INFORMATION SPILLOVERS IN THE SPOT AND ETF INDICES IN TAIWAN

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ABSTRACT

This paper empirically explores the impact of the spot index on the exchange trade fund (ETF) indices in Taiwan, with the vector autoregressive (VAR) model revealing positive relationships between the six time-series variables. Our results indicate that the ETF 52 index has the greatest volatility as well as the most negative returns, whilst also suggesting the existence of at least five cointegrating vectors among the variables; thus, through the concept of cointegration, we demonstrate that vectors will not arbitrarily wander far from each other in long-run relationships. We also examine Granger (1980) causality in the relationships between the variables and find that the guiding relationship exists within the spot index, with stronger indications of the spot index leading the ETF indices. Among the six time-series variables, depending on the decomposition of the forecast residual variance, the spot index is the least affected by external forces. Furthermore, the spot index is affected mainly by its own shocks, and less so by those of the other time-series variables. Although the spot index variance decomposition can identify all but its own excess shocks, none of the indices can consistently trace out the effects of one-unit impulses.

JEL: G11, G13, G14

INTRODUCTION

There are many theories on financial trading throughout the world, with evidence having already been presented of linkages across financial markets, particularly with regard to the capital markets of the more developed economies. The disappearance of international investment barriers which has occurred over recent decades, combined with globalization (and its effects on further liberalization), have led to continuing progress in international financing, which has in turn accelerated the correlations between economic activity and international financing.

The significant expansion in derivative securities facilitates the more effective administration by investors of their individual stock market positions. In the context of capital markets, extensive efforts have been undertaken to develop new index products within the equity markets, whilst within the stock exchange indices, the primary role of ETF derivatives involves the measurement of the trend in the securities dependent upon financial records. The Dow Jones Industrial Average (DJIA) is the most significantly quoted and traded stock index, with the index information provided by the index being widely reported in the global media; therefore, following the emergence of ETFs and subsequent trading in them, the DJIA may well be the easiest stock index to track. The first ETF, the Standard & Poor's Depositary Receipts (SPDR) 500 fund, began trading in January 1993; however, up until the present day, the Nasdaq 100 Trust (QQQ) fund has remained the most active of all the global markets, in terms of overall trading volume.

In April 2002, the Taiwan Stock Exchange Corporation (TSEC) introduced the first Taiwanese ETF, the Taiwan Top 50 Tracker Fund, which is calculated using the trading prices of the largest 50 listed companies by market value. According to Morgan Stanley research on the global ETF market, the assets of ETF have grown from $0.13 billion USD in December 2003 to $1.89 billion USD in December 2006, and the Taiwan market is the 7th largest ETF market in terms of total assets at the end of December 2006.

This study uses the vector autoregression approach to reexamine the existing evidence on the spot and ETF indices. Our study differs from many of the prior studies in that it analyses the causal impact of the spot index on the ETF indices in Taiwan by taking into consideration the dynamic data relationship. The presence of these indices in Taiwan represents the product of a joint venture between the Taiwan Stock

Exchange Corporation (TSEC) and the FTSE Group; the FTSE indices are widely used for trading in an extremely diverse range of index-linked funds and structured products across 58 different countries.

We also undertake further investigation into the role of the lead/lag relationship between the spot index and the five different stock indices currently making up the Taiwan Stock Exchange (TSE). The rationale for this investigation is the need to gain a better understanding of the characteristics of various trading strategies and to explain the spillover effects arising from the disclosure of information. The TSEC/FTSE partnership collectively guides both local market sophistication and international indexing capabilities which provide investors with the tools to achieve purposeful direction within the Taiwanese market.

For reasons of simplicity, it is typical for time-series data to be examined with the following three objectives in mind: (i) an attempt to determine which of the index contracts maintains the lead/lag position; (ii) an examination of whether related/assured feedback trading exists amongst ETF traders; and (iii) an investigation into the entire effects arising from the disclosure of information between the index returns in Taiwan and the ultimate effects on the trading behavior of ETF investors.

The remainder of this paper is organized as follows. The literature review is discussed in section 2. The next section describes the data and the methodology adopted for this study. Section 4 presents and explains the empirical results, followed in Section 5 by presentation of the conclusions drawn from this study.

LITERATURE REVIEW

Based upon significant research undertaken into the long-run co-movements of stock prices in the international stock markets, Taylor and Tonks (1989) provide strong evidence of cointegration, demonstrating the presence of cointegrational relationships between stock prices in the markets of the Netherlands, Germany, the UK and Japan; although not the US. Furthermore, from their observations of nine major stock markets (Australia, Germany, Hong Kong, Japan, Singapore, South Korea, Taiwan, the UK and the US), Kwan et al. (1995) also present evidence to show that these markets are not 'weak form efficient', given that significant lead/lag relationships are discernible between them. It has, however, been inferred by both Chan et al. (1992) and Hung and Cheung (1995) that cointegration is not discernible for these Asian markets, with specific reference to their equity markets.

It is suggested, in particular by Ghosh et al. (1999), that some Asian stock markets have a long-run equilibrium relationship, whilst others do not. Furthermore, until quite recently, Wong et al. (2004) pursued quite strong arguments on the issue of co-movements between stock markets in the major developed economies (i.e., those of the US, the UK and Japan) along with the concept of cointegration in the emerging markets of Asia (Malaysia, Thailand, South Korea, Taiwan, Singapore and Hong Kong). Wong et al. (2004) point to the existence of a co-movement relationship between Singapore, Taiwan and Japan and between the UK, the US and Hong Kong; however, they could find no long-run cointegrational relationships between the emerging markets of South Korea, Malaysia and Thailand and the developed markets of the Japan, the UK and the US.

Other research over recent decades points to the existence of certain correlations with the financial markets (for example, Edwards, 1988; Harris, 1989; and Antoniou and Holmes, 1995). In more specific terms, Tse (1999) undertakes an examination of the price discovery process and the transference of volatility between the spot index and DJIA futures markets through the evaluation of an exponential GARCH model in the Chicago Board of Trade (CBOT); Tse subsequently went on to present evidence of the existence of bi-directional feedback, noting that price discovery occurs first of all in the futures market.

The dynamic relationship which exists between the spot and futures markets of the Dow Jones Industrial Average (DJIA) is demonstrated by Gokce and Petrie (2002) using a vector autoregressive (VAR) model. Their results provide evidence of two-way causality; nevertheless, the impact on futures return volatility from a single unit increase in spot returns is found to be inferior to the impact on the spot return volatility from a single unit increase in futures returns. They also note, however, that increased movement in spot trading leads to a reduction in overall volatility levels in both spot and futures returns. Intraday price formation in the US equity index markets is examined by Hasbrouck (2003) using a vector error correction model (VECM) to demonstrate that small denomination futures contracts (i.e., electronically traded mini futures) provide price discovery across the S&P500 and Nasdaq-100 indices. Furthermore, such findings indicate that price discovery is shared between the ETF and regular futures contracts in the S&P400 Mid Cap index.

The analysis of Tse, Bandyopadhyay and Shen (2006) reveals discernible intraday price discovery, both in the DJIA index markets and in its three derivatives, DIAMOND exchange-traded funds (ETFs), regular floor-traded futures and electronically-traded mini (E-mini) futures. Tse et al. (2006) adopt the vector error correction model (VECM) to identify the actual data-generation process, with their results indicating that E-mini futures provide the greatest contribution to price discovery, followed by DIAMOND ETFs, with the DJIA index itself and the regular floor-traded futures providing only a minimum contribution to price discovery. Thus, there is an apparent correlation between market integration and asset pricing.

DATA PROCESSING AND METHODOLOGY

We explore the stock and ETF indices of the TSE; the base period is the inauguration of the stock index in 1966, with the subsequent formation of the TSEC indices following the order of: (i) the launch of the TSEC Taiwan 50 (ETF 50) index on 30 April 2002; (ii) the launch of the TSEC Taiwan Mid-Cap 100 (ETF 51) index and the TSEC Taiwan Technology (ETF 52) index on 30 June 2003; and (iii) the launch of the TSEC Taiwan Dividend-plus (ETF 56) index and the Taiwan 8 industries (ETF 58) index on 31 July 2006. The intraday sample period runs from 15 January 2007 to 15 July 2008 with the five-minute data subsequently being rerun from the local databank of the Taiwan Economic Journal (TEJ). A total of 19,710 five-minute observations are examined in this study in an attempt to explore the information spillover effects between the various indices.

Vector autoregression (VAR) methodology is adopted in this study, using high-frequency time-series data to identify the level of information spillovers between the stock index and the ETF indices. The return for interval *t* on day *i* is:

$$R_{i,t} = \ln(I_{i,t} / I_{i,t-1}) \tag{1}$$

where *R* is the last index return/change for the stock index, the Taiwan 50 index, the Taiwan Mid-Cap 100 index, the Taiwan Technology index, the Taiwan Dividend-plus index and the Taiwan 8 industries index.

Prior to running the tests for cointegration and causality, we should point out that all of the variables concerned are stationary; thus, considering the stationary nature of the individual variables, the first determinate test will be the unit root test. Dickey and Fuller (1979) describe the situation under the following three equations:

$$\Delta Y_t = a_0 + \beta Y_{t-1} + a_2 t + \varepsilon_t \tag{2}$$

$$\Delta Y_t = a_0 + \beta Y_{t-1} + \varepsilon_t \tag{3}$$

$$\Delta Y_t = \beta Y_{t-1} + \varepsilon_t \tag{4}$$

The discrepancy between the three linear regressions affects the existence of the deterministic elements α_0 and $\alpha_0 t$. The first regression includes both a drift (α_0) and a linear time trend ($\alpha_2 t$), the second reduces the deterministic element and the third is a pure random walk model. The coefficient of interest is β. If $\beta = 0$, then the equation has a unit root; that is, the variables are non-stationary, which means that they will differ under diverse situations.

The lag length of the test equations is determined by the Schwartz Bayesian Criterion (SBC), where the error term is a 'white-noise' process. According to the information criterion, the SBC model is superior to models with large sample characteristics; this criterion is therefore adopted in this study. The cointegration of the variables is then examined to determine whether those variables which are individually non-stationary will subsequently become stationary when associated with the linear regression models.

One of the fundamental properties of the cointegrated variables is that their time paths are affected by the magnitude of any deviations from long-run equilibrium. If the equilibrium is meaningful, then there must be an indication that the equilibrium error item is stationary; this could refer to any long-run relationship between the stationary and non-stationary variables.

Following the Johnansen (1988) approach, the results of the maximum likelihood estimation indicate the total number of cointegrated vectors, with the numbers of the test characteristic roots of the estimated variables being given by the trace and maximum eigenvalues statistics. Our main area of interest in this study is in the hypothesis of no cointegration between the variables ($\gamma = 0$) vis-à-vis the alternative hypothesis of one or more cointegrated vectors ($\gamma > 0$). Thus we have Equations (5) and (6):

$$\lambda_{trace}(\gamma) = -T\sum_{i=r+1}^{n}\ln(1-\hat{\lambda}_i) \quad (5)$$

$$\lambda_{\max}(\gamma, \gamma+1) = -T\ln(1-\hat{\lambda}_{r+1}) \quad (6)$$

where $\hat{\lambda}_i$ are the estimated eigenvalues and T refers to the total number of available observations.

Causality, as shown by Granger (1980), refers only to the effects of the past value of the dependent variable on the current value of the independent variables. In other words, Granger causality actually measures whether the current and past values of the dependent variables are of any assistance in forecasting the future values of the independent variables. We consider the following equation models:

$$x_t = a_0 + a_1x_{t-1} + ... + a_nx_{t-1} + \beta_1y_{t-1} + \beta_2y_{t-2} + .. + \beta_ny_{t-n} + \varepsilon_t \quad (7)$$

$$y_t = a_0 + a_1y_{t-1} + ... + a_ny_{t-1} + \beta_1x_{t-1} + \beta_2x_{t-2} + .. + \beta_nx_{t-n} + \mu_t\,. \quad (8)$$

The null hypothesis is that y does not Granger cause x in Equation (7), and that x does not Granger cause y in Equation (8). Finally, when there is no convincing evidence from the time-series data that a variable is actually exogenous, each variable can be considered symmetrically under 'natural expansion of transfer function' analysis; in other words, it is of no consequence that one of the variables is dependent whilst the others are independent. Sims (1980) notes that the primary aim of VAR analysis is to determine the interrelationship between the variables, and not to ascertain the parameter estimation. Furthermore, the multivariate generalization of an autoregressive process is:

$$Y_t = \beta_0 + \beta_1Y_{t-1} + \beta_2Y_{t-2} + ... + \beta_pY_{t-p} + e_t\,, \quad (9)$$

where $Y_t = an(n,1)$ is the vector containing each of the n variables; $\beta_0 = an(n,1)$ is the vector of the intercept terms; $\beta_i = (n,n)$ are the matrices of the coefficients; and $e_t = an(n,1)$ is the vector of the error terms.

EMPIRICAL RESULTS

The descriptive statistics of the spot and ETF indices, dependent upon the time-series variable measures, are presented in Table 1, with all of the descriptions provided within the table referring to the variable specifications. Each of the time-series variables has platykurtic distribution with positive skewness, with the one exception of the ETF 58 index. Although the standard deviation of the variables is quite substantial for the ETF 51 index, there is a much smaller standard deviation for the ETF 50 index. Furthermore, as evidenced by the Jarque-Bera normality test, none of the six time-series variables have normal distribution.

Table 1: Descriptive Statistics of the Six Time-series Variables for the Spot and ETF Indices

	Spot Index	ETF 50	ETF 51	ETF 52	ETF 56	ETF 58
Mean	8464.054	6071.397	8541.978	7963.262	6713.645	6924.518
Median	8433.180	6057.520	8416.175	7851.200	6759.510	7019.175
Maximum	9851.590	7086.700	10496.44	9572.920	7991.070	8296.630
Minimum	6834.240	4878.260	6553.900	6126.640	5480.550	5733.600
Std. Dev.	630.1139	410.6779	754.9518	708.6602	519.1793	607.2309
Skewness	0.148807	0.148580	0.133094	0.136220	0.115905	−0.048095
Kurtosis	2.237010	2.557973	2.704490	2.488966	2.376991	2.075479
Jarque-Bera	550.8352	232.9823	129.9074	275.4302	362.8908	709.5528
P-value	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**
No. of Obs.	19,710	19,710	19,710	19,710	19,710	19,710

*This table presents details of the appropriate values between the spot and ETF indices. ** indicates significance at the 1% level.*

The correlation matrix of the spot and ETF indices is presented in Table 2, which shows that the relationship is better between the spot and ETF 50 indices, which are also positively correlated in the time-series variables.

Table 2: Correlation Matrix for the Spot and ETF Indices

	Spot index	ETF 50	ETF 51	ETF 52	ETF 56	ETF 58
Spot index	1.000000	–	–	–	–	–
ETF 50	0.986173	1.000000	–	–	–	–
ETF 51	0.945368	0.915268	1.000000	–	–	–
ETF 52	0.856066	0.871955	0.926732	1.000000	–	–
ETF 56	0.952658	0.936302	0.861829	0.757126	1.000000	–
ETF 58	0.861954	0.849881	0.682949	0.528341	0.934201	1.000000

This table presents the correlation matrix describing the relationships between the spot and ETF indices.

Table 3 presents the results of the descriptive statistics for the variation in the changes/returns. It is clear from this table that each of the average returns has a negative position; in other words, the financial market does not represent a good situation. Furthermore, when comparing volatility and returns, it is also clear that the ETF 52 index still has the greatest volatility and negative financial returns. Both the ETF 52 and ETF 56 indices have positive skewness, whereas this is negative in all of the other variables.

Table 3: Descriptive Statistics of Changes/Returns for the Six Time-series Variables in the Spot and ETF Indices

	Spot index	**ETF 50**	**ETF 51**	**ETF 52**	**ETF 56**	**ETF 58**
Mean	−0.000294	−0.000356	−0.000471	−0.000535	−0.000162	−4.82E-05
Median	−0.000203	−0.000298	−0.000000	−0.000310	−0.000115	0.000133
Maximum	2.357228	2.255341	2.287601	2.746763	2.064519	1.874421
Minimum	−2.316735	−2.496755	−2.599057	−2.278043	−2.031064	−2.316454
Std. Dev.	0.085418	0.101347	0.103556	0.116695	0.095906	0.091554
Skewness	−1.836502	−0.648120	−1.764487	0.089452	0.332635	−1.020657
Kurtosis	134.2787	101.5608	112.5587	96.34095	97.61094	100.7007
Jarque-Bera	14163863	7978787	9867283	7154831	7351188	7842211
P-value	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**	0.0000**

This table provides details of the appropriate values of the changes/returns of the spot index and ETF indices.
*** indicates significance at the 1% level.*

Leptokurtic distribution is demonstrated by each of the six time-series variables, whilst the Jarque-Bera tests for normality clearly indicate that the variables do not have normal distribution. Furthermore, as shown in Table 4, although positive correlations are revealed between each of the six time-series variables, the correlations between the spot index and each of the ETF indices are much more significant. Thus, market investors could simultaneously respond to a general shock which would cause them to shift their position in a positive direction, thereby rejecting normality at the 1 per cent level for all of the variables.

Table 4: Correlation Matrix of Changes/Returns for the Six Time-series Variables in the Spot and ETF Indices

	Spot index	**ETF 50**	**ETF 51**	**ETF 52**	**ETF 56**	**ETF 58**
Spot	1.000000	–	–	–	–	–
ETF 50	0.868688	1.000000	–	–	–	–
ETF 51	0.832858	0.751863	1.000000	–	–	–
ETF 52	0.799025	0.865714	0.782757	1.000000	–	–
ETF 56	0.769487	0.842331	0.717623	0.744093	1.000000	–
ETF 58	0.861861	0.851793	0.784121	0.736118	0.843863	1.000000

This table presents the correlation matrix of the relationships between the changes/returns of the spot and ETF indices.

The results of the unit root test are presented in Table 5, with Table 6 also presenting the results obtained under appropriate distancing. As Table 5 shows, we cannot reject the null hypothesis in this study of source variables.

Table 5: Unit Root Test Results for the Six Time-series Variables

	Spot index	**ETF 50**	**ETF 51**	**ETF 52**	**ETF 56**	**ETF 58**
ADF statistic	−0.498480	−0.571837	−0.660943	−0.750448	−0.324169	−0.188062
PP statistic	−0.492496	−0.566558	−0.647167	−0.740357	−0.327602	−0.197665
Lag length	2	2	3	2	2	2

This table presents the results of the unit root test on the six time-series variables. The null hypothesis is (H_0): $\beta = 0$; the alternative hypothesis is (H_1): $\beta < 1$.

By appropriate differencing (Table 6), the data-generating process is also found to be non-stationary, whilst further demonstrating strategy adoption. Clearly, it is a simple matter to explain that the six time-series variables are all stationary and that they reject the null hypothesis; such a procedure is integrated in the order of 1, and is described by I(1).

Table 6: Unit Root Test Results for the Six Time-series Variables, by Appropriate Differencing

	Spot index	ETF 50	ETF 51	ETF 52	ETF 56	ETF 58
ADF statistic	–102.8860**	–108.6910**	–86.71183**	–89.18715**	–108.6621**	–106.330**6
PP statistic	–132.4686**	–152.4152**	–141.8740**	–157.9868**	–157.1629**	–149.7439**
Lag length	1	1	2	2	1	1

*The null hypothesis is (H_0): $\beta = 0$; the alternative hypothesis is (H_1): $\beta < 1$. ** indicates significance at the 1% level, ADF critical value: –2.5652.*

The Johansen (1988) cointegration test can be adopted to observe the effects; that is, to determine whether or not a cointegration relationship exists. Table 7 reports the results of the cointegration test for the change/return series variables. We take note of the trace and maximum eigenvalue statistics from the two types of test statistics presented in Table 7, and note that we can also acquire at least five cointegrating numbers.

Table 7: Cointegration Rank Test

Hypothesized No. of CE(s)	Eigenvalues	Trace Statistic	5% Critical Value	1% Critical Value
None**	0.203040	16256.31	82.49	90.45
At most 1**	0.143658	11785.38	59.46	66.52
At most 2**	0.130666	8730.203	39.89	45.58
At most 3**	0.100509	5971.655	24.31	29.75
At most 4**	0.097657	3884.901	12.53	16.31
At most 5**	0.090120	1860.527	3.84	6.51

*This table reports the results of the Johansen test for cointegration within the series. ** indicates rejection of the hypothesis at the 1% level.*

The process involved in concluding that long-run equilibrium relationships exist between any set of integrated variables is a relatively simple one, with the behavior of investments indicating that they cannot arbitrarily wander far from each other in long-run relationships. Thereafter, the greater the number of cointegration vectors, the more steady the system will be (Dickey et al, 1994). In contrast to these results, any lack of cointegration implies that no long-run equilibrium relationships exist between any of the time-series variables.

Table 8 explores the results of the test for Granger (1980) causality, which clearly indicates that there is one-way Granger causality running from the ETF 50 and spot indices to the ETF 56 index, from the ETF 51 index to the ETF 58 index and from the ETF 52 index to the ETF 56 index. All of the others variables indicate bi-directional information spillovers.

According to the strength of the *F*-statistic, the spot index is the first lead operator among the time series, with the greatest effects of the spot index being felt by the ETF 56 index. The next sequence is that for the ETF 50 index, whilst the third sequence is that for the ETF 58 index; thus, the ETF 51 index is only slightly affected by the spot index. These results clearly indicate that these indices are prone to changes induced by causal relationships; thus, market trading strategies will be employed by investors based upon the information spillover effects.

Strictly speaking, there is a requirement to specify an appropriate lag length when using the vector autoregression (VAR) model. Therefore, in the present study, we adopt a maximum equal lag length of 8. If the residual series is still found to be autoregressive, then a more appropriate lag length will need to be added. The 'illustrative purpose decomposition' of the residual variance provides an indication of the proportion of the movement in a sequence attributable to its 'own' shocks, vis-à-vis the movement attributable to the shocks of the other variables.

Table 8: Granger Causality Tests

Null Hypothesis	F-Statistic	Probability
ETF 50 does not Granger cause the spot index	3.72712	0.00023**
The spot index does not Granger cause ETF 50	138.868	0.00000**
ETF 51 does not Granger cause the spot index	4.58431	0.00001**
The spot index does not Granger cause ETF 51	43.2700	0.00000**
ETF 52 does not Granger cause the spot index	2.77543	0.00457**
The spot index does not Granger cause ETF 52	96.1180	0.00000**
ETF 56 does not Granger cause the spot index	2.35835	0.01562
The spot index does not Granger cause ETF 56	180.063	0.00000**
ETF 58 does not Granger cause the spot index	6.52969	0.00000**
The spot index does not Granger cause ETF 58	116.278	0.00000**
ETF 51 does not Granger cause ETF 50	29.4228	0.00000**
ETF 50 does not Granger cause ETF 51	8.79558	0.00000**
ETF 52 does not Granger cause ETF 50	9.66074	0.00000**
ETF 50 does not Granger cause ETF 52	19.2403	0.00000**
ETF 56 does not Granger cause ETF 50	0.77623	0.62374
ETF 50 does not Granger cause ETF 56	39.8273	0.00000**
ETF 58 does not Granger cause ETF 50	7.17318	0.00000**
ETF 50 does not Granger cause ETF 58	23.6730	0.00000**
ETF 52 does not Granger cause ETF 51	5.05651	0.00000**
ETF 51 does not Granger cause ETF 52	32.6528	0.00000**
ETF 56 does not Granger cause ETF 51	3.51634	0.00045**
ETF 51 does not Granger cause ETF 56	88.9378	0.00000**
ETF 58 does not Granger cause ETF 51	1.24703	0.26677**
ETF 51 does not Granger cause ETF 58	36.1483	0.00000**
ETF 56 does not Granger cause ETF 52	2.46549	0.01146
ETF 52 does not Granger cause ETF 56	29.2887	0.00000**
ETF 58 does not Granger cause ETF 52	10.9880	0.00000**
ETF 52 does not Granger cause ETF 58	20.1622	0.00000**
ETF 58 does not Granger cause ETF 56	43.3168	0.00000**
ETF 56 does not Granger cause ETF 58	6.14069	0.00000**

*This table presents the results of the Granger causality test. The null hypothesis is that y does not Granger cause x; the alternative hypothesis is x does not Granger cause y. ** indicates significance at the 1% level.*

For the sake of brevity, we concentrate here on the forecasting of the residual variance within the VAR system for only 1, 4, 7, 10, 13 and 16 days. The results are presented in Table 9, from which we can see that within the VAR ordering, the total one-period decomposition for the spot index is totally attributable to its own innovation, whilst that for the residual variance of the ETF 50 index is attributable both to its own innovations and those of the spot index.

Furthermore, the first period decomposition for the ETF 51 index is affected by its own innovations and those of the ETF 50 and spot indices; the first period decomposition for the ETF 52 index is affected by its own innovations and those of the ETF 50, ETF 51 and spot indices; the first period decomposition for the ETF 56 is affected by its own innovations and those of the ETF 50, ETF 51, ETF 52 and spot indices; and the first period decomposition for the ETF 58 is affected by its own innovations and those of the other variables.

Table 9: Decomposition of Forecast Residual Variance in the Six Time-series Variables

Dependent Variable	Lag Days	By the Residual Item in Spot Index	ETF 50	ETF 51	ETF 52	ETF 56	ETF 58
Spot Index	1	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
	4	99.32557	0.147699	0.119885	0.004716	0.038426	0.363708
	7	99.27295	0.170992	0.126394	0.012406	0.044470	0.372856
	10	99.19560	0.177715	0.184730	0.016668	0.047696	0.377592
	13	99.19471	0.178203	0.184899	0.016795	0.047726	0.377670
	16	99.19427	0.178252	0.185025	0.016893	0.047757	0.377800
ETF 50	1	82.34370	17.65630	0.000000	0.000000	0.000000	0.000000
	4	76.98454	22.35429	0.118952	0.151228	0.211789	0.179197
	7	76.97661	22.33979	0.128587	0.154107	0.215083	0.185826
	10	76.94581	22.33288	0.156355	0.157020	0.220370	0.187570
	13	76.93896	22.33665	0.158110	0.158080	0.220585	0.187606
	16	76.93883	22.33666	0.158188	0.158103	0.220596	0.187625
ETF 51	1	71.71787	0.017862	28.26427	0.000000	0.000000	0.000000
	4	70.07946	0.513485	28.73006	0.058171	0.049155	0.569669
	7	69.99022	0.557005	28.71454	0.085398	0.063486	0.589351
	10	69.95218	0.572881	28.70311	0.093639	0.081807	0.596381
	13	69.94717	0.579364	28.70117	0.093908	0.081976	0.596412
	16	69.94698	0.579410	28.70133	0.093959	0.081988	0.596435
ETF 52	1	69.08158	8.884989	3.278030	18.75540	0.000000	0.000000
	4	64.89456	11.02122	3.536491	19.62486	0.477103	0.445767
	7	64.88293	11.02114	3.535276	19.61718	0.487447	0.456027
	10	64.85784	11.02015	3.561933	19.61025	0.492191	0.457638
	13	64.85519	11.02249	3.562590	19.60965	0.492192	0.457888
	16	64.85514	11.02249	3.562600	19.60965	0.492205	0.457914
ETF 56	1	66.0061	6.782012	1.035319	0.228115	25.94844	0.000000
	4	60.10494	10.56350	1.049314	0.210339	27.96775	0.104160
	7	60.06439	10.57943	1.063858	0.221142	27.95676	0.114423
	10	60.00796	10.57911	1.120266	0.226844	27.93515	0.130675
	13	60.00101	10.58680	1.121521	0.227599	27.93204	0.131036
	16	60.00088	10.58680	1.121564	0.227685	27.93196	0.131116
ETF 58	1	77.59679	2.312982	0.719634	1.218849	3.258634	14.89311
	4	71.69752	3.480598	0.786766	1.247683	3.584942	17.20249
	7	73.64731	3.485843	0.805515	1.252852	3.594479	17.21400
	10	73.59952	3.488875	0.828627	1.256860	3.608032	17.21809
	13	73.59756	3.490476	0.829369	1.256943	3.607951	17.21776
	16	73.59748	3.490488	0.829385	1.256986	3.607970	17.21769

This table provides details of the respective variance decompositions for each of the endogenous variables; the variance decomposition provides information on the relative importance of each random innovation with regard to its effect on the variables.

It is clear from Table 9 that among the six time-series variables, the trading behavior within the spot index is least affected by external forces. By contrast, the trading behavior in the ETF 58 index is most heavily influenced by the other five external forces; for example, the 99 per cent volatility for the intraday index change on the 16^{th} day is self-explanatory, whereas for the ETF 58 index, the figure is only 17 per cent. Further detailed analysis reveals that the spot returns will affect the other variables, thereby shedding some light on the fact that the characteristics of the spot index in Taiwan have significant impacts on the financial market. This is consistent with Table 8, which shows that the largest *F*-statistic of the spot index has the greatest effect on all of the other variables. For simplicity, we investigate the spillovers from the changes (returns) over 16 trading days.

It is a fairly simple matter to identify the speed of the information spillovers arising from a single standard unit shock in the spot index from Table 10. Only the spot index variable elicits instantaneous changes, whilst the other five variables are at zero state in the first period. In the next period, only the ETF 56 and ETF 58 indices have negative impulse responses, with each of the other three variables being positive. In principle, it is possible to trace out the time path of the effects of each of these positive/negative shocks.

Table 10: Impulse Response to a Unit Shock for the Spot Index

Period	Spot index	ETF 50	ETF 51	ETF 52	ETF 56	ETF 58
1	0.084841	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.005134	0.002723	0.002572	0.000511	−0.000853	−0.004831
3	−0.005115	0.000710	0.001391	−0.000242	0.001392	0.001788
4	−0.001593	−0.001694	0.000449	−0.000156	−0.000375	−0.000150
5	0.000064	−0.001141	0.000504	−0.000602	−0.000661	−0.000564
6	0.001623	0.000027	0.000361	0.000334	0.000052	0.000049
7	0.000194	−0.000636	0.000315	0.000298	0.000072	0.000610
8	−0.001108	−0.000591	0.001970	0.000213	0.000455	0.000484
9	−0.000047	−0.000373	−0.000586	−0.000517	0.000180	0.000185
10	0.000130	0.000144	−0.000231	−0.000022	−0.000043	−0.000322
11	0.000080	0.000166	0.000022	−0.000431	0.000034	−0.000006
12	−0.000035	−0.000036	0.000101	−0.000041	−0.000026	0.000061
13	−0.000534	−0.000084	0.000042	−0.000076	−0.000020	−0.000048
14	0.000062	−0.000060	−0.000044	−0.000071	0.000056	−0.000084
15	0.000093	−0.000021	−0.000068	0.000035	0.000045	0.000032
16	−0.000006	0.000008	0.000052	0.000038	0.000013	0.000040

The table shows the appropriate value of the impulse response function for the spot index; the impulse response function traces the effects of a one-time shock.

The very slight effects of the information spillovers in the ETF 50 index are revealed in Table 11, from which we can see that the instantaneous impact of a one-unit change in the ETF 50 index is its influence not only on the spot index, but also on the ETF 50 index itself.

Table 11: Impulse Response to a Unit Shock for the ETF 50 Index

Period	Spot index	ETF 50	ETF 51	ETF 52	ETF 56	ETF 58
1	0.088707	0.041076	0.000000	0.000000	0.000000	0.000000
2	0.003039	−0.024676	−0.003204	0.003926	−0.004367	−0.003594
3	−0.006294	0.001021	0.001348	−0.000366	0.001503	0.001782
4	−0.000434	−0.001400	0.000391	−0.000078	−0.000676	−0.001529
5	0.000055	−0.000333	0.000169	−0.000034	−0.000457	0.000284
6	0.001774	0.000394	0.000769	0.000541	0.000366	0.000784
7	−0.001454	0.000080	0.000617	0.000121	−0.000115	−0.000031
8	0.000339	−0.000318	0.001186	−0.000291	0.000676	0.000143
9	−0.000380	0.000083	−0.000919	−0.000397	−0.000215	0.000317
10	0.000217	0.000436	0.000784	−0.000254	0.000225	−0.000259
11	0.000031	−0.000771	−0.000423	0.000324	−0.000148	0.000046
12	−0.000044	0.000002	0.000036	−0.000058	0.000009	0.000004
13	0.000018	−0.000004	−0.000044	−0.000044	0.000047	−0.000074
14	0.000066	−0.000016	−0.000057	−0.000017	0.000004	0.000017
15	−0.000006	0.000069	0.000049	0.000014	0.000038	0.000038
16	−0.000023	0.000030	0.000050	−0.000044	−0.000012	−0.000017

The table shows the appropriate value of the impulse response function for the ETF 50 index; the impulse response function traces the effects of a one-time shock.

The results of the effects of information spillovers in the ETF 51 index are presented in Table 12. It would appear that the spot and ETF 51 indices will remain the same when the ETF 51 index responds positively in the first period; thereafter, there are no consequential impulse responses in the ETF 51 index.

Table 12: Impulse Response to a Unit Shock for the ETF 51 Index

Period	Spot index	ETF 50	ETF 51	ETF 52	ETF 56	ETF 58
1	0.086189	–0.001360	0.054107	0.000000	0.000000	0.000000
2	0.006576	–0.006808	–0.012157	0.001661	–0.000920	–0.007339
3	–0.006698	–0.000491	–0.000847	0.001525	0.001940	0.002413
4	–0.001712	–0.002580	–0.002574	0.001077	0.000814	–0.001202
5	0.000281	–0.001860	0.000687	–0.001156	–0.001117	0.000403
6	0.001247	0.000270	0.001356	–0.000762	–0.000347	–0.000745
7	0.000200	–0.001107	0.000799	–0.001010	–0.000424	–0.001220
8	–0.000231	–0.000585	0.000528	0.000785	0.001369	0.000862
9	–0.000429	0.000360	0.000233	–0.000423	0.000316	0.000203
10	0.000266	0.001127	0.000492	–0.000312	0.000002	–0.000090
11	0.000091	–0.000753	–0.000074	0.000158	–0.000132	–0.000029
12	–0.000047	–0.000289	0.000078	0.000040	–0.000038	0.000062
13	–0.000047	–0.000226	–0.000088	0.000054	0.000009	–0.000060
14	–0.000044	–0.000030	–0.000076	0.000004	0.000009	0.000045
15	0.000000	–0.000060	0.000085	–0.000047	0.000035	0.000018
16	–0.000004	0.000026	0.000039	–0.000046	0.000010	–0.000018

The table shows the appropriate value of the impulse response function for the ETF 51 index; the impulse response function traces the effects of a one-time shock.

The trivial effects of the information spillovers in the ETF 52 index are reported in Table 13, which shows a positive direction for these effects in the first period, with the exceptions of the ETF 56 and ETF 58 indices, which maintain a zero state. The results indicate that the impulse response will also return to zero.

Table 13: Impulse Response to a Unit Shock for the ETF 52 Index

Period	Spot index	ETF 50	ETF 51	ETF 52	ETF 56	ETF 58
1	0.093757	0.033624	0.020423	0.048852	0.000000	0.000000
2	0.001798	–0.019161	–0.007959	–0.017018	–0.007631	–0.007722
3	–0.007511	0.000724	0.001012	–0.000705	0.002488	0.000774
4	–0.001070	–0.002228	0.000934	0.000140	–0.000809	–0.000757
5	0.000340	–0.000199	0.000154	–0.000488	–0.001197	–0.000422
6	0.001697	0.000660	0.000064	0.000204	0.000049	–0.000911
7	–0.000461	–0.000574	–0.000261	–0.000352	0.000111	–0.000652
8	0.000497	–0.000310	0.001722	0.000353	0.000817	–0.000281
9	–0.000175	–0.000021	–0.000671	–0.000222	0.000050	0.000273
10	–0.000092	0.000632	0.000653	0.000032	–0.000078	0.000304
11	–0.000065	–0.000615	–0.000324	0.000171	–0.000053	–0.000190
12	–0.000060	–0.000042	0.000068	–0.000010	0.000008	–0.000009
13	–0.000024	–0.000045	0.000025	0.000030	–0.000000	–0.000026
14	–0.000047	–0.000040	0.000021	–0.000015	–0.000030	0.000033
15	–0.000020	0.000018	0.000012	0.000012	0.000030	0.000017
16	–0.000021	0.000009	0.000021	–0.000047	0.000004	–0.000047

The table shows the appropriate value of the impulse response function for the ETF 52 index; the impulse response function traces the effects of a one-time shock.

Table 14 reports the noise effects of information spillovers in the ETF 56 index. The first period impulse responses for the ETF 56 index are positive movements in the spot, ETF 50 and ETF 51 indices, whilst the ETF 52 reveals negative movement and the ETF 58 index remains at a zero state. It should also be noted that there is no consistency in the shocks.

Table 14: Impulse Response to a Unit Shock for the ETF 56 Index

Period	Spot index	ETF 50	ETF 51	ETF 52	ETF 56	ETF 58
1	0.073998	0.023719	0.009268	−0.004350	0.046396	0.000000
2	0.006256	−0.020209	−0.002978	0.000413	−0.020518	−0.002601
3	−0.003984	0.000191	0.001316	−0.000010	0.000777	0.001675
4	−0.001421	−0.001145	0.000323	−0.000517	−0.000504	−0.000133
5	0.000275	−0.001451	0.000347	−0.000355	−0.000545	−0.000541
6	0.001035	−0.000135	0.001047	−0.000589	0.000933	0.000335
7	−0.000117	−0.000452	0.000458	0.000734	−0.000313	0.000741
8	−0.000213	−0.000543	0.002298	−0.000186	0.000692	0.000917
9	−0.000415	−0.000037	−0.000129	−0.000647	0.000128	0.000371
10	0.000248	0.000801	0.000033	−0.000304	0.000253	−0.000728
11	0.000084	−0.000903	−0.000354	0.000251	−0.000117	0.000153
12	−0.000056	−0.000063	0.000057	0.000001	−0.000048	0.000091
13	−0.000029	−0.000062	0.000002	−0.000096	0.000005	−0.000055
14	0.000073	−0.000042	−0.000041	−0.000088	0.000014	−0.000076
15	0.000097	0.000048	−0.000026	−0.000011	0.000070	0.000024
16	−0.000019	0.000028	0.000047	0.000012	0.000011	0.000034

The table shows the appropriate value of the impulse response function for the ETF 56 index; the impulse response function traces the effects of a one-time shock.

Table 15 reveals the insignificant information spillover effects of the ETF 58 index, with the impulse responses in the first period all being positive, with the one exception of the negative response for the ETF 52 index.

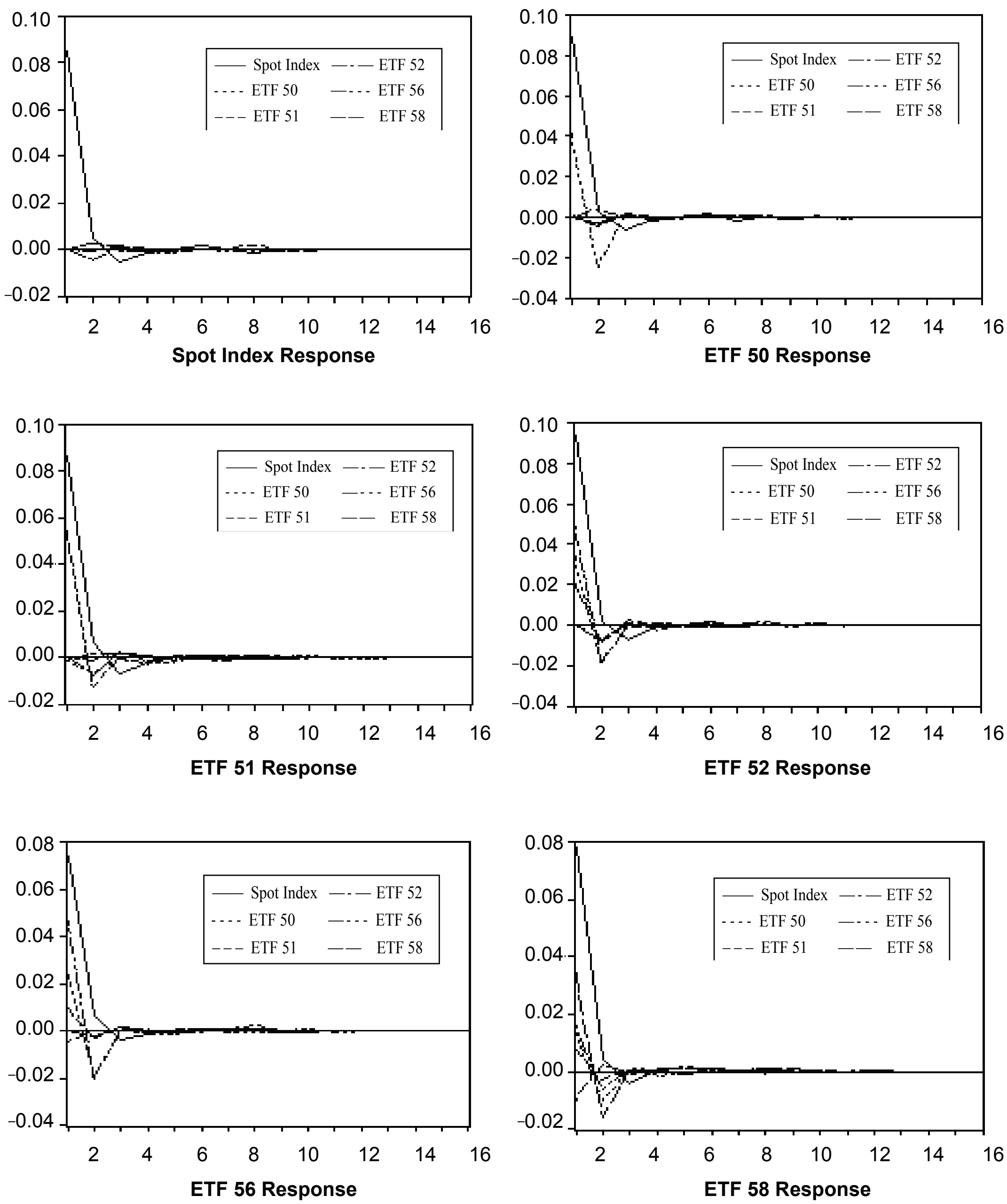
Table 15: Impulse Response to a Unit Shock for the ETF 58 Index

Period	Spot index	ETF 50	ETF 51	ETF 52	ETF 56	ETF 58
1	0.078390	0.013534	0.007549	−0.009825	0.016064	0.034342
2	0.004320	−0.010316	−0.002914	0.002644	−0.006400	−0.016237
3	−0.004476	0.000357	0.000517	−0.001019	0.001330	0.000577
4	0.000123	−0.001529	0.000519	−0.000369	0.000098	0.000120
5	−0.000739	−0.008270	0.000958	−0.000547	−0.000991	0.001514
6	0.000963	−0.000145	0.000767	−0.000384	0.000314	−0.000151
7	0.000402	−0.000107	−0.000361	−0.000294	−0.000077	−0.000131
8	0.000688	−0.000636	0.001232	−0.000643	0.001165	0.000845
9	−0.000041	0.000062	−0.000423	−0.000021	−0.000049	0.000726
10	−0.000184	0.000247	0.000543	0.000010	0.000002	−0.000399
11	0.000016	−0.000369	−0.000253	−0.000062	−0.000024	−0.000048
12	0.000091	−0.000075	−0.000017	−0.000077	0.000026	0.000065
13	−0.000018	−0.000024	0.000010	0.000005	0.000022	0.000038
14	0.000012	−0.000031	0.000026	−0.000027	−0.000015	0.000015
15	0.000022	0.000020	−0.000047	−0.000037	0.000039	0.000030
16	0.000021	−0.000006	0.000260	−0.000040	0.000016	−0.000006

The table shows the appropriate value of the impulse response function for the ETF 58 index; the impulse response function traces the effects of a one-time shock.

In summary, we can find no consistent directions in the impulse responses; and indeed, we find that they may asymptotically converge to their long-run levels. In other words, investors will apply different trading strategies in the subsequent period. The impulse responses for the six time-series variables, based upon a one-unit innovation shock within 16 days, are illustrated in Figure 1, where we graphically demonstrate that these impulse responses do not exist at, or converge quickly to, a zero state. This is consistent with the values presented in the tables.

Figure 1: Index Responses to Cholesky One S.D. Innovations



The figure illustrates the spillovers in changes/returns within sixteen days; an impulse response traces the effects of a one-unit standard innovation.

CONCLUSIONS

This study presents evidence of cointegration between the spot index and the ETF indices, with the results showing that there are at least five cointegrating vectors among the variables. Our results suggest the existence of long-run relationships between a set of integrated variables, and therefore, that investments will not arbitrarily wander far from each other in situations of long-run equilibrium.

On the other hand, the findings of the application of the Granger causality test examining the causality linkages between the variables indicate that among all of the exchange trade fund indices, the spot index leads first. Our results further suggest that Granger causality runs one-way from the spot index to the ETF 56 index, from the ETF 50 index to the ETF 56 index, from the ETF 51 index to the ETF 58 index and from the ETF 52 index to the ETF 56 index, with all of the other variables revealing bi-directional information spillover effects; as such, market trading strategies are apparent as a result of information spillovers, and this will affect the other variables.

Depending on the stationary nature of the variables in a VAR system, this will provide two policy indications for investors. Firstly, the forecast residual variance decomposition explains the proportion of the change in a sequence attributable to its own shocks vis-à-vis the shocks of other variables; therefore, the spot index is mostly affected by its own shocks, but less so by shocks from the other variables. Furthermore, in addition to the correlation with itself, the spot index is closely correlated to the other variables.

Secondly, it is clear that the changes which a one-unit shock may induce in the shift of the time-series variables are in fact only temporary; in other words, there are no consequent impulse responses in the time trend. Generally speaking, investors can apply such information spillover to manage risky situations and their resultant trading actions; consequently, such information spillovers may be capable of promoting trading interest within both the spot index and the ETF indices.

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