the implementation of the selective capital controls as a policy instrument to stabilize the Malaysian financial market, at least for the short run.

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