EVALUATION OF LINKAGES BETWEEN EQUITY INDICES: EVIDENCE FROM ISTANBUL STOCK EXCHANGE AND DOW JONES

A Master's Thesis

by
AYTEKİN ERTAN

Department of
Management
Bilkent University
Ankara
July 2009

EVALUATION OF LINKAGES BETWEEN EQUITY INDICES:
EVIDENCE FROM ISTANBUL STOCK EXCHANGE AND DOW
JONES

The Institute of Economics and Social Sciences
of
Bilkent University

by

AYTEKİN ERTAN

In Partial Fulfillment of the Requirements for the Degree of
MASTER OF BUSINESS ADMINISTRATION

in

THE DEPARTMENT OF
MANAGEMENT
BİLKENT UNIVERSITY
ANKARA

July 2009

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Business Administration.

Assoc. Prof. Levent Akdeniz
Supervisor

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Business Administration.

Assoc. Prof. Süheyla Özyıldırım
Examining Committee Member

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Business Administration.

Asst. Prof. Ümit Özlale
Examining Committee Member

Approval of the Institute of Economics and Social Sciences

Prof. Erdal Erel
Director

ABSTRACT

EVALUATION OF LINKAGES BETWEEN EQUITY INDICES: EVIDENCE FROM ISTANBUL STOCK EXCHANGE AND DOW JONES

Ertan, Aytekin
M.B.A., Department of Business Administration
Supervisor: Assoc. Prof. Levent Akdeniz

July 2009

This study investigates the linkage between the major stock market indices of Turkey (ISE National 100) and USA (Dow Jones Industrial Average). Main purpose of this research is to measure the interdependence and cointegration between these indices and figure out the significance and the direction of short run relationship, if there exists any. Cointegration analyses based on Johansen Method demonstrated that there is not any cointegrating vector between these indices, refuting an integrated long term relationship. On the other hand -in this case of no cointegration- Granger Causality studies on the first differenced VAR model pointed out a significant unidirectional effect of Dow Jones to Istanbul Stock Exchange in the short run; which would enable feasible forecasts of ISE via index data from the US. These findings could be valuable to investors holding long and short term investment portfolios in ISE and/or in Dow Jones.

Keywords: *Stock Market Indices, Cointegration, Granger Causality*

ÖZET

HİSSE SENEDİ ENDEKSLERİ ARASINDAKİ BAĞLANTILARIN DEĞERLENDİRİLMESİ: İSTANBUL MENKUL KIYMETLER BORSASI VE DOW JONES

Ertan, Aytekin

M.B.A., İşletme Bölümü

Tez Yöneticisi: Doç. Dr. Levent Akdeniz

Temmuz 2009

Bu çalışma Türkiye ve Amerika Birleşik Devletleri'nin ana hisse senedi endekslerinden İMKB Ulusal 100 Endeksi ile Dow Jones Sanayi Ortalaması Endeksi'nin arasındaki ilişkiyi araştırmaktadır. Bu tezin ana amacı söz konusu endeksler arasındaki karşılıklı bağımlılık ve eşbütünleşmeyi ölçmek ve eğer varsa endeksler arası kısa vadeli etkileşimin gücünü ve yönünü belirlemektir. Johansen Yöntemi'ne dayanan eşbütünleşme çözümlemeleri endeksler arasında eşbütünleşen bir vektör olmadığını ortaya koymuş ve bütünleşik bir uzun vadeli ilişkiyi çürütmüştür. Bununla birlikte, eşbütünleşmenin olmadığı bu durumda ilk farklardaki VAR Modeli'ne uygulanan Granger Nedensellik Testi çalışmaları Dow Jones'tan İMKB'ye olan tek yönlü ve anlamlı kısa vadeli bir etkiyi ortaya koymuştur. Bu durum Dow Jones'tan gelecek endeks verileri doğrultusunda İMKB'nin tahmin edilmesini olanaklı kılmıştır. Bu bulgular İMKB'de ve/veya Dow Jones'ta uzun ve kısa vadeli yatırım portföyü sahiplerine yararlı olabilir.

Anahtar Sözcükler: *Hisse Senedi Endeksleri, Eşbütünleşme, Granger Nedenselliği*

ACKNOWLEDGEMENTS

I would like to express my gratitude to my supervisor Assoc. Professor Levent Akdeniz for his guidance and suggestions throughout the development of this thesis. I would also like to thank to Assoc. Professor Süheyla Özyıldırım and Asst. Professor Ümit Özlale for reading and commenting on my study. I am grateful to my family and my friends for their support and encouragement during the completion of this thesis. Finally, I owe special thanks to Bilkent University and TÜBİTAK for financing my graduate education and providing a pleasant environment for this study.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Stock market linkages and testing international diversification opportunities have attracted the interest of academic research particularly starting from the end of 1980s. Globalization started to interconnect the financial markets of developing countries as well as those of developed countries. Liberalization of capital controls amplified the interests of investors in international diversification. Severe financial issues in last decade have renewed and modified this interest. Investors would benefit from the concept and practice of international diversification when co-movements among the equity indices are low and they may enjoy multiple gain opportunities by making use of cointegration.

Over the past decades various studies have been conducted measuring the interrelation among emerging markets as well as among developed stock markets using cointegrating techniques (Chan *et al.*, 1992; Kasa, 1992; Arshanapalli and Doukas, 1993; Arshanapalli *et al.*, 1995; Kanas, 1998a, 1998b; Scheicher, 2001; Chang 2001; Engsted and Tanggard, 2004; Constantinou *et al.*, 2008 etc).

The purpose of this paper is to investigate the linkage ISE-100 (Istanbul Stock Exchange National 100) and DJIA (Dow Jones Industrial Average) Indices by evaluating their end-of-day level values. Turkey is worth to be evaluated for yielding insights for domestic and international investors in terms of diversification and forecast opportunities.

Main motivation for this research is to evaluate the interdependence between the US stock market and ISE. Istanbul Stock Exchange has not been analyzed very much in terms of its financial integration status with Dow Jones. Starting from the early 2000s, Turkish stock market has maintained notable development and the concept of portfolio diversification through cointegration status has attracted significant attention. Assessing the interdependence between Turkey and the US, and thus providing conclusions to investors are the factors motivating for this paper.

The results of this thesis would be contributing to the literature because it will display the cointegration status of ISE National 100 and Dow Jones Industrial Average Indices originating from the updated data. This could inform the investors about the diversification potential between these markets in the long run. Besides, conclusions about short run causality would also be beneficial.

As a final remark, Dow Jones experiences changes through fundamentals as well as by non-fundamentals. A reasonable question in this point is whether the reactions of Turkey are driven by speculation or by market fundamentals? Assessing and decomposing the fundamental and non-fundamental changes of Dow Jones enable the investors equip with more accurate conclusions and approaches. Thus, such an analysis can be regarded as a further step of research in this field. However, due to the necessity of much more advanced information and tools, this quest is beyond the scope of this paper.

The remainder of the study continues as follows. First, literature is reviewed and empirical results are evaluated. Then, data is introduced, evaluated by descriptive statistics, autocorrelation and correlation analysis in the third section. Unit root tests for the stationarity of the series are in Part 4. Analyses of cointegration (with the use of Johansen (1988) and Johansen and Juselius (1990) methodologies) and Granger Causality application are also in this part. Finally the last section concludes the paper by discussing the results.

CHAPTER II

LITERATURE REVIEW

Topics such as the globalization of world stock markets, the interdependence of the movements in universal equity markets, test of the spillovers, contagions, cointegration and opportunities for international diversification have been in vogue starting from the last twenty years. In most of these studies price levels are often used instead of returns.

Jeon and Chiang (1991) analyzed the daily stock price indices in the New York, London, Tokyo and Frankfurt Stock Exchanges during the period 1975 to 1990. They tested the hypothesis that the stock price indices share common stochastic trends by Johansen cointegration method. They found evidence for greater globalization of world stock markets during the 1980s and concluded that the globalization of world stock markets is an ongoing process.

Mathur and Subrahamyan (1990), discussed the interdependencies between the US and Scandinavian stock markets. They used monthly data of the stock indices for the period between 1974 and 1985 and examined the data using Granger Causality. They concluded that the United States stock market affected only one of the four Scandinavian markets – that of Denmark's. However, considerable amounts of Granger Causality were observed among the Nordic markets and they concluded that it was possible to earn extra returns by anticipating and taking positions on stock price changes in one market by observing the changes in others.

Eun and Shim (1989) viewed international trading by examining daily data for the indices of nine major markets during the period from 1980 to 1985. They found that significant amount of interdependence exists among international stock markets and also showed that the US stock market is the most influential market. Their findings, on the other hand, indicated that there is not enough evidence of the influence of Japan, France and UK on the US stock market.

Malliaris and Urrutia (1992) investigated unidirectional and bi-directional causality relationships between six stock market indices before, during, and after the market crash of October 19, 1987. They applied Granger causality test assuming 5 trading days (5 lags). The authors found a dramatic increase in bidirectional causality and unidirectional causality is observed in the month of the crash. These findings are consistent with the argument that claims shocks in major stock markets are transferred very fast.

Becker *et al.* (1990), using the opening price to the closing price returns of the Japanese and U.S. stock markets, found out that the U.S. market Granger caused the Japanese market, while the Japanese market had only a small impact on the U.S. market return.

Ammer and Mei (1996) discovered that the covariance among stock markets is influenced by contemporaneous co-movement in macroeconomic variables. But they argued that this could be in negligible levels, because the real linkages are much stronger from a long-run than a short-run perspective.

Kasa (1992) studied the common stochastic trends between stock markets. He used a cointegration system to examine where there is a common long run trend in the international stock indices. According to Kasa's work, within the case of cointegration among equity markets; realizing gain from diversification is possible in the short term but not likely in the long term. Also, there is strong evidence in favor of a single common stochastic trend that determines the stock indices in the USA, Canada, Germany, Japan and the UK.

Jeon and Von Furstenberg (1989), similar to Ammer and Mei (1996) examined time-varying weekly and monthly global return correlations and found that factors such as aggregate dividend yields, interest rates and exchange rates were only weakly associated with the changes over time.

Longin and Solnik (2001) investigated the interdependence between international equity markets and mainly concluded that the correlation between international equity markets increase in the bear markets but not in the bull markets. Their findings are based on a comparison of empirical and theoretical conditional correlation measures in an extreme value theory framework.

Arshanapalli and Doukas (1993) found strong evidence of bivariate cointegration between three European markets (UK, Germany, France) emphasizing the increasing cointegration among major developed markets after the crash in October 1987. Arshanapalli, Doukas and L. Lang (1995) also presented evidence, which suggested that after October 1987 the cointegration structure that tied Asian markets together had substantially increased. The influence of the U.S. market on major Asia markets was found to be greater during the post-October period.

Chen, Firth, and Rui (2002) in their geographical group of market study; examined the interdependence of the major stock markets in Latin America for the period 1995-2000, by making use of cointegration analyses and especially the Johansen Juselius Method. Their results demonstrate that the risk diversification potential -by investing across Latin American markets- is somewhat limited due to the single cointegrating vector among these market indices.

Engsted and Tanggard (2004) further analyzed the existence of long-run linkages between US and UK stock markets. They provided evidence in favor of co-movements between the US and UK stock markets within a present value model.

The papers of Scheicher (2001), Constantinou, Kazandjian, Kouretas and Tahmazian (2008), Seabra (2001), Chang (2001) and Fernández-Serrano and Sosvilla-Rivero (2003) examined the linkages among other various stock market indices. Applying diverse econometric tools some of the authors (Constantinou *et al.*, Seabra, and Fernández-Serrano *et al.*) proved the existence of long-run relationship while some others (Chang and Scheicher) came up with contrary conclusions. Main reason behind these contradictory evidences is the data used (namely the countries and time horizons observed and investigated).

On the other hand, Chan, Gup, and Pan (1992) and DeFusco, Geppert, and Tsetsekos (1996) examined the temporal relation between Asia-Pacific stock markets and showed that the stock market indices are not cointegrated.

Kanas (1998b) investigated the potential linkages among the U.S. stock market and the European stock markets in U.K., Germany, France, Switzerland, Italy, and the Netherlands. He concluded that the U.S. stock market actually did not share long run relationships with any of these countries. According to Kanas, this finding implied that -in terms of risk reduction- there were potential long run benefits by means of diversification in US stocks and European stocks.

As for the studies on Turkey, Drakos and Kutan (2005) and Aktar (2009) found cointegration between Turkey and Greece and Turkey, Hungary and Russia respectively. On the other hand, Kucukkaya (2008) argued that there was diversification potential between ISE and MSCI (Morgan Stanley Composite Index) by proving the lack of cointegration between Turkey and the US.

Previous researches indicate that there is contradiction (at least a lack of consensus) for the existence of the international linkages between stock markets. Yet, it is proved that integration among developed indices is high and this arises as a fact preventing the investors from diversifying portfolio opportunities. That's why investors tend maintaining international diversification through other market regions. Emerging markets and -Turkey in this case- could address the requirements for this issue.

CHAPTER III

DATA

The data used in this study consist of time series of daily stock market indices of the US and Turkey. In this research there are 1304 daily observations ranging from 31 May 2004 to 30 May 2009, obtained from Thomson Datastream. They are the closing levels of ISE-100 (in Turkish Lira and in US Dollars) and Dow Jones (in US Dollars). For the sake of continuity, the series values are assumed to remain same in holidays, which is a widely accepted convention in similar studies.

Roll (1992) points out a couple of issues regarding to the stock market linkages by expressing that the behaviors of stock indices are affected by two substantial facts: first the structure, ways of index composition and construction; and second, the level of exchange rates. As a response, ISE National 100's end-of-day values have been collected also in terms of US dollars in order to include the exchange rate impacts in the study. Tests are conducted for ISE in US dollars as well. In this context, results in terms of

US dollars are especially useful for addressing the international investors. It should also be noted that, currency conversions are made according to the official end-of-day rates.

As another remark, the natural logarithms of variables are used during the analyses instead of original values. This is because taking the natural logarithm would reduce the heteroskedasticity problem.

As for the descriptive statistics of the time series displayed in Table 1, preliminary information makes sense for analyzing the studies hereinafter. According to the abbreviations; ISE, ISE$ and DJIA represent the level values of time series (ISE$ is the dollar level of ISE National 100). ISEdf, ISE$df and DJIAdf are used for demonstrating the level differences.

Table 1 Descriptive Statistics

	ISE	**ISE$**	**DJIA**
Mean	35714.56	26438.05	11140.62
Median	36912.58	25806.65	11017.4
Maximum	58231.9	49191.57	14164.53
Minimum	16752.76	11085.47	6547.05
Std. Dev.	10066.98	9210.656	1567.288
Skewness	0.102806	0.388955	-0.378704
Kurtosis	2.118138	2.40836	2.882214

Apart from these generic information regarding to the time series that will be analyzed, mentioning the autocorrelations as a preliminary step to unit root and cointegration tests would be accurate. Unsurprisingly, autocorrelations of the index levels die out much more rapidly than the autocorrelations of the differences of the stock index series. This result actually signals that the differences of stock returns are likely to be stationary processes. One other important fact here is that these insights do not really change with respect to the type of currency used for ISE.

Table 2 Autocorrelations Series

	k = 1	k = 2	k = 3	k = 4	k = 5
ISE	0.996	0.992	0.988	0.984	0.980
ISE$	0.996	0.992	0.987	0.983	0.978
DJIA	0.995	0.991	0.988	0.984	0.980
ISEdf	0.054	-0.008	-0.017	0.025	0.006
ISE$df	0.073	0.014	-0.012	0.034	-0.007
DJIAdf	-0.138	-0.105	0.095	-0.020	-0.021

Additionally, Table 3 includes the correlation matrix of stock index series of the both countries. Pairwise correlations between Turkey (in both currencies) and the US are in considerable levels. It is 0.7985 for DJIA and ISE and 0.8201 for DJIA and ISE$.

Table 3

Correlations Matrix of Index Levels

	ISE	ISE$	DJIA
ISE	1		
ISE$	0.9773	1	
DJIA	0.7985	0.8201	1

CHAPTER IV

METHODOLOGY AND RESULTS

4.1 Unit Root Tests

Regressing non-stationary variables on each other most probably leads to spurious regression and potentially misleading insights or inferences about the degree of association and the estimated parameters. For that reason, the order of integration of index series must be figured out before applying the Johansen and Juselius (1990) method to test the long run relationship and to see the Granger Causality status. In this study, in order to test for a unit root, both the Augmented Dickey–Fuller (ADF) test (Dickey and Fuller, 1979) and the Phillips–Perron (P–P) test (Phillips and Perron, 1988) are employed. Corresponding regression equations of these unit root tests are given below:

(a) Augmented Dickey–Fuller regression:

$$\Delta x_t = \rho_0 + \rho x_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta x_{t-1} + u_t \qquad \textbf{(1)}$$

where Δx is the first difference of y series, ρ_0 is a constant term, u is the residual term and k is the lagged values of Δx_t which are incorporated to allow for serial correlation in the residuals.

In the ADF test, a test for nonstationarity of the series (namely 'x') is actually applying a t-test for $\rho = 0$. The alternative hypothesis of stationarity understandably necessitates that ρ be statistically significantly negative. If the absolute value of the computed t-statistics for ρ exceeds the absolute critical value, then the null hypothesis that x series is not stationary must be rejected against its alternative.

On the other hand, if the absolute value of the computed t-statistics for ρ is less than the critical value, it is suggested that x series is nonstationary. In this case, the same regression will be repeated for the first difference of the series. In this study, the appropriate lag order of k has been chosen on the Akaike Information Criteria (AIC).

(b) Phillips–Perron regression:

$$x_t = \alpha_0 + \alpha x_{t-1} + u_1 \qquad \textbf{(2)}$$

As for the Phillips-Perron Test, it does not require that the $\boldsymbol{u}$'s are conditionally homoskedastic, which is an implicit assumption in the Augmented Dickey-Fuller test. This test is also regarded as a complement of ADF test rather than a substitute for it. Besides, Phillips-Perron test needs a bandwidth parameter selection (for the construction of the Newey-West covariance estimator), which was accomplished by Bartlett kernel. This would generate finite sample problems similar to those related the lag length selection issue in the ADF test.

The difference between these two unit root tests is their treatment of serial correlation. As Serletis (2007) points out, the Phillips–Perron test tends to be more robust to a wide range of serial correlations and time-dependent heteroskedasticity.

To remark again, in these tests, the null hypothesis is that the series in question is non-stationary provided that $\boldsymbol{\rho} = \mathbf{0}$ and $\boldsymbol{\alpha} = \mathbf{1}$. In this sense, rejection of the unit root null hypothesis is necessary to support stationarity of time series.

Table 4 reports the result summaries of the Augmented Dickey-Fuller unit root test and the Phillips–Perron unit root test of stationarity in the natural logarithms and the first differences natural logarithms of stock indexes. The test results -regardless of the type of test that has been conducted- show that the null hypothesis that stock indices in the levels are non-stationary fails to be rejected for each of the series. However, the null hypothesis that first differences in the stock indices are non-stationary is strongly rejected for each series. These results mean that the stock index series in question contain a unit root and thus, should be first differenced to achieve stationarity.

We find out from the table that the null hypothesis of a unit root in stock index levels cannot be rejected, whereas the hypothesis that there is a unit root in the differences is rejected. Even shortly and more explicitly, the series tested in this study are non-stationary in the levels, but stationary in differences. Thus, each stock index is integrated in order one, namely they are I(1) processes and can be evaluated by cointegration analysis.

Table 4 Unit Root Test Results

	ADF		PP	
	Lags (k)	**$\tau(\rho)$**	**Bandwidth**	**$z(t_\alpha)$**
ISElog	1	-2.411	15	-2.338
ISE$log	1	-2.285	10	-2.212
DJIAlog	18	-0.642	22	-0.789
ISElogdf	0	-34.175 *	17	-34.149 *
ISE$logdf	0	-33.520 *	13	-33.479 *
DJIAlogdf	17	-8.709 *	18	-42.045 *

* Significant at 1% level

The lag length in the ADF regression is selected by Akaike's Information Criterion (AIC). The bandwidth in PP is chosen by the Newey-West method using the Bartlett kernel

4.2 Cointegration Tests

When analyzing the linkages among national equity markets, determining the common factors probably driving the long-run movement of the time series data or concluding that each single stock market is driven only by its own dynamics is very important. This relationship can be evaluated by cointegration analysis. Cointegration of a vector of stock price indices implies that the number of unit roots in the system is less than the number of unit roots in the series. The concept of cointegration is developed by Engle and Granger (1987). It actually is the description of the phenomenon that some linear combination of two (or more) series is stationary even though the series themselves are non-stationary and some long-run equilibrium interrelations link the individual series together. In such cases, series would not drift apart too much, even though they may move away from each other in the short run. Due to this closeness of series, in cointegration cases the benefit of international portfolio diversification is limited.

In evaluating cointegration, Johansen (1988) and Johansen and Juselius (1990) procedures of testing for the presence of cointegrating vectors are employed. The Johansen and Juselius procedure has several advantages over the Engle-Granger (1987) two-step approach for testing cointegration. Particularly, the Johansen and Juselius tests do not assume the existence of (at most) a single cointegrating vector. But instead they explicitly test for the amount of cointegration relations.

Also, the Johansen and Juselius Method takes the error structure of the process into account. By incorporating the different short and long run dynamics, this technique allows the assessment of the relationship among series while decomposing the short-term deviations.

Thus, Johansen and Juselius approach provides relatively powerful tests and results when the model is accurately specified. The procedures of this test for cointegration are given below.

Consider an n-dimensional vector autoregressive model:

$$X_t = \alpha + \sum_{i=1}^{k} \pi_i X_{t-i} + \varepsilon_t \qquad \textbf{(3)}$$

where $\boldsymbol{X_t}$ is an (n x 1) vector of I(1) variables, $\boldsymbol{\pi_i}$ is an (n x n) matrix of parameters and $\boldsymbol{\alpha}$ is a constant.

Following Johansen (1988) and Johansen and Juselius (1990) procedure, an n-dimensional vector autoregressive (VAR) model with Gaussian errors is constructed, expressed by its first-differenced error correction form as (both explicit and implicit representations):

$$\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \varepsilon_t \qquad \textbf{(4)}$$

or

$$\Delta X_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-k} + \varepsilon_t \qquad \textbf{(5)}$$

where the coefficient matrices are:

$$\Gamma_i = -I + \sum_{i=1}^{m} \pi_i, \qquad for \quad m = 1, 2, \ldots, k-1 \qquad \textbf{(6)}$$

$$\Pi = -I + \sum_{i=1}^{k} \pi_i \qquad \textbf{(7)}$$

In above expressions, $\boldsymbol{\Delta}$ is the difference operator and $\boldsymbol{X}$ denotes the vector of variables, which are ln DJIA and ln ISE (in TL) and ln DJIA and ln ISE (in \$) representing two different applications. $\boldsymbol{k}$ denotes the lag length, $\boldsymbol{\mu}$ is a constant drift parameter. White noise error term is $\boldsymbol{\varepsilon_t} \sim$ *n.i.i.d* (0, Σ).

In addition to these, $\boldsymbol{\Gamma}$ is the short-run dynamics and **I** is an identity matrix. $\boldsymbol{\Pi}$ is known as the long-run matrix and the rank $\boldsymbol{r}$ (that will yield the number of cointegrating vectors) determines the number of stationary linear combinations of $\boldsymbol{X_t}$.

$\mathbf{\Pi}$ can be of full rank. But in this situation, the stationarity of the error term requires that the levels of the $\boldsymbol{X_t}$ process themselves be stationary, which is a contrary condition to the original I(1) specification. In this case, the Equations (4) and (5) reduce to a standard VAR.

On the other hand, $\mathbf{\Pi}$ could have rank zero, in which case Equations (4) and (5) reduce to a standard VAR in first differences, and there are no stationary long-run relations among the elements of $\boldsymbol{X_t}$.

For $0 < \boldsymbol{r} < \boldsymbol{n}$, there exist $\boldsymbol{r}$ cointegrating vectors. In other words, if the rank (namely $\boldsymbol{r}$) of $\mathbf{\Pi}$ is greater than zero, there might exist $\boldsymbol{r}$ stationary linear combinations and $\mathbf{\Pi}$ can be factorized into two matrices $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ -both which are ($\boldsymbol{n}$ x $\boldsymbol{r}$) matrices- in such a way that $\mathbf{\Pi} = \boldsymbol{\alpha\beta'}$. In this representation $\boldsymbol{\beta}$ is the matrix that contains the long-run coefficients and the $\boldsymbol{r}$ amount of cointegrating vectors; whereas $\boldsymbol{\alpha}$ would be the one that will include the error-correction parameters - the speed of adjustment coefficients for the equation.

Johansen (1988) and Johansen and Juselius (1990) proposed two different test statistics for determining the number of cointegrating vectors (or the rank of $\mathbf{\Pi}$). The trace statistics and the maximum eigenvalue statistics can be used for testing cointegrating vectors. Johansen and Juselius (1990) expressed that the trace test might result in less powerful results relative to the maximum eigenvalue test. Based on the power of the test, the maximum eigenvalue test statistic is often preferred. Nevertheless, both test statistics are taken into consideration in this study.

The likelihood ratio statistic for the trace test is shown below:

$$LR_{tr}(r \mid k) = -T \sum_{i=r+1}^{k} \ln(1-\hat{\lambda}_i) \quad \textbf{(8)}$$

The null hypothesis to be tested in this test is the one claiming that there are at most $\boldsymbol{r}$ cointegrating vectors. This means that the number of cointegrating vectors is not greater than $\boldsymbol{r}$. In each case, the null hypothesis is tested against the alternative.

On the other hand, the L-max statistic is:

$$LR_{\max}(r \mid r+1) = -T \ln(1-\hat{\lambda}_{r+1}) \quad \textbf{(9)}$$

In this particular test, the null hypothesis of r cointegrating vectors is tested against the alternative that includes $\boldsymbol{r}$ **+ 1** cointegrating vectors. More explicitly, the null hypothesis $\boldsymbol{r} = \mathbf{0}$ is tested against the alternative that $\boldsymbol{r} = \mathbf{1}$. The null hypothesis $\boldsymbol{r} = \mathbf{1}$ is tested against the alternative $\boldsymbol{r} = \mathbf{2}$, and so on.

Finally, it is very well known that the Johansen-Juselius cointegration test is very sensitive to the lag structure specified, where different lags may yield different cointegration test result. In accordance to this approach a VAR model is first fit to the time series data to find an appropriate lag structure. Schwartz Criterion (SC) and Hannan-Quinn Information Criterion (HQ) suggested 2 lags both for the ISE (TL) - DJIA and ISE ($) - DJIA bivariate VAR models. On the other hand, Final Prediction Error (FPE) and Akaike Information Criterion (AIC) suggest 5 lags both for the ISE (TL) - DJIA and ISE ($) - DJIA bivariate VAR models. In order to be as responsive and as solid as possible; tests for both lags are included in this study. Johansen Cointegration test results are displayed in Table 5.1 and Table 5.2.

Table 5.1 Cointegration tests based on the Johansen (1988) and Johansen and Juselius (1990) approach

	Eigenvalue	Trace test	5% critical value	L-max test	5% critical value
(A) ISElog - DJIAlog					
$H_0: r = 0$	0.005654	7.593	15.41	7.377	14.07
$H_0: r < 1$	0.000166	0.216	3.76	0.216	3.76
(B) ISElog$ - DJIAlog					
$H_0: r = 0$	0.006193	8.238	15.41	8.08	14.07
$H_0: r < 1$	0.000120	0.156	3.76	0.156	3.76

Notes: Critical values are taken from Osterwald-Lenum (1992). r denotes the number of cointegrating vectors. Schwarz Criteria (SC) and Hannor-Quinn Criterion (HQ) were used to select the number of lags. (VAR lag 2) is valid and used for both test conditions.

Table 5.2 Cointegration tests based on the Johansen (1988) and Johansen and Juselius (1990) approach

	Eigenvalue	Trace test	5% critical value	L-max test	5% critical value
(A) ISElog - DJIAlog					
$H_0 : r = 0$	0.004852	6.608	15.41	6.314	14.07
$H_0 : r \leq 1$	0.000227	0.294	3.76	0.294	3.76
(B) ISElog$ - DJIAlog					
$H_0 : r = 0$	0.005054	6.738	15.41	6.577	14.07
$H_0 : r < 1$	0.000124	0.161	3.76	0.161	3.76

Notes: Critical values are taken from Osterwald-Lenum (1992). r denotes the number of cointegrating vectors. Final Prediction Error (FPE) and Akaike Information Criterion (AIC) were used to select the number of lags. (VAR lag 5) is valid and used for both test conditions.

As reported in these tables, both Trace statistic and L-max statistic indicate that the null hypothesis of no cointegration cannot be rejected in any case. These results suggest that there is not a significant linkage between the Turkish (both in TL and $) and the US stock markets. As seen in Table 5.1 and 5.2 neither Trace test nor L-max test have significant enough values for rejecting the null hypothesis claiming that there is no cointegrating vector.

The lack of a cointegration suggests that there might be potential long-run diversification benefit for Turkish investors who invest in the US equity markets and vice versa. More explicitly, this supports that the Turkish Stock market can be used to achieve diversification benefits when included in an investment portfolio that contains the US market.

4.3 Granger Causality

In order to detect cointegration between ISE and DJIA, Johansen Cointegration Test has been conducted. The null hypothesis is that the stock indices of the two countries are not cointegrated (***r*** is equal to **0** → no cointegrating vectors). On the other hand, the alternative hypothesis is that there are one or more cointegrating vectors (***r*** is greater than **0**). Results indicated that absence of cointegration cannot be rejected no matter what the currencies ($ and TL) and lags (2 and 5) are. This result suggests that there is not a significant long-run relationship between ISE 100 and DJIA. In other words, they do not behave in a way that they are a single or an integrated market. The results of Johansen cointegration tests with both trace and maximum eigenvalue statistics indicate that there might be opportunities for portfolio diversification.

The cointegration test confirms that these equity markets do not share the same stochastic trend and hence a long run relationship might not exist. In this point, seeking the presence of short run relationship would be a further step.

When series are cointegrated, error correction models are used to evaluate the short-term relationships. These models are based on the scheme that cointegrated series have only short-term deviations from equilibrium and they are corrected in the long run. In error correction models -in addition to the lagged values of variables- there needs to be an error correction term for each cointegrating vector included in each equation.

On the other hand, when there is no cointegration, Vector Autoregression system can be used to evaluate short-term influences. The reason behind this approach is that the distinction between the Vector Error Correction Mechanism (VECM) and first differenced Vector Autoregression (VAR) is only the one period lagged error-correction term obtained from the (previously determined) cointegrating vectors. More explicitly, in cases with no cointegration, there are not any cointegrating vectors and hence no error correction terms. This makes VECM a first differenced VAR. This is the reduction of Equation 4 and 5 to a standard VAR in first differences.

Note that since no cointegration is found during this analysis, Vector Error Correction Mechanism (VECM) is not required to be implemented in this particular study with these data. Granger Causality tests would yield conclusions about the short run relationship of the US and Turkish stock markets (whether it exists or not and whether the relationship is unidirectional or bidirectional assuming it exists).

More explicitly, the primary Granger Causality method is based on the hypothesis that compared series are stationary. However, in the absence of cointegration vector and with I(1) series, valid results in Granger causality testing (regarding the short run relationships of time series) are obtained by first differentiating the VAR model as previously expressed.

Hassapis *et al.* (1999) demonstrated that in the absence of cointegration, the direction of causality could be determined by the standard F-tests that will be applied to the first differenced VAR.

The first differenced VAR can be expressed as:

$$\Delta X_t = c_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta X_{t-i} + \sum_{j=1}^{k} b_{1j} \Delta Y_{t-j} + \varepsilon_{1t} \quad \textbf{(10)}$$

$$\Delta Y_t = c_1 + \sum_{i=1}^{k} \alpha_{2i} \Delta X_{t-i} + \sum_{j=1}^{k} b_{2j} \Delta Y_{t-j} + \varepsilon_{2t} \quad \textbf{(11)}$$

where $\boldsymbol{\Delta X_t}$ and $\boldsymbol{\Delta Y_t}$ represent a pair of stock index prices among ln DJIA – ln ISE and ln DJIA – ln ISE. F-test is carried out for the null hypothesis of no Granger causality.

Table 6 Granger Causality Results

Null Hypothesis	F-Statistics Lag 1	Lag 2	Lag 3	Lag 4
USA does not Granger cause Turkey (TL)	95.752*	50.306*	33.432*	25.097*
Turkey (TL) does not Granger cause USA	0.653	1.286	0.292	0.624
USA does not Granger cause Turkey ($)	118.160*	59.841*	40.114*	30.189*
Turkey ($) does not Granger cause USA	0.041	3.106**	1.491	1.703

Note: * and ** represents rejection of the null hypothesis at the 1% and 5% levels respectively.

Results of Granger Causality tests can be seen in Table 6. In accordance with the target of responsiveness, lag alternatives from 1 to 4 are employed in this analysis. From the results highlighted with asterisks in the table, it could be concluded that the DJIA Granger causes to Istanbul Stock

Exchange's National 100 Index both in terms of US Dollars and Turkish Liras.

However, mentioning bidirectional causality cannot be an accurate implication. The reason behind this argument is the statistically not significant F-Statistic values for ISE in Table 6. More explicitly, Turkish market does not Granger cause to the US market. These findings imply the forecast potential of ISE by the data from Dow Jones. But -according to the findings- the lead-lags of ISE National 100 could not be used to properly forecast Dow Jones.

This is a consistent conclusion to the one that was argued by Eun and Shim (1989) and many other researchers: The US stock market is the most influential stock market in the world. Changes and especially severe shocks in the US stock market are rapidly transmitted to the other national markets enabling the investors somehow make forecasts and take measures accordingly.

CHAPTER V

CONCLUSION AND DISCUSSION

This study investigates the relationship between DJIA and ISE over the period May 2004 to May 2009. The results of this research may provide valuable information for investors in Turkish stock market. While interconnections in developed markets have been analyzed a lot so far, researches on emerging stock markets and developed markets are not that many. Turkey's opening to foreign investors and its financial and business environment as a rapidly developing economy make the major stock index of this country taken into consideration in these analyses with one of the primary indices of the US, the Dow Jones Industrial Average.

During the sample period, we found no cointegrating vectors and hence no long run equilibrium relationship between ISE and DJIA via the cointegration tests implemented by Johansen Method. This finding enables the diversification using these indices to an extent.

On the other hand, adapting the Granger Causality tests to first differenced VAR (instead of considering VECM due to lack of cointegration) proved the significant unidirectional short-term effect of Dow Jones Industrial Average on ISE National 100 Index. This finding may lead to increase in short run forecast opportunities.

It might also be suggested that the lack of cointegration between these markets can be regarded as the indicators of Turkey's own dynamics as well as its active and distinctive structure driving the domestic stock market.

These findings could lead to further insights about interconnections of these markets and provide useful information to both domestic and foreign investors in terms of forming portfolios, maintaining diversification opportunities and making forecasts of the index levels in both short and long terms.

This study can be regarded as another contribution to the usefulness of technical examination in international equity markets. Another study might be analyzing the other countries or other indices. Provided that cointegration is found, interpreting the cointegration of ISE with other emerging indices would contribute to the relevant literature.

Also, as mentioned in the beginning, assessing and decomposing the fundamental and non-fundamental changes of Dow Jones and their effects on ISE can be regarded as a further step of research in this field.

BIBLIOGRAPHY

Aktar, I. 2009. "Is there any co-movement between stock markets of Turkey, Russia and Hungary?" *International Research Journal of Finance and Economics 26*: 192–200

Ammer, J. and J. Mei. 1996. "Measuring international economic linkages with stock market data," Journal of Finance 51: 1743–1763.

Arshanapalli, A. and J. Doukas. 1993. "International stock market linkages: Evidence from the pre- and post-October 1987 period," Journal of Banking and Finance 17: 193–208.

Arshanapalli, A., J. Doukas and L.H.P. Lang. 1995. "Pre- and post-October 1987 stock market linkages between US and Asian markets," Pacific-Basin Finance Journal 3: 57–73.

Becker K.G., G. Kent G, J.E. Finnerty and M. Gupta. 1990. "The intertemporal relation between the US and the Japanese stock markets," Journal of Finance 4: 1297–1306.

Chan, K.C., B.E. Gup and M.S. Pan. 1992. "An empirical analysis of stock prices in major Asian markets and the United States," The Financial Review 27: 289–307.

Chang, T., 2001. "Are there any long-run benefits from international equity diversification for Taiwan investors diversifying in the equity markets of its major trading partners, Hong Kong, Japan, South Korea, Thailand and the USA," Applied Economic Letters 8: 441–446.

Chen, G., M. Firth and O. M. Rui. 2002. "Stock market linkages: Evidence from Latin America," Journal of Banking and Finance 26: 1113–1141.

Constantinou, E., A. Kazandjian, G.P. Kouretas and V. Tahmazian. 2008. "Common stochastic trends among the Cyprus Stock Exchange and the ASE, LSE and NYSE," Bulletin of Economic Research 60: 327–349.

DeFusco, R. A., J. M. Geppert and G. P. Tsetsekos. 1996. "Long-run diversification potential in emerging stock markets," Financial Review 31: 343–363.

Dickey, D.A. and W.A. Fuller. 1979. "Distribution of the estimators for autoregressive time series with a unit root," Journal of the American Statistical Association 74: 427–431.

Drakos, K. and M.A. Kutan. 2005. "Why do financial markets move together?" Eastern European Economics 43: 5-26.

Engle, R.F. and C.W.J Granger. 1987. "Cointegration and error correction: representation, estimation and testing," Econometrica 55: 251–276.

Engsted, T. and C. Tanggard. 2004. "The comovement of US and UK stock markets," European Financial Management 10: 593–607.

Eun, C.S. and S. Shim. 1989. "International transmission of stock market movements," Journal of Financial and Quantitative Analysis 24: 241–256.

Fernández-Serrano, J.L. and S. Sosvilla-Rivero. 2003. "Modelling the linkages between US and Latin American stock markets," Applied Economics 35: 1423–1434.

Granger, C.W.J. 1981. "Some properties of time series data and their use in econometric model specification," Journal of Econometrics 16: 121–130.

Hassapis, C., N. Pittis and K. Prodromidis, 1999. "Unit roots and Granger causality in the EMS interest rates: the German dominance hypothesis revisited," Journal of International Money and Finance 18 (1): 47–73.

Jeon B.N. and T.C. Chiang. 1991. "A system of stock prices in world stock exchanges: Common stochastic trends for 1975-1990?" Journal of Economics and Business 43: 329-338.

Jeon B.N. and G.M. Von Furstenberg. 1989. "International stock price movements: Links and messages," Brookings Papers on Economic Activity: 125–179.

Johansen, S. 1988. "Statistical analysis of cointegration vectors," Journal of Economic Dynamics and Control 12: 231–254.

Johansen, S. and K. Juselius. 1990. "Maximum likelihood estimation and inference on cointegration with applications to the demand for money," Oxford Bulletin of Economics and Statistics 52: 169–210.

Kanas, A. 1998a. "Long-run benefits from international equity diversification: a note on the Canadian evidence," Applied Economics Letters 5: 659–663.

Kanas, A., 1998b. "Linkages between the US and European equity markets: further evidence from cointegration tests," Applied Financial Economics 8: 607–614.

Kasa, K. 1992. "Common stochastic trends in international stock markets," Journal of Monetary Economics 29: 95–124.

Kucukkaya, E., 2008. "Diversification by investing in the Turkish stock market," Ankara, Turkey: Department of Business Administration, Middle East Technical University, Ankara.

Longin, F. and B. Solnik. 2001. "Extreme correlation of international equity markets," Journal of Finance 56: 649–676.

Mathur I. and V. Subrahmanyam V. 1990. "Interdependencies among the Nordic and US stock markets," Scandinavian Journal of Economics 4: 587–597.

Malliaris, A.G. and J.L. Urrutia. 1992. "The international crash of October 1987: causality tests," Journal of Financial and Quantitative Analysis 27: 353–364.

Newey, W. K. and K.D. West. 1987. "Automatic lag selection in covariance matrix estimation," Review of Economic Studies 61: 631–653.

Osterwald-Lanum, M. 1992. "A note with quintiles of the asymptotic distribution of the ML cointegration rank test statistics," Oxford Bulletin of Economics and Statistics 54: 461–472.

Phillips, P. C. B. and P. Perron. 1988. "Testing for a unit root in time series regression," Biometrika 75: 335–346.

Roll, R. 1992. "Industrial structure and the comparative behaviour of international stock market indices," Journal of Finance 47: 3–42.

Scheicher, M. 2001. “The comovements of stock markets in Hungary, Poland and Czech Republic,” International Journal of Finance and Economics 6: 27–39.

Seabra, F. 2001. “A cointegration analysis between Mercosur and international stock markets,” Applied Economic Letters 8: 475–478.

Serletis, A. 2007. Quantitative and Empirical Analysis of Energy Markets. Hackensack, NJ: World Scientific Publishing Company

APPENDIX A

AUTOCORRELATION RESULTS

ISELOG

Included observations: 1304

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
|*******	|*******	1	0.996	0.996	1296.0	0.000
|*******	| |	2	0.991	-0.043	2581.0	0.000
|*******	| |	3	0.987	0.007	3855.4	0.000
|*******	| |	4	0.982	0.012	5119.5	0.000
|*******	| |	5	0.978	0.010	6373.5	0.000

ISELOGDF

Included observations: 1304

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
| |	| |	1	0.054	0.054	3.8231	0.051
| |	| |	2	-0.008	-0.011	3.8977	0.142
| |	| |	3	-0.017	-0.016	4.2629	0.234
| |	| |	4	0.025	0.027	5.1073	0.276
| |	| |	5	0.006	0.002	5.1479	0.398

ISE$LOG

Included observations: 1304

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>|*******</td><td>|*******</td><td>1</td><td>0.996</td><td>0.996</td><td>1295.4</td><td>0.000</td></tr>
<tr><td>|*******</td><td>| |</td><td>2</td><td>0.991</td><td>-0.058</td><td>2579.0</td><td>0.000</td></tr>
<tr><td>|*******</td><td>| |</td><td>3</td><td>0.986</td><td>-0.006</td><td>3850.5</td><td>0.000</td></tr>
<tr><td>|*******</td><td>| |</td><td>4</td><td>0.981</td><td>0.013</td><td>5110.6</td><td>0.000</td></tr>
<tr><td>|*******</td><td>| |</td><td>5</td><td>0.976</td><td>-0.001</td><td>6359.2</td><td>0.000</td></tr>
</table>

ISE$LOGDF

Included observations: 1304

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>| |</td><td>| |</td><td>1</td><td>0.073</td><td>0.073</td><td>7.0123</td><td>0.008</td></tr>
<tr><td>| |</td><td>| |</td><td>2</td><td>0.014</td><td>0.009</td><td>7.2758</td><td>0.026</td></tr>
<tr><td>| |</td><td>| |</td><td>3</td><td>-0.012</td><td>-0.014</td><td>7.4763</td><td>0.058</td></tr>
<tr><td>| |</td><td>| |</td><td>4</td><td>0.034</td><td>0.036</td><td>9.0272</td><td>0.060</td></tr>
<tr><td>| |</td><td>| |</td><td>5</td><td>-0.007</td><td>-0.012</td><td>9.0866</td><td>0.106</td></tr>
</table>

DJIALOG

Included observations: 1304

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>|*******</td><td>|*******</td><td>1</td><td>0.995</td><td>0.995</td><td>1292.7</td><td>0.000</td></tr>
<tr><td>|*******</td><td>|* |</td><td>2</td><td>0.990</td><td>0.090</td><td>2574.8</td><td>0.000</td></tr>
<tr><td>|*******</td><td>|* |</td><td>3</td><td>0.987</td><td>0.105</td><td>3849.0</td><td>0.000</td></tr>
<tr><td>|*******</td><td>*| |</td><td>4</td><td>0.982</td><td>-0.076</td><td>5112.9</td><td>0.000</td></tr>
<tr><td>|*******</td><td>| |</td><td>5</td><td>0.978</td><td>0.009</td><td>6366.8</td><td>0.000</td></tr>
</table>

DJIALOGDF

Included observations: 1304

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>*| |</td><td>*| |</td><td>1</td><td>-0.138</td><td>-0.138</td><td>24.729</td><td>0.000</td></tr>
<tr><td>*| |</td><td>*| |</td><td>2</td><td>-0.105</td><td>-0.126</td><td>39.095</td><td>0.000</td></tr>
<tr><td>|* |</td><td>| |</td><td>3</td><td>0.095</td><td>0.063</td><td>50.802</td><td>0.000</td></tr>
<tr><td>| |</td><td>| |</td><td>4</td><td>-0.020</td><td>-0.010</td><td>51.346</td><td>0.000</td></tr>
<tr><td>| |</td><td>| |</td><td>5</td><td>-0.021</td><td>-0.009</td><td>51.951</td><td>0.000</td></tr>
</table>

APPENDIX B.1

ADF TEST OUTPUTS

Null Hypothesis: ISELOG has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on AIC, MAXLAG=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.410525	0.1390
Test critical values:	1% level	-3.435161	
	5% level	-2.863552	
	10% level	-2.567891	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ISELOG)
Method: Least Squares
Included observations: 1302 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISELOG(-1)	-0.004363	0.001810	-2.410525	0.0161
D(ISELOG(-1))	0.053580	0.027634	1.938866	0.0527
C	0.046087	0.018904	2.437902	0.0149

R-squared	0.007308	Mean dependent var	0.000566
Adjusted R-squared	0.005780	S.D. dependent var	0.019466
S.E. of regression	0.019409	Akaike info criterion	-5.043826
Sum squared resid	0.489361	Schwarz criterion	-5.031909
Log likelihood	3286.530	Hannan-Quinn criter.	-5.039355
F-statistic	4.781662	Durbin-Watson stat	1.998543
Prob(F-statistic)	0.008530		

Null Hypothesis: ISELOGDF has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on AIC, MAXLAG=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-34.17544	0.0000
Test critical values:	1% level	-3.435157	
	5% level	-2.863550	
	10% level	-2.567890	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ISELOGDF)
Method: Least Squares
Included observations: 1303 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISELOGDF(-1)	-0.945914	0.027678	-34.17544	0.0000
C	0.000522	0.000539	0.968004	0.3332

R-squared	0.473058	Mean dependent var	7.78E-06
Adjusted R-squared	0.472653	S.D. dependent var	0.026776
S.E. of regression	0.019444	Akaike info criterion	-5.040985
Sum squared resid	0.491886	Schwarz criterion	-5.033046
Log likelihood	3286.202	Hannan-Quinn criter.	-5.038007
F-statistic	1167.961	Durbin-Watson stat	1.999234
Prob(F-statistic)	0.000000		

Null Hypothesis: ISE$LOG has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on AIC, MAXLAG=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.284472	0.1772
Test critical values:	1% level	-3.435161	
	5% level	-2.863552	
	10% level	-2.567891	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ISE$LOG)
Method: Least Squares
Included observations: 1302 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISE$LOG(-1)	-0.004588	0.002008	-2.284472	0.0225
D(ISE$LOG(-1))	0.073603	0.027609	2.665905	0.0078
C	0.046932	0.020337	2.307707	0.0212

R-squared	0.009289	Mean dependent var	0.000541
Adjusted R-squared	0.007764	S.D. dependent var	0.026316
S.E. of regression	0.026214	Akaike info criterion	-4.442741
Sum squared resid	0.892642	Schwarz criterion	-4.430825
Log likelihood	2895.224	Hannan-Quinn criter.	-4.438270
F-statistic	6.089774	Durbin-Watson stat	2.001176
Prob(F-statistic)	0.002331		

Null Hypothesis: ISE$LOGDF has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on AIC, MAXLAG=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-33.51984	0.0000
Test critical values:	1% level	-3.435157	
	5% level	-2.863550	
	10% level	-2.567890	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ISE$LOGDF)
Method: Least Squares
Included observations: 1303 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISE$LOGDF(-1)	-0.926746	0.027648	-33.51984	0.0000
C	0.000483	0.000728	0.663292	0.5073

R-squared	0.463412	Mean dependent var	4.54E-06
Adjusted R-squared	0.463000	S.D. dependent var	0.035829
S.E. of regression	0.026256	Akaike info criterion	-4.440323
Sum squared resid	0.896869	Schwarz criterion	-4.432384
Log likelihood	2894.870	Hannan-Quinn criter.	-4.437344
F-statistic	1123.580	Durbin-Watson stat	2.001324
Prob(F-statistic)	0.000000		

Null Hypothesis: DJIALOG has a unit root
Exogenous: Constant
Lag Length: 18 (Automatic based on AIC, MAXLAG=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.642406	0.8585
Test critical values:	1% level	-3.435227	
	5% level	-2.863581	
	10% level	-2.567906	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DJIALOG)
Method: Least Squares
Included observations: 1285 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DJIALOG(-1)	-0.001625	0.002530	-0.642406	0.5207
D(DJIALOG(-1))	-0.137044	0.028124	-4.872868	0.0000
D(DJIALOG(-2))	-0.111011	0.028341	-3.916958	0.0001
D(DJIALOG(-3))	0.062352	0.028554	2.183634	0.0292
D(DJIALOG(-4))	-0.007017	0.028583	-0.245478	0.8061
D(DJIALOG(-5))	-0.018900	0.028533	-0.662378	0.5078
D(DJIALOG(-6))	-0.023740	0.028552	-0.831450	0.4059
D(DJIALOG(-7))	-0.052151	0.028558	-1.826146	0.0681
D(DJIALOG(-8))	0.062548	0.028576	2.188857	0.0288
D(DJIALOG(-9))	-0.017598	0.028656	-0.614119	0.5392
D(DJIALOG(-10))	0.049851	0.028656	1.739633	0.0822
D(DJIALOG(-11))	0.037967	0.028653	1.325046	0.1854
D(DJIALOG(-12))	-0.012635	0.028674	-0.440661	0.6595
D(DJIALOG(-13))	0.022056	0.028656	0.769672	0.4416
D(DJIALOG(-14))	-0.053031	0.028666	-1.849936	0.0646
D(DJIALOG(-15))	-0.038552	0.028733	-1.341734	0.1799
D(DJIALOG(-16))	0.013676	0.028690	0.476696	0.6337
D(DJIALOG(-17))	0.065895	0.028496	2.312420	0.0209
D(DJIALOG(-18))	-0.066957	0.028305	-2.365510	0.0182
C	0.014922	0.023557	0.633464	0.5265

R-squared	0.065135	Mean dependent var	-0.000169
Adjusted R-squared	0.051094	S.D. dependent var	0.013502
S.E. of regression	0.013153	Akaike info criterion	-5.808953
Sum squared resid	0.218834	Schwarz criterion	-5.728664
Log likelihood	3752.252	Hannan-Quinn criter.	-5.778811
F-statistic	4.638800	Durbin-Watson stat	2.000490
Prob(F-statistic)	0.000000		

Null Hypothesis: DJIALOGDF has a unit root
Exogenous: Constant
Lag Length: 17 (Automatic based on AIC, MAXLAG=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.709263	0.0000
Test critical values:	1% level	-3.435223	
	5% level	-2.863580	
	10% level	-2.567905	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DJIALOGDF)
Method: Least Squares
Included observations: 1286 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DJIALOGDF(-1)	-1.246016	0.143068	-8.709263	0.0000
D(DJIALOGDF(-1))	0.107671	0.139363	0.772594	0.4399
D(DJIALOGDF(-2))	-0.004600	0.134965	-0.034081	0.9728
D(DJIALOGDF(-3))	0.056503	0.130292	0.433665	0.6646
D(DJIALOGDF(-4))	0.048220	0.125757	0.383436	0.7015
D(DJIALOGDF(-5))	0.028129	0.121485	0.231544	0.8169
D(DJIALOGDF(-6))	0.003218	0.116860	0.027534	0.9780
D(DJIALOGDF(-7))	-0.050083	0.112180	-0.446452	0.6553
D(DJIALOGDF(-8))	0.011354	0.106954	0.106157	0.9155
D(DJIALOGDF(-9))	-0.007507	0.101004	-0.074321	0.9408
D(DJIALOGDF(-10))	0.041093	0.094831	0.433327	0.6649
D(DJIALOGDF(-11))	0.077756	0.087585	0.887776	0.3748
D(DJIALOGDF(-12))	0.063853	0.080327	0.794915	0.4268
D(DJIALOGDF(-13))	0.084629	0.072786	1.162701	0.2452
D(DJIALOGDF(-14))	0.030412	0.064624	0.470605	0.6380
D(DJIALOGDF(-15))	-0.009271	0.055401	-0.167335	0.8671
D(DJIALOGDF(-16))	0.003176	0.042678	0.074409	0.9407
D(DJIALOGDF(-17))	0.067958	0.028245	2.406007	0.0163
C	-0.000210	0.000367	-0.571274	0.5679

R-squared	0.588991	Mean dependent var	3.37E-06
Adjusted R-squared	0.583151	S.D. dependent var	0.020359
S.E. of regression	0.013144	Akaike info criterion	-5.810977
Sum squared resid	0.218906	Schwarz criterion	-5.734751
Log likelihood	3755.458	Hannan-Quinn criter.	-5.782361
F-statistic	100.8697	Durbin-Watson stat	2.000607
Prob(F-statistic)	0.000000		

APPENDIX B.2

PP TEST OUTPUTS

Null Hypothesis: ISELOG has a unit root
Exogenous: Constant
Bandwidth: 15 (Newey-West using Bartlett kernel)

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.338409	0.1601
Test critical values:	1% level	-3.435157	
	5% level	-2.863550	
	10% level	-2.567890	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000377
HAC corrected variance (Bartlett kernel)	0.000392

Phillips-Perron Test Equation
Dependent Variable: D(ISELOG)
Method: Least Squares
Included observations: 1303 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISELOG(-1)	-0.004227	0.001808	-2.337609	0.0196
C	0.044681	0.018886	2.365835	0.0181

R-squared	0.004183	Mean dependent var	0.000551
Adjusted R-squared	0.003417	S.D. dependent var	0.019465
S.E. of regression	0.019432	Akaike info criterion	-5.042246
Sum squared resid	0.491267	Schwarz criterion	-5.034307
Log likelihood	3287.023	Hannan-Quinn criter.	-5.039267
F-statistic	5.464414	Durbin-Watson stat	1.892083
Prob(F-statistic)	0.019559		

Null Hypothesis: ISELOGDF has a unit root
Exogenous: Constant
Bandwidth: 17 (Newey-West using Bartlett kernel)

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-34.14933	0.0000
Test critical values:	1% level	-3.435157	
	5% level	-2.863550	
	10% level	-2.567890	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000378
HAC corrected variance (Bartlett kernel)	0.000365

Phillips-Perron Test Equation
Dependent Variable: D(ISELOGDF)
Method: Least Squares
Included observations: 1303 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISELOGDF(-1)	-0.945914	0.027678	-34.17544	0.0000
C	0.000522	0.000539	0.968004	0.3332

R-squared	0.473058	Mean dependent var	7.78E-06
Adjusted R-squared	0.472653	S.D. dependent var	0.026776
S.E. of regression	0.019444	Akaike info criterion	-5.040985
Sum squared resid	0.491886	Schwarz criterion	-5.033046
Log likelihood	3286.202	Hannan-Quinn criter.	-5.038007
F-statistic	1167.961	Durbin-Watson stat	1.999234
Prob(F-statistic)	0.000000		

Null Hypothesis: ISE$LOG has a unit root
Exogenous: Constant
Bandwidth: 10 (Newey-West using Bartlett kernel)

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.211874	0.2022
Test critical values:	1% level	-3.435157	
	5% level	-2.863550	
	10% level	-2.567890	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000690
HAC corrected variance (Bartlett kernel)	0.000775

Phillips-Perron Test Equation
Dependent Variable: D(ISE$LOG)
Method: Least Squares
Included observations: 1303 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISE$LOG(-1)	-0.004386	0.002010	-2.182739	0.0292
C	0.044907	0.020348	2.206913	0.0275

R-squared	0.003649	Mean dependent var	0.000520
Adjusted R-squared	0.002883	S.D. dependent var	0.026316
S.E. of regression	0.026279	Akaike info criterion	-4.438597
Sum squared resid	0.898419	Schwarz criterion	-4.430658
Log likelihood	2893.746	Hannan-Quinn criter.	-4.435618
F-statistic	4.764349	Durbin-Watson stat	1.852123
Prob(F-statistic)	0.029233		

Null Hypothesis: ISE$LOGDF has a unit root
Exogenous: Constant
Bandwidth: 13 (Newey-West using Bartlett kernel)

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-33.47862	0.0000
Test critical values:	1% level	-3.435157	
	5% level	-2.863550	
	10% level	-2.567890	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000688
HAC corrected variance (Bartlett kernel)	0.000662

Phillips-Perron Test Equation
Dependent Variable: D(ISE$LOGDF)
Method: Least Squares
Included observations: 1303 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISE$LOGDF(-1)	-0.926746	0.027648	-33.51984	0.0000
C	0.000483	0.000728	0.663292	0.5073

R-squared	0.463412	Mean dependent var	4.54E-06
Adjusted R-squared	0.463000	S.D. dependent var	0.035829
S.E. of regression	0.026256	Akaike info criterion	-4.440323
Sum squared resid	0.896869	Schwarz criterion	-4.432384
Log likelihood	2894.870	Hannan-Quinn criter.	-4.437344
F-statistic	1123.580	Durbin-Watson stat	2.001324
Prob(F-statistic)	0.000000		

Null Hypothesis: DJIALOG has a unit root
Exogenous: Constant
Bandwidth: 22 (Newey-West using Bartlett kernel)

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.788494	0.8215
Test critical values:	1% level	-3.435157	
	5% level	-2.863550	
	10% level	-2.567890	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000180
HAC corrected variance (Bartlett kernel)	0.000124

Phillips-Perron Test Equation
Dependent Variable: D(DJIALOG)
Method: Least Squares
Included observations: 1303 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DJIALOG(-1)	-0.002923	0.002510	-1.164513	0.2444
C	0.027059	0.023367	1.158040	0.2471

R-squared	0.001041	Mean dependent var	-0.000148
Adjusted R-squared	0.000273	S.D. dependent var	0.013425
S.E. of regression	0.013423	Akaike info criterion	-5.782166
Sum squared resid	0.234409	Schwarz criterion	-5.774226
Log likelihood	3769.081	Hannan-Quinn criter.	-5.779187
F-statistic	1.356089	Durbin-Watson stat	2.270145
Prob(F-statistic)	0.244430		

Null Hypothesis: DJIALOGDF has a unit root
Exogenous: Constant
Bandwidth: 18 (Newey-West using Bartlett kernel)

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-42.04471	0.0000
Test critical values:	1% level	-3.435157	
	5% level	-2.863550	
	10% level	-2.567890	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000177
HAC corrected variance (Bartlett kernel)	0.000149

Phillips-Perron Test Equation
Dependent Variable: D(DJIALOGDF)
Method: Least Squares
Included observations: 1303 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DJIALOGDF(-1)	-1.137643	0.027470	-41.41417	0.0000
C	-0.000169	0.000369	-0.459778	0.6458

R-squared	0.568653	Mean dependent var	9.54E-06
Adjusted R-squared	0.568321	S.D. dependent var	0.020246
S.E. of regression	0.013302	Akaike info criterion	-5.800238
Sum squared resid	0.230211	Schwarz criterion	-5.792299
Log likelihood	3780.855	Hannan-Quinn criter.	-5.797260
F-statistic	1715.133	Durbin-Watson stat	2.034256
Prob(F-statistic)	0.000000		

APPENDIX C

VECTOR AUTOREGRESSION ESTIMATES

Vector Autoregression Estimates
Included observations: 1302 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	ISELOG	DJIALOG
ISELOG(-1)	0.961376	-0.016177
	(0.02819)	(0.02004)
	[34.0985]	[-0.80738]
ISELOG(-2)	0.032843	0.016294
	(0.02811)	(0.01997)
	[1.16850]	[0.81574]
DJIALOG(-1)	0.401429	0.868966
	(0.04080)	(0.02899)
	[9.84003]	[29.9734]
DJIALOG(-2)	-0.397720	0.128652
	(0.04091)	(0.02907)
	[-9.72103]	[4.42486]
C	0.026482	0.020786
	(0.03387)	(0.02407)
	[0.78193]	[0.86365]
R-squared	0.996024	0.991976
Adj. R-squared	0.996011	0.991951
Sum sq. resids	0.455337	0.229954
S.E. equation	0.018737	0.013315
F-statistic	81218.83	40086.90
Log likelihood	3333.444	3778.180
Akaike AIC	-5.112817	-5.795976
Schwarz SC	-5.092957	-5.776115
Mean dependent	10.44193	9.307898
S.D. dependent	0.296675	0.148420

Determinant resid covariance (dof adj.)	5.38E-08
Determinant resid covariance	5.34E-08

Log likelihood	7205.923
Akaike information criterion	-11.05364
Schwarz criterion	-11.01392

VAR Lag Order Selection Criteria
Endogenous variables: ISELOG DJIALOG
Exogenous variables: C
Included observations: 1292

Lag	LogL	LR	FPE	AIC	SC	HQ
0	914.7850	NA	0.000834	-1.412980	-1.404986	-1.409980
1	7061.470	12264.83	6.19e-08	-10.92178	-10.89780	-10.91278
2	7148.530	173.4466	5.44e-08	-11.05036	-11.01039	-11.03536
3	7168.434	39.59087	5.31e-08	-11.07497	-11.01902*	-11.05397*
4	7170.975	5.047132	5.32e-08	-11.07272	-11.00077	-11.04571
5	7172.131	2.292218	5.35e-08	-11.06831	-10.98038	-11.03531
6	7186.381	28.21438	5.26e-08*	-11.08418*	-10.98026	-11.04518
7	7187.617	2.442777	5.29e-08	-11.07990	-10.96000	-11.03490
8	7191.976	8.603289	5.28e-08	-11.08046	-10.94457	-11.02946
9	7194.924	5.808773	5.29e-08	-11.07883	-10.92695	-11.02183
10	7197.932	5.917816	5.30e-08	-11.07729	-10.90943	-11.01429
11	7203.040	10.03441*	5.29e-08	-11.07901	-10.89515	-11.01000
12	7207.740	9.218573	5.28e-08	-11.08009	-10.88025	-11.00509

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Vector Autoregression Estimates
Included observations: 1302 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	ISE$LOG	DJIALOG
ISE$LOG(-1)	0.958493	0.002566
	(0.02833)	(0.01504)
	[33.8387]	[0.17068]
ISE$LOG(-2)	0.033067	-0.003217
	(0.02820)	(0.01497)
	[1.17271]	[-0.21496]
DJIALOG(-1)	0.605908	0.859839
	(0.05534)	(0.02937)
	[10.9493]	[29.2724]
DJIALOG(-2)	-0.593775	0.139242
	(0.05554)	(0.02948)
	[-10.6912]	[4.72320]
C	-0.026871	0.014963
	(0.05060)	(0.02686)
	[-0.53099]	[0.55705]
R-squared	0.995190	0.991973
Adj. R-squared	0.995176	0.991949
Sum sq. resids	0.816443	0.230038
S.E. equation	0.025090	0.013318
F-statistic	67092.41	40072.10
Log likelihood	2953.312	3777.942
Akaike AIC	-4.528898	-5.795609
Schwarz SC	-4.509037	-5.775749
Mean dependent	10.12046	9.307898
S.D. dependent	0.361217	0.148420
Determinant resid covariance (dof adj.)		9.27E-08
Determinant resid covariance		9.20E-08
Log likelihood		6852.233
Akaike information criterion		-10.51034
Schwarz criterion		-10.47062

VAR Lag Order Selection Criteria
Endogenous variables: ISE$LOG
DJIALOG
Exogenous variables: C
Included observations: 1292

Lag	LogL	LR	FPE	AIC	SC	HQ
0	793.9619	NA	0.001006	-1.225947	-1.217953	-1.222947
1	6689.742	11764.18	1.10e-07	-10.34635	-10.32237	-10.33735
2	6797.208	214.1001	9.38e-08	-10.50651	-10.46655	-10.49151
3	6815.536	36.45708	9.17e-08	-10.52869	-10.47274*	-10.50769*
4	6819.699	8.268163	9.17e-08	-10.52895	-10.45700	-10.50194
5	6821.693	3.954987	9.20e-08	-10.52584	-10.43791	-10.49284
6	6835.797	27.92313	9.06e-08*	-10.54148*	-10.43756	-10.50248
7	6837.174	2.721752	9.09e-08	-10.53742	-10.41751	-10.49242
8	6840.910	7.374630	9.10e-08	-10.53701	-10.40112	-10.48601
9	6843.381	4.870027	9.12e-08	-10.53465	-10.38277	-10.47764
10	6846.297	5.735458	9.13e-08	-10.53297	-10.36510	-10.46996
11	6850.316	7.895604	9.13e-08	-10.53300	-10.34914	-10.46399
12	6857.033	13.17347*	9.10e-08	-10.53720	-10.33736	-10.46220

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Vector Autoregression Estimates
Included observations: 1302 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	ISELOGDF	DJIALOGDF
ISELOGDF(-1)	-0.054302	0.016085
	(0.02978)	(0.02097)
	[-1.82339]	[0.76712]
ISELOGDF(-2)	-0.005736	0.028287
	(0.02815)	(0.01982)
	[-0.20381]	[1.42743]
DJIALOGDF(-1)	0.421545	-0.162317
	(0.04203)	(0.02959)
	[10.0294]	[-5.48509]
DJIALOGDF(-2)	0.091717	-0.146402
	(0.04344)	(0.03058)
	[2.11140]	[-4.78692]
C	0.000678	-0.000219
	(0.00052)	(0.00037)
	[1.30311]	[-0.59860]
R-squared	0.074752	0.036446
Adj. R-squared	0.071899	0.033475
Sum sq. resids	0.456114	0.226099
S.E. equation	0.018753	0.013203
F-statistic	26.19669	12.26469
Log likelihood	3332.334	3789.187
Akaike AIC	-5.111112	-5.812883
Schwarz SC	-5.091252	-5.793022
Mean dependent	0.000566	-0.000149
S.D. dependent	0.019466	0.013430
Determinant resid covariance (dof adj.)		5.25E-08
Determinant resid covariance		5.21E-08
Log likelihood		7222.277
Akaike information criterion		-11.07877
Schwarz criterion		-11.03905

VAR Lag Order Selection Criteria
Endogenous variables: ISELOGDF DJIALOGDF
Exogenous variables: C
Included observations: 1292

Lag	LogL	LR	FPE	AIC	SC	HQ
0	7055.993	NA	6.21e-08	-10.91949	-10.91150	-10.91649
1	7144.422	176.4473	5.45e-08	-11.05019	-11.02621	-11.04119
2	7164.477	39.95555	5.31e-08	-11.07504	-11.03507*	-11.06004*
3	7166.979	4.975786	5.32e-08	-11.07272	-11.01677	-11.05172
4	7168.176	2.377794	5.35e-08	-11.06838	-10.99644	-11.04138
5	7182.298	28.00354	5.26e-08*	-11.08405*	-10.99612	-11.05105
6	7183.485	2.350995	5.29e-08	-11.07970	-10.97578	-11.04070
7	7187.869	8.664985	5.28e-08	-11.08029	-10.96039	-11.03529
8	7190.716	5.620183	5.29e-08	-11.07851	-10.94262	-11.02751
9	7193.678	5.836796	5.30e-08	-11.07690	-10.92502	-11.01990
10	7198.513	9.512460*	5.29e-08	-11.07819	-10.91033	-11.01519
11	7203.212	9.231007	5.29e-08	-11.07928	-10.89542	-11.01027
12	7204.040	1.622451	5.32e-08	-11.07436	-10.87452	-10.99936

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Vector Autoregression Estimates
Included observations: 1302 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	ISE$LOGDF	DJIALOGDF
ISE$LOGDF(-1)	-0.042707	0.033514
	(0.03044)	(0.01596)
	[-1.40321]	[2.10051]
ISE$LOGDF(-2)	0.025631	0.021089
	(0.02829)	(0.01483)
	[0.90606]	[1.42210]
DJIALOGDF(-1)	0.614511	-0.181142
	(0.05753)	(0.03016)
	[10.6818]	[-6.00647]
DJIALOGDF(-2)	0.028985	-0.163720
	(0.05999)	(0.03145)
	[0.48317]	[-5.20601]
C	0.000651	-0.000229
	(0.00070)	(0.00037)
	[0.93287]	[-0.62635]
R-squared	0.089413	0.039137
Adj. R-squared	0.086604	0.036174
Sum sq. resids	0.820450	0.225467
S.E. equation	0.025151	0.013185
F-statistic	31.83883	13.20722
Log likelihood	2950.125	3791.007
Akaike AIC	-4.524002	-5.815680
Schwarz SC	-4.504141	-5.795819
Mean dependent	0.000541	-0.000149
S.D. dependent	0.026316	0.013430

Determinant resid covariance (dof adj.)	9.07E-08
Determinant resid covariance	9.00E-08
Log likelihood	6866.558
Akaike information criterion	-10.53235
Schwarz criterion	-10.49263

VAR Lag Order Selection Criteria
Endogenous variables: ISE$LOGDF DJIALOGDF
Exogenous variables: C
Included observations: 1292

Lag	LogL	LR	FPE	AIC	SC	HQ
0	6682.324	NA	1.11e-07	-10.34106	-10.33306	-10.33806
1	6792.680	220.1999	9.39e-08	-10.50570	-10.48172	-10.49670
2	6811.308	37.11202	9.18e-08	-10.52834	-10.48837*	-10.51334*
3	6815.300	7.941512	9.18e-08	-10.52833	-10.47237	-10.50733
4	6817.169	3.711497	9.21e-08	-10.52503	-10.45309	-10.49803
5	6831.585	28.58670	9.06e-08*	-10.54115*	-10.45322	-10.50815
6	6832.933	2.668049	9.10e-08	-10.53705	-10.43313	-10.49805
7	6836.825	7.694989	9.10e-08	-10.53688	-10.41698	-10.49188
8	6839.296	4.876243	9.12e-08	-10.53451	-10.39862	-10.48351
9	6842.280	5.879163	9.13e-08	-10.53294	-10.38106	-10.47594
10	6846.286	7.882418	9.13e-08	-10.53295	-10.36508	-10.46995
11	6853.039	13.26652*	9.09e-08	-10.53721	-10.35336	-10.46821
12	6853.628	1.153560	9.14e-08	-10.53193	-10.33209	-10.45693

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

APPENDIX D

JOHANSEN COINTEGRATION TEST OUTPUTS

Included observations: 1301 after adjustments
Trend assumption: Linear deterministic trend
Series: DJIALOG ISELOG
Lags interval (in first differences): 1 to 2

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.005654	7.593360	15.41	20.04
At most 1	0.000166	0.216192	3.76	6.65

Trace test indicates no cointegration at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.005654	7.377168	14.07	18.63
At most 1	0.000166	0.216192	3.76	6.65

Max-eigenvalue test indicates no cointegration at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

DJIALOG	ISELOG
-2.584169	4.213641
9.760620	-2.741514

Unrestricted Adjustment Coefficients (alpha):

D(DJIALOG)	-0.000137	-0.000168
D(ISELOG)	-0.001364	-5.96E-05

1 Cointegrating Equation(s): Log likelihood 7219.562

Normalized cointegrating coefficients (standard error in parentheses)	
DJIALOG	ISELOG
1.000000	-1.630559
	(0.48080)
Adjustment coefficients (standard error in parentheses)	
D(DJIALOG)	0.000354
	(0.00095)
D(ISELOG)	0.003526
	(0.00134)

Included observations: 1298 after adjustments
Trend assumption: Linear deterministic trend
Series: DJIALOG ISELOG
Lags interval (in first differences): 1 to 5

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.004852	6.608003	15.41	20.04
At most 1	0.000227	0.294319	3.76	6.65

Trace test indicates no cointegration at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.004852	6.313684	14.07	18.63
At most 1	0.000227	0.294319	3.76	6.65

Max-eigenvalue test indicates no cointegration at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

DJIALOG	ISELOG
-1.622782	3.951363
10.06594	-3.191056

Unrestricted Adjustment Coefficients (alpha):

D(DJIALOG)	-0.000134	-0.000195
D(ISELOG)	-0.001259	-6.76E-05

1 Cointegrating Equation(s): Log likelihood 7220.306

Normalized cointegrating coefficients (standard error in parentheses)

DJIALOG	ISELOG
1.000000	-2.434931
	(0.83500)

Adjustment coefficients (standard error in parentheses)

D(DJIALOG)	0.000217
	(0.00059)
D(ISELOG)	0.002043
	(0.00084)

Included observations: 1301 after adjustments
Trend assumption: Linear deterministic trend
Series: DJIALOG ISE$LOG
Lags interval (in first differences): 1 to 2

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.006193	8.238430	15.41	20.04
At most 1	0.000120	0.155844	3.76	6.65

Trace test indicates no cointegration at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.006193	8.082586	14.07	18.63
At most 1	0.000120	0.155844	3.76	6.65

Max-eigenvalue test indicates no cointegration at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

DJIALOG	ISE$LOG
-6.272353	4.340937
9.293109	-1.481384

Unrestricted Adjustment Coefficients (alpha):

D(DJIALOG)	-0.000275	-0.000139
D(ISE$LOG)	-0.001950	-4.47E-05

1 Cointegrating Equation(s): Log likelihood 6864.500

Normalized cointegrating coefficients (standard error in parentheses)

DJIALOG	ISE$LOG
1.000000	-0.692075
	(0.15542)

Adjustment coefficients (standard error in parentheses)

D(DJIALOG)	0.001724
	(0.00229)
D(ISE$LOG)	0.012231
	(0.00436)

Included observations: 1298 after adjustments
Trend assumption: Linear deterministic trend
Series: DJIALOG ISE$LOG
Lags interval (in first differences): 1 to 5

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.005054	6.737865	15.41	20.04
At most 1	0.000124	0.161331	3.76	6.65

Trace test indicates no cointegration at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.005054	6.576534	14.07	18.63
At most 1	0.000124	0.161331	3.76	6.65

Max-eigenvalue test indicates no cointegration at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

DJIALOG	ISE$LOG
-6.126751	4.349826
9.542425	-1.623370

Unrestricted Adjustment Coefficients (alpha):

D(DJIALOG)	-0.000242	-0.000140
D(ISE$LOG)	-0.001748	-4.72E-05

1 Cointegrating Equation(s): Log likelihood 6868.226

Normalized cointegrating coefficients (standard error in parentheses)

DJIALOG	ISE$LOG
1.000000	-0.709973
	(0.17774)

Adjustment coefficients (standard error in parentheses)

D(DJIALOG)	0.001483
	(0.00223)
D(ISE$LOG)	0.010712
	(0.00425)

APPENDIX E

GRANGER CAUSALITY TEST OUTPUTS

Pairwise Granger Causality Tests
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
ISELOGDF does not Granger Cause DJIALOGDF	1303	0.65245	0.4194
DJIALOGDF does not Granger Cause ISELOGDF		95.7524	7.E-22
ISE$LOGDF does not Granger Cause DJIALOGDF	1303	0.04131	0.8390
DJIALOGDF does not Granger Cause ISE$LOGDF		118.160	2.E-26

Pairwise Granger Causality Tests
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
ISELOGDF does not Granger Cause DJIALOGDF	1302	1.28593	0.2767
DJIALOGDF does not Granger Cause ISELOGDF		50.3064	9.E-22
ISE$LOGDF does not Granger Cause DJIALOGDF	1302	3.10589	0.0451
DJIALOGDF does not Granger Cause ISE$LOGDF		59.8407	1.E-25

Pairwise Granger Causality Tests
Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
ISELOGDF does not Granger Cause DJIALOGDF	1301	0.29241	0.8309
DJIALOGDF does not Granger Cause ISELOGDF		33.4319	8.E-21
ISE$LOGDF does not Granger Cause DJIALOGDF	1301	1.49102	0.2152
DJIALOGDF does not Granger Cause ISE$LOGDF		40.1138	9.E-25

Pairwise Granger Causality Tests
Lags: 4

Null Hypothesis:	Obs	F-Statistic	Prob.
ISELOGDF does not Granger Cause DJIALOGDF	1300	0.62403	0.6454
DJIALOGDF does not Granger Cause ISELOGDF		25.0970	5.E-20
ISE$LOGDF does not Granger Cause DJIALOGDF	1300	1.70264	0.1470
DJIALOGDF does not Granger Cause ISE$LOGDF		30.1893	5.E-24