MODELLING THE IMPACT OF US STOCK MARKET ON ASEAN COUNTRIES STOCK MARKETS

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ABSTRACT

The ASEAN countries which located on the Southeast Asian consist of 10 countries. Most of these countries depend on US as their main trading partner. As a result, if something does happen to US economy it surely will affect the economy of all these countries. Usually stock market fluctuation is used as the main indicator whether the economy of one country is in expansion or recession. Therefore, in this paper, we investigate the impact of US stock market fluctuation on four ASEAN countries stock markets namely Singapore, Indonesia, Thailand and Malaysia. Rather than using linear VAR model we used a two regimes multivariate Markov switching vector autoregressive (MS-VAR) model with regime shifts in both the mean and the variance to show how US stock market effect the four stock markets. Results revealed that when US stock market decline the four stock markets would also follow the same trend of decline and vice versa. Furthermore, it also found that the interaction between US stock market and the four stock markets is much stronger during declining period than expansion period. In addition, the MS-VAR model fitted the data better than the linear vector autoregressive model (VAR).

1. INTRODUCTION

The Association of Southeast Asian Nation or ASEAN was established in 1967 consists of 10 countries namely Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei, Laos, Cambodia, Vietnam and Myanmar. One of the purposes of the ASEAN association was to accelerate economy growth, social progress and cultural development in the region. All the countries not only have a trade agreement between each other but they also have the same main trading partner outside the region. Many investors are attracted to invest in ASEAN region because of low wages labour, a lot of raw materials and many incentives from the government of each country. US were the biggest trading partner follow by Japan then China and India was not far behind. Except for Singapore all the other countries are developing countries.

It is well known that US is main trading partner of many developing countries. Therefore, whatever happens to the US economy will also affect the economy of these countries. Usually the decline and increasing of the stock market is used as an indicator whether a country is in recession or expansion. This interrelationship phenomenon in international market is not only a result of the liberalization of capital markets in developed and developing countries and the increasing variety and complexity of financial instrument but also a result of the increasing relatively of the developing and developed economies as developing countries become more integrated in international flow of trade and payment. As a result, this has triggered the interest of economists and policy makers to find the linkages between the stock market of developed countries mainly the US and the stock market of developing countries

Numerous related studies on the relationship between stock market of US and developing countries have been done by researchers. For instance, Ghosh et al. (1999) examined whether the stock markets of nine Asian-Pacific countries are driven by US or Japan stock market during the financial turmoil in 1997 using the theory of cointegration. They had identified nine stock markets which can be divided into three groups; those that move with the US stock market, those that move with Japan stock market and those that are not affected by the two stock markets. Then Arshanapalli and Kulkarni (2001) studied the interdependence between Indian stock market and the US stock market and the results showed that the Indian stock market was not interrelated with the US stock market.

Later, Yang et al (2003), investigated the long run relationship and short-run dynamic causal linkages among the US, Japanese, and ten Asian emerging stock markets. They discovered that both long-run cointegration relationships and short-run causal linkages among these markets were strengthened during the financial crisis in 1997 and that these markets have generally been more integrated after the 1997 crisis than before the crisis. Wang et al. (2003) studied relationship among the five largest emerging African stock markets and US market and uncovered that both long-run relationships and short-run causal linkages show that regional integration between most of African stock markets was weakened after the 1997–1998 crisis. Finally, Serrano and Rivero (2003), revealed the mixed results on the existence of long run relationship due to structural breaks between the US and Latin Americans stock markets.

It appears that most of the research mention above did not focus on the ASEAN region specifically. Furthermore all the papers used similar methodology to analyze the interaction among the stock market. They begin their studies by finding whether the variables are cointegrated or not using cointegration test and followed by modelling the variables using Vector Autoregressive (VAR) or Vector Error Correction (VEC) to show the existent of short run or long run relationships among the variables. However in this paper we focus on finding the relationship between 4 ASEAN countries stock markets and the US stock markets. We also apply a different approach to study the interaction between the US and the four stock markets. Rather then finding linear interaction, we concentrate on investigate whether nonlinear interaction because of common regime switching behaviour exists among the stock markets by assuming that all the series are regime dependent. We use a two regime multivariate Markov Switching Vector Autoregressive (MS-VAR) model with regime shifts that happened in both the mean and the variance to extract common regime switching behaviour from all the series.

This paper is organized as follows. The specification and estimation of the Markov Switching Vector Autoregressive model are given in Section II. Section III presents the empirical results and discussion on the results. Section IV contains the summary and the conclusion.

2. MARKOV SWITCHING VECTOR AUTOREGRESSIVE (MS-VAR) MODEL

Hamilton in 1989 developed the Markov Switching Autoregressive model (MS-AR) to identify changes between fast and slow growth regimes in the US economy. The model assume that a time series, y_t is normally distributed with μ_i in each of k possible regime where $i = 1, 2, ..., k$. A MS-AR model of two states with an AR process of order p, $MS - AR(p)$ is given as follows:

$$\begin{aligned} y_t &= \mu(s_t) + \left[\sum_{i=1}^{p} \alpha_i \left(y_{t-i} - \mu(s_{t-i})\right)\right] + u_t \\ u_t \left| s_t \right. &\sim NID\left(0, \sigma^2\right) \quad and \quad s_t = 1, 2 \end{aligned} \tag{1}$$

where α_i are the autoregressive parameters with $i = 1, 2, ..., p$.

The MS-AR framework of Equation (1) can be readily extended to MS-VAR model with two regimes that allows the mean and the variance to shifts simultaneously across the regime. The model is given below:

$$\begin{aligned} &Y_t - \psi(s_t) = A_1(s_t)\left(Y_{t-1} - \psi(s_{t-1})\right) + ... \\ &+ A_p(s_t)\left(Y_{t-p} - \psi\left(s_{t-p}\right)\right) + \varepsilon_t \end{aligned} \tag{2}$$

where $Y_t = \left(Y_{1t}, ..., Y_{nt}\right)$ is the n dimensional time series vector, ψ is the vector of means, $A_1, ..., A_p$ are the matrices containing the autoregressive parameters, and ε_t is the white noise vector process such that $\varepsilon_t \left| s_t \right. \sim NID\left(0, \Sigma(s_t)\right)$ Other specifications of MS-VAR model are being discussed by Krolzig (1997).

From Equation (1) and (2), s_t is a random variable that triggers the behaviour of Y_t to change from one regime to another. Therefore the simplest time series model that can describe a discrete value random variable such as the unobserved regime variable s_t is the Markov chain. Generally, s_t follow a first order Markov process where it implies that the current regime s_t depends on the regime one period ago, s_{t-1} and denoted as:

$$\begin{aligned} &P\left[s_t = j \left| s_{t-1} = i, s_{t-2} = k, ...\right.\right] \\ &= P\left[s_t = j \left| s_{t-1} = i\right.\right] = p_{ij} \end{aligned} \tag{3}$$

where p_{ij} is the transition probability from one regime to another. From m regimes, these transition probabilities can be collected in a $(m \times m)$ transition matrix denoted as P.

$$\mathrm{P} = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1m} \\ p_{21} & p_{22} & \cdots & p_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ p_{m1} & p_{m2} & \cdots & p_{mm} \end{bmatrix} \tag{4}$$

with $\sum_{j=1}^{m} p_{ij} = 1, \quad i = 1, 2, ..., m \quad and \quad 0 \le p_{ij} \le 1$.

The transition probabilities also provide the expected duration that is the expected length the system is going to be stay in a certain regime. Let D define the duration of regime j. Then, the expected duration of the regime j is given by

$$E(D) = \frac{1}{1 - p_{jj}} \quad j = 1, 2, ... \tag{5}$$

The conventional procedure for estimating the model parameters is to maximize the log-likelihood function and then use these parameters to obtain the filtered and smoothed inferences for the unobserved regime variable s_t. However, this method becomes disadvantageous as the number of parameters to be estimated increases. Generally, in such cases, the Expectation Maximization (EM) algorithm is used. This technique starts with the initial estimates of the unobserved regime variable, s_t and iteratively produces a new joint distribution that increases the probability of observed data. These two steps are referred to Hamilton (1994) and Kim and Nelson (1999).

3. MODELLING DYNAMIC RELATIONSHIP

This section presents the results of the econometric specifications used for modelling the relationship between US and four ASEAN countries stock markets. It begins with a description of the data and testing for stationary using two unit root tests. Then if the data is stationary at the same order, Johansen test is used to examine the existent of cointegration. Later, the MS-VAR model is used to show the dynamic relationships.

3.1 Data

The data under investigation are 10 years old monthly average data from August 1999 until Julai 2009 which includes US Dow Jones Index (DWJON) and four ASEAN stock markets namely Kuala Lumpur Composite Index (KLCI), Jakarta Composite Index (JKI), Singapore Straits Time Index (STI) and Thailand Composite Index (TSI). Figure 1 and Figure 2 show the behaviour of the original and return series (which is the first difference of natural logarithms multiplied by 100 to express them in percentage terms) of the DWJON Index, the KLCI Index, the JKI index, the STI index and the TSI Index over the study period. A close inspection of the two figures reveals that the trend of up and down in the original series and the large positive and negative returns happen quite similar for the five series.

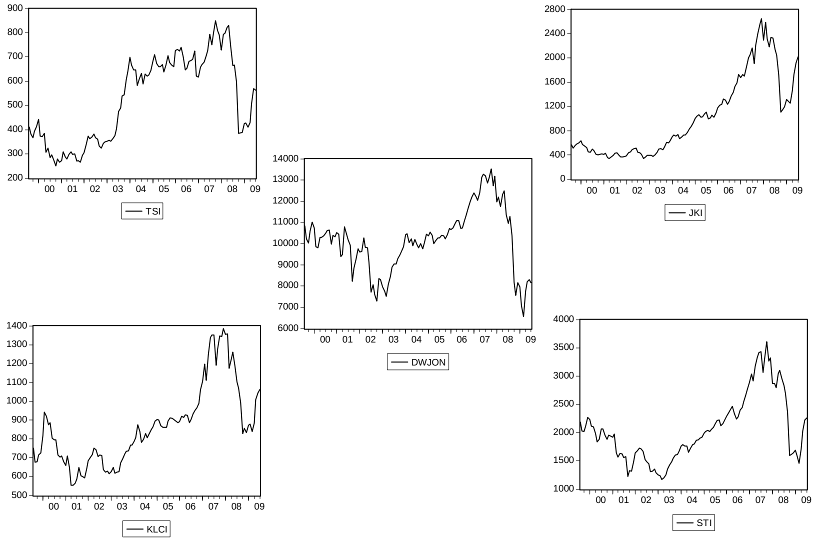

Figure 1: Original Series

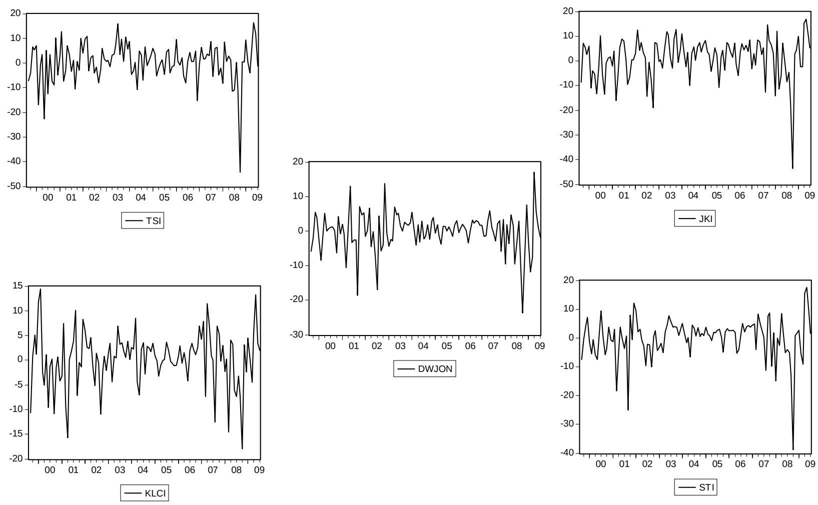

Figure 2: Return Series

3.2 Stationarity and Cointegration Tests

Many of the econometric models require the knowledge of stationarity and order of integration for the variables. The unit root test is usually used to determine whether the order of integration of a variable is at level or first differences. Two of the common unit root tests are used in this paper namely the ADF test and the PP test. Besides that the two tests have been implemented with and without time trend. The ADF test was developed by Dickey and Fuller (1979) and the PP tests was suggested by Philips and Perron (1988)

From Table 1, most of the statistics for series at level are not significant. This suggests that the null hypothesis of unit root test cannot be rejected and the indices are not stationary at level. After first differencing has been employed for the series, the null hypothesis of unit root test can be rejected at 1% level of significance for series with or without trend, Thus, the series are stationary at first difference and integrated of order 1, I(1). Thus, the cointegration test can be carried out after all the series are integrated at the same order.

Table 1 Unit Root Test

ADF test for sector indices

Variables	Level		1st Differentiation	
	No Trend	Trend	No trend	Trend
DWJON	-1.702	-1.642	-10.117**	-10.102**
STI	-1.356	-1.838	-9.503**	-9.015**
TSI	-1.278	-1.524	-9.639**	-9.610**
JKI	-0.429	-2.064	-9.323**	-9.139**
KLCI	-1.209	-2.031	-9.840**	-9.796**

PP test for sector indices

Variables	Level		1st Differentiation	
	No Trend	Trend	No trend	Trend
DWJON	-1.729	-1.671	-10.096**	-10.064**
STI	-1.542	-2.063	-9.059**	-9.021**
TSI	-1.487	-1.926	-9.668**	-9.638**
JKI	-0.669	-2.371	-9.323**	-9.139**
KLCI	-1.383	-2.299	-9.855**	-9.811**

Note:** indicates significance at 5%

The Johansen and Juselius (1990) cointegration test or JJ test is carried out to examine the existence of the long-run relationship among the indices. This test identifies the number of the cointegration vector by using the maximum likelihood method. Two test statistics are used to test the presence of *r* cointegrating vectors, namely trace statistic and maximum eigen statistic. The existence of cointegration among the variables indicates the rejection of the non-causality among the variables. The result of the cointegration test is shown in Table 2 and *r* represents the number of the cointegration relationships of the hypothesis test.

According to Table 2, both trace statistic and maximal eigen statistic suggests that there is no cointegrating vector at 5% level of significance. Thus, each indices does not sustain a stable equilibrium relationship with each other's therefore, this suggests that there is no long-run cointegration among the indices. Next we modeled the relationship among the return series using MS-VAR model.

Table 2 JJ Cointegration Test for Indices

Null hypothesis	Trace		Max-eigen	
	Statistic	5% critical value	Statistic	5% critical value
$r = 0$	56.47	68.52	26.68	33.46
$r \leq 1$	29.78	47.21	17.68	27.07
$r \leq 2$	12.09	29.68	6.55	20.97
$r \leq 3$	5.54	15.41	3.79	14.07
$r \leq 4$	1.74	3.76	1.74	3.76

3.3 Estimating MS-VAR Model

Following the principle of parsimony, we found that two regimes Markov Switching Vector Autoregressive model of order one with switching in the mean and the variance or MS-VAR(1) manage to capture the interaction among the five series very well. Before further discussing the estimation model, we need to determine whether regime shifts happened in the five return series. For this purpose, we use the likelihood ratio (LR) test suggested by Garcia and Perron (1996). As denoted in Table 3, the likelihood ratio test for testing the null hypothesis of linear model against an alternative of regime switching model, it is found that the null hypothesis can be rejected because the Davies (1987) *p*-value (value in the [] bracket) show significance results. Therefore, a nonlinear MS-VAR(1) model is better than linear VAR(1) model in describing the data. Moreover, the minimum value of AIC (Akaike), HQC (Hannan-Quinn) and SBC (Schwartz Bayesian) criteria indicate that the performance of the MS-VAR(1) models are better than the nested linear VAR(1) model.

Table 3 Model Comparison

	MS-VAR(1)	Linear VAR(1)
Log-likelihood	-1699.1097	-1765.3312
AIC	29.9341	30.6836
HQC	30.5728	31.1126
SBC	31.5072	31.7402
Log-likelihood Ratio (LR) Test	132.4430 [.000]	

Table 4 reports the parameters estimated of the two regimes MS-VAR (1). It can be seen from Table 4 that the estimated means of the MS-VAR(1) model for each of the two regimes has a clear economic interpretation. The first regime $(s_t = 1)$ indicates that all the stock market indices are in the Bear market or contraction phase with negative sign of the monthly expected return, $\mu(s_t = 1)$ and higher volatility, $\sigma^2(s_t = 1)$ Conversely, the second regime captures the Bull market or expansion phase of the stock market indices with positive sign of the monthly expected return, $\mu(s_t = 2)$ and lower volatility $\sigma^2(s_t = 2)$. However, the probabilities of staying in regime 1 and regime 2 are almost the same 0.8678 and 0.8660 respectively. It means on average the duration of staying in either regime is 7 to 8 months.

Table 4 MS-VAR (1) estimates for indices

	$DWJON_t$	STI_t	TSI_t	JKI_t	$KLCI_t$
	Regime-dependent means				
$\mu(s_t = 1)$	-1.4513	-1.8210	-1.6633	-1.5344	-0.4866
$\mu(s_t = 2)$	0.9551	1.8229	2.1968	3.6816	1.1531
	Coefficients				
$DWJON_{t-1}$	0.00672	0.1267	0.0341	0.1871	0.0650
STI_{t-1}	0.2161	0.3698	0.4723	0.4017	0.2226
TSI_{t-1}	-0.1129	-0.1158	-0.1738	0.0308	-0.0575
JKI_{t-1}	0.0269	0.0319	0.0401	-0.0397	0.0945
$KLCI_{t-1}$	-0.1150	-0.1676	-0.0502	-0.1857	-0.1261
	Regime-dependent variances				
$\sigma^2(s_t = 1)$	6.8992	8.9063	9.1021	10.0091	7.0208
$\sigma^2(s_t = 2)$	2.7194	2.5893	4.7544	4.0698	2.1378
p_{ij}	$s_{t-1} = 1$		$s_{t-1} = 2$		$E(D)$
$s_t = 1$	0.8678		0.1322		7.56
$s_t = 2$	0.1340		0.8660		7.46

Furthermore, the main advantage of using MS-VAR model is that it provides us with smoothed regime probability plots of regime 1 and regime 2 which are the probability of staying in either regime 1 or regime 2 at time *t*. As seen in Figure 2, the smoothed probabilities of regime 1 are near one just after the smoothed probabilities of regime 2 are near zero. While Table 5 stated all the dating of staying in each regime. This means the smoothed regime probability plot tell us at which point in time all the series follow the same behavior which is either all the indices are increasing (regime 2) or decreasing (regime 1).

As note on Table 5, the contraction period in early 2000 and 2001 happen because of the US economic downturn as the IT industry crash follow by the September 11 2001 attack on US. Nevertheless the longest contraction period happen from August 2007 until Mei 2009 with inline with the recession period in US. This is the longest and deepest recession period since 1930an recession. The recession period was triggered by the US housing market collapse and the ensuing global credit crisis. Until recently US recover from this recession and the MS-VAR model manages to capture it. The finding from Figure 3 and Table 5 ensure us that the suggestion of regime 1 as the state where all the stock markets are in the recession phase or the bear market and regime 2 as the state where all the stock markets are in the expansion phase or the bull market by using the estimated parameters is justified.

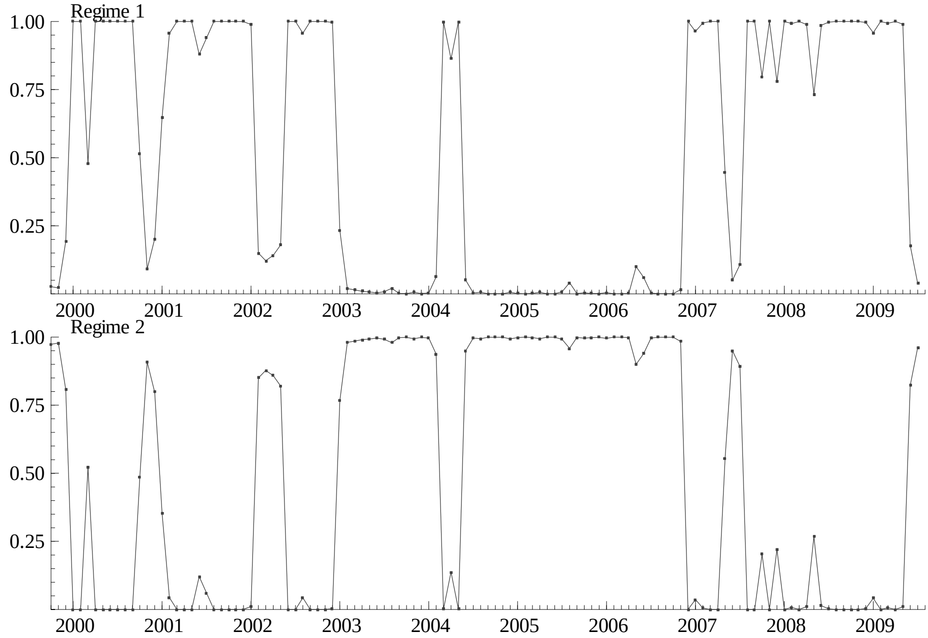

Figure 3 Smoothed Probability Plots of the MS-VAR(1) model

Table 5 Duration of Regime 1 and Regime 2

Regime 1 $(s_t = 1)$ (Contraction Period)	Regime 2 $(s_t = 2)$ (Expansion Period)
2000:1 - 2000:2 [1.0000]	1999:10 - 1999:12 [0.9197]
2000:4 - 2000:10 [0.9306]	2000:3 - 2000:3 [0.5211]
2001:1 - 2002:1 [0.9546]	2000:11 - 2000:12 [0.8532]
2002:6 - 2002:12 [0.9933]	2002:2 - 2002:5 [0.8517]
2004:3 - 2004:5 [0.9536]	2003:1 - 2004:2 [0.9719]
2006:12 - 2007:4 [0.9917]	2004:6 - 2006:11 [0.9891]
2007:8 - 2009:5 [0.9643]	2007:5 - 2007:7 [0.7993]
	2009:6 - 2009:7 [0.8924]

5. COMMENTS AND CONCLUSION

In this paper we have discussed modelling the interactions of US stock market (DWJON) and 4 ASEAN stock markets namely the KLCI (Malaysia), STI (Singapore), TSI (Thailand), and JKI (Indonesia). Results showed that the 4 ASEAN stock markets really depend on the increasing and decreasing of the US stock market. In addition the MS-VAR(1) model outperform linear VAR(1) in modelling the interaction.

REFERENCES

1. Arshanapalli, B and Kulkarni, M. S, (2001). Interrelationship between Indian and US Stock Markets. *Journal of Management Research*, 1, 141-148.
2. Davies, R. B. (1987). Hypothesis testing when a nuisance parameter is present only under the alternative. *Biometrika*, 74, 33-43.
3. Dickey, D. A. and Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74,:427-431.
4. Garcia, R. and Perron, P (1996). An analysis of the real interest rate under regime shifts. *Review of Economics and Statistics,* 78, 111-125.
5. Ghosh, A., Saidi, R and Johnson, K. H. (1999). Who moves the Asia-Pacific stock markets- US or Japan? Empirical evidence based on the theory of cointegration, *The Financial Review*, 34, 159-170.
6. Hamilton, J. D. (1989). A new approach to the economic analysis of nonstationary time series and the business cycle. *Econometrica*,57, 357-384.
7. Hamilton, J. D. (1994). *Time Series Analysis*. Princeton: Princeton University Press.
8. Johansen, S and Juselius, K (1990). Maximum likelihood estimation and inference on cointegration with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, 52, 169–210.
9. Kim, C. J. and Nelson, C. R. (1999). *State-space Models with Regime Switching: Classical and Gibbs-sampling Approaches with Application.* Cambridge: The MIT Press.
10. Krolzig, H. -M. (1997). *Markov-switching Vector Autoregression*. Berlin: Springer.
11. Phillips, P. C. B., and Perron, P. (1988). Testing for unit root in time series regression, *Biometrika*, 75, 335-346.
12. Wang, Z., Yang, J and Bessler, D. A. (2003). Financial crisis and African stock market integration. *Applied Economics Letters*, 10, 527–533.
13. Yang, J., Kolari, J. W. and Min, I. (2003). Stock market integration and financial crises: the case of Asia. *Applied Financial Economics*, 13, 477–486.
14. Serrano, J.L.F. and Rivero, S. S. (2003). Modelling the linkages between US and Latin American stock markets. *Applied Economics*, 35, 1423–1434.