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Full Length Research Paper

Transmission of returns between the U.S. stock market and four other major international stock market indexes

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This paper explored the transmission of returns between the U.S. stock market and four international (Canada, Japan, France, U.K.) stock market indexes from January 1996 to December 2006, using a nonlinear model which focused on threshold effects. The nonlinear, MARS (multivariate adaptive regression spline) model was applied to study this relationship at the general as well as industry specific levels. The nonlinear characteristic of the MARS model was able to provide valuable detailed information with its unique ability to capture and highlight the asymmetric nature of the international financial markets. The findings displayed evidence of asymmetric influence from the previous market from both extreme positive and negative price movements. This paper posits that there are advantages of applying the MARS model to international financial markets, as the results revealed significant information which may be beneficial for managing risk and hedging portfolios.

Key words: Transmission of returns, multivariate adaptive regression spline (MARS), stock market.

INTRODUCTION

Understanding the transmission of price movements in international financial markets is both important for academics and critical for portfolio managers. Since the globalization of the international equity markets in the 1980's, many have come to suspect international financial markets may be more linked than originally speculated. Masih and Masih (2002) showed that there is a strong cross-exchange of market covariation, resulting in information being transmitted from one market to another with great efficiency. Many studies have revealed evidence of interdependence in international stock indexes (Eun and Shim, 1989; Odier and Solnik, 1993; Lin et al., 1994; Hseih, 1991). Jeon et al. (1990) examined changes in price relations among global stock markets after the US stock market crash of October, 1987. They discovered that world financial markets after the crash became more closely linked resulting in an integration that has helped increase the efficiency in the allocation of capital and the global processing of information.

Additionally, the rise in international activity in equity transactions such as cross-border investment and 24 h global trading, and the technological innovations in communications and trading operations throughout the world has also contributed to the growing interdependence among the national stock markets. Interdependence has created a heightened sensitivity to movements in stock prices as a result of foreign disturbances and has been constant since October, 1987. In a study by Forbes and Rigobon (2002), the researchers analyzed three global financial crisis, 1) the October 1997, Hong Kong market decline; 2) the December 1994, Mexican market decline; and 3) the October 1987, US market crash. Their examination utilizing unconditional correlation coefficients (adjusted for bias) revealed no contagion (transmission of financial shock from one region to another) existed, but their estimates did show a high level of market interdependence in all three cases. Findings from these studies may have major implications on equity pricing models and reveal the limitations of an internationally diversified portfolio. This paper explores the transmission

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of returns between the US stock market and international stock market indexes, using a nonlinear model, focusing on threshold effects.

According to Beine et al. (2008), nonlinearity is based on thresholds and transaction costs. That is, transaction costs can generate thresholds within which trades are no longer profitable, and that if transaction prices are too high traders adopt a herding behavior which results in a limited information surge.

Additionally, Hirayama and Tusutsui (1998) examined daily stock price index data from 1975 to 1995 in the US, UK, German and Japanese exchanges. Using a dummy regression analysis, they demonstrated how small changes in the stock price index of any country do not affect the other country's index.

They observed that large changes in stock price indexes have a more significant effect in most cases, especially large negative changes. This study demonstrated that there is a threshold effect in international linkages of stock prices.

Thus, the notion of threshold influence comes from the belief that good and bad news impact markets differently. Bialkowski et al. (2006) tested for asymmetries in financial markets using a bivariate Markov switching framework for US, Japan, UK, and Germany during 1984 to 2003 and discovered transmission of returns were stronger during times of crisis. In another study by Longin and Solnik (2001), their results supported the explanation that correlation in international stock markets increases during bear markets, but not in bull markets. Kim et al. (2009) used a modified nonlinear unit root test (inf-t test) to investigate the existence of nonlinear cointegration between G7 stock indexes for the period 1969 to 2007. Their research revealed strong evidence of nonlinear comovement between stock indexes in France, Germany, Italy, UK, and the US.

Evans and McMillan (2009) studied asymmetric return patterns for 33 international stock market indexes during 1990 to 2005 and found evidence of asymmetric behavior in returns across all the markets. Hseih (1991) found that ARCH-type models could not fully capture the nonlinearity characteristics in stock returns.

Therefore, if the intent is to fit conditional density functions on stock returns, nonlinear dependence must be accounted for.

In order for this study to corroborate the results of prior studies and investigate the effectiveness of a nonlinear model the multivariate adaptive regression spline (MARS) model was utilized. The MARS model gives very specific price movement transmission information from one market to the next and is especially effective during periods of shock.

Therefore, information provided by the MARS model may allow risk managers and traders the opportunity to adjust their positions based on what occurred in the country which traded just prior to their own country's open.

METHODOLOGY

MARS is a relatively new methodology, attributable to Jerome Friedman, for nonlinear regression modeling. The MARS method allows for spline fitting of models in situations where the underlying probability density function of the coefficient and complex variable interactions change over time. Stokes (2009) summarizes the main idea about MARS as follows. MARS can be conceptualized as a generalization of recursive partitioning that uses spline fitting in lieu of other simple fitting functions. Given a set of predictor variables, MARS fits a model in the form of an expansion in project spline basis functions of predictors chosen during a forward and backward recursive partitioning strategy. MARS produces continuous models for high-dimensional data that can have multiple partitions and predictor variable interactions. Predictor variable contributions and interactions in a MARS model may be analyzed using ANOVA style decomposition. By letting the predictor variables in MARS be lagged values of a time series, one obtains a new method for nonlinear autoregressive threshold modeling of time series.
MARS builds models of the form

$$\hat{f}(x) = \sum_{i=1}^{s} c_i M_i(x),$$

The model is a weighted sum of basis function where c_i is a constant coefficient. In terms of the MARS notation, this is written as

$$y = \alpha' + c_1(x - \tau^*)_+ - c_2(\tau^* - x)_+ + e$$

MARS starts by repeatedly adding basis function in pairs to the model by forward pass and is estimated by backward pass using a modified form of the generalized cross validation (MGCV) to confirm the best possible model.

$$MGCV = [(1/N)\sum_{i=1}^{N}(y_i - \hat{f}(X))^2]/[1-[C(M)^*/N]^2],$$

where there are N observations, and C(M) is a complexity penalty. The default is set equal to a function of the effective number of parameters. The formula used is

$$C(M)^* = C(M) + \delta M.$$

A significant feature of the extension of MARS is its ability to produce models with limit cycles when modeling time series data that exhibit periodic behavior. In a physical context, limit cycles represent a stationary state of sustained oscillations, a satisfying behavior for any model of a time series with periodic behavior. The theory of MARS modeling has been adapted from papers by Friedman (1991) and Lewis and Stevens (1991).

RESULTS

The MARS model is able to provide valuable information. The nonlinear aspect of the MARS model allowed us to capture the periodic behavior of international financial markets and the asymmetric nature of their relationship to

Table 1. MARS results for U.S. broad-based stock index.

MARS Model	t	Non-zero Obs	% of Non-zero	Importance
DUS =				
-0.29 +	-4.18	2211	100	
+ 0.45 * max(DFR{ 0} +1.51 , 0.0)	21.1	2011	91	100
-0.42 * max(-1.51 - DFR{ 0} , 0.0)	-6.8	199	9	32
-0.13 * max(DUS{ 1} +2.90 , 0.0)	-6.54	2191	99	31
+ 1.08 * max(-2.90 - DUS{ 1} , 0.0)	6.31	19	1	30

Data: Morgan Stanley capital international perspective (January, 1996 to December, 2006). Daily close, Canada, France, Japan, U.K., U.S. (All data are daily returns). Indexes – broad-based, utility, energy, technology, healthcare. Daily stock market opening and closing: Japan: Tokyo (18:00-2:00 EST), Europe: Paris (3:00–9:30 EST), London (4:00–10:30 EST), North America: New York, Toronto (9:30-16:00 EST).

one another. The MARS results displayed the vulnerability of the international equity market to extreme daily price movement of the market which closed just prior to its own market's open. The results of this study confirm the asymmetric nature and the vulnerability of the international financial markets to one another's shocks. By observing Table 1, the asymmetric relationship between the U.S. stock market index and other international broad indexes (Canada, Japan, U.K., France) can be summarized.

The threshold values were identified by MARS using the modified form of the generalized cross validation (MGCV). The marginal effects can be interpreted as the percent change impact on the target country's equivalent market's daily return given a 1% change in the equivalent market's daily return from the country where the shock originated. The MARS model results, only reveal statistically significant variables and orders them in importance through an internal ranking system. The MARS model output shows the number of times (non-zero obs) and the percentage (% of non-zero) the threshold was reached during the period under study. In addition, the MARS model ranks the variables in order of significance (Importance) with a score of 100 being the most influential. Scores of less than 100 is based on its relative importance compared to the most significant factor.

U.S. broad-based index results

As reflected in Table 1, whenever the U.S. previous day's stock market daily return (DUS{1}) experienced a negative performance of less than -2.90%, it transmitted over as a marginal effect of 1.08% in the following day's U.S. stock market while a U.S. previous day's daily market movement of greater than -2.90% impacted the U.S. following day's daily market performance by -0.13%. During the period under investigation, the negative threshold level for the previous U.S. stock market's daily move was reached 19 times. This confirms the asymmetric influences of the stock market when there were big negative shocks. Two important aspects of this finding are the asymmetric behavior and threshold values. This is a great extension from the asymmetric behavior on negative and positive shocks or financial crisis shocks to asymmetric threshold effects by MARS that indentifies the actual threshold value instead of the traditional negative and positive shock argument. In this example, MARS identifies the excessive negative shocks defined as the daily return is -2.9%. The size effects of shock are an additional interesting aspect of the results. For example, any excessive negative market shock below -2.9%, has more than the previous shocks by 1.08 times. This explains the explosive market movement when the market is in panic mode.

We also observed that whenever the excessive negative France's daily return (DFR{0}) was lower than -1.51%, the U.S. daily market return was impacted by -0.42% and when France's daily performance was greater than -1.51% the U.S. market was influenced by 0.45%. The excessive negative shock transmission from France to U.S. occurred 199 times during the time period under study. The results from this study reveal the U.S. broad stock index market was influenced by shocks in the market which closed just prior to its own open (France).

U.S. industry specific results

The MARS model estimates a new linear relationship within the threshold zone which is expressed through a change in the slope once the threshold level is reached. Figures 1 to 4 show graphically illustrated examples of results from Table 2. Utility, technology, healthcare, and energy markets were observed to investigate whether certain sectors revealed more external influence. Results from Table 2 show the European market (France, U.K.) which is the last to trade prior to U.S.'s market, significantly impacts the U.S. trading session in every sector index (utility, technology, healthcare, energy) under study. The results also revealed the asymmetric behavior of these sector specific markets. For example,

Table 2. MARS Results for U.S. industry specific stock indexes.

MARS Model	t	Non-zero Obs	% of Non-zero	Importance
Utility index				
UTIUS =				
-0.93 +	-8.99	2562	100	
+ 0.09 * max(UTIUS{ 1} +3.59 , 0.0)	4.41	2542	99	48
+ 1.30 * max(-3.59 - UTIUS{ 1} , 0.0)	9.17	19	1	100
+ 0.07 * max(UTIFR{ 0} +6.43 , 0.0)	5.62	2542	99	61
+ 0.21 * max(-6.43 - UTIFR{ 0} , 0.0)	2.31	19	1	25
-0.17 * max(-2.99 - UTIFR{ 1} , 0.0)	-4.4	119	5	48
+ 0.10 * max(UTIUK{ 0} +1.67 , 0.0)	4.25	2452	96	46
Technology index				
TECUS =				
0.19 +	0.788	2694	100	
+ 0.27 * max(TECFR{ 0} +5.25 , 0.0)	13.6	2624	97	100
-0.14 * max(TECUS{ 1} +5.22 , 0.0)	-7.13	2664	99	52
+ 1.15 * max(-5.22 - TECUS{ 1} , 0.0)	4.96	29	1	36
+ 0.41 * max(TECUK{ 0} - 7.25 , 0.0)	2.45	24	1	18
-0.12 * max(7.25 - TECUK{ 0} , 0.0)	-6.15	2669	99	45
+ 0.68 * max(TECUK{ 1} - 7.25 , 0.0)	4.16	24	1	31
Health index				
HTHUS =				
0.86 +	7.9	2679	100	
-0.19 * max(4.78 - HTHUK{ 0} , 0.0)	-11	2659	99	100
+ 1.40 * max(-3.85 - HTHUS{ 1} , 0.0)	8.35	19	1	75
+ 0.13 * max(HTHFR{ 0} - 1.19 , 0.0)	3.61	569	21	33
-0.10 * max(1.19 - HTHFR{ 0} , 0.0)	-4.76	2109	79	43
+ 0.50 * max(HTHJP{ 1} - 3.58 , 0.0)	3.43	19	1	31
+ 0.06 * max(3.58 - HTHJP{ 1} , 0.0)	2.86	2659	99	26
Energy index				
ENGUS =				
1.48 +	8.07	2673	100	
-0.33 * max(4.70 - ENGUK{ 0} , 0.0)	-16.1	2649	99	100
-0.15 * max(ENGUS{ 1} +3.60 , 0.0)	-7.8	2653	99	48
+ 0.12 * max(ENGFR{ 0} +5.10 , 0.0)	6.78	2653	99	42
-1.06 * max(-5.10 - ENGFR{ 0} , 0.0)	-4.1	19	1	25
+ 0.37 * max(-2.69 - ENGCA{ 1} , 0.0)	3.35	79	3	21

Data: Morgan Stanley capital international perspective (January, 1996 to December, 2006). Daily close, Canada, France, Japan, U.K., U.S. (All data are daily returns). Indexes – broad-based, utility, energy, technology, healthcare. Daily stock market opening and closing: Japan: Tokyo (18:00-2:00 EST), Europe: Paris (3:00–9:30 EST), London (4:00–10:30 EST), North America: New York, Toronto (9:30-16:00 EST).

the marginal effects on the U.S. technology index changes from 0.12 to 0.41 when the positive threshold of 7.25% of U.K.'s daily market movement is reached (Figure 2), while in the U.S. energy index market, once France experienced an excessive negative shock which exceeded -5.10%, the marginal effect changed from 0.12 to 1.06 (Figure 4). The results displayed the vulnerability of the U.S. market to extreme daily price movements of the European market. The sector specific study results revealed the strong linkages when markets were

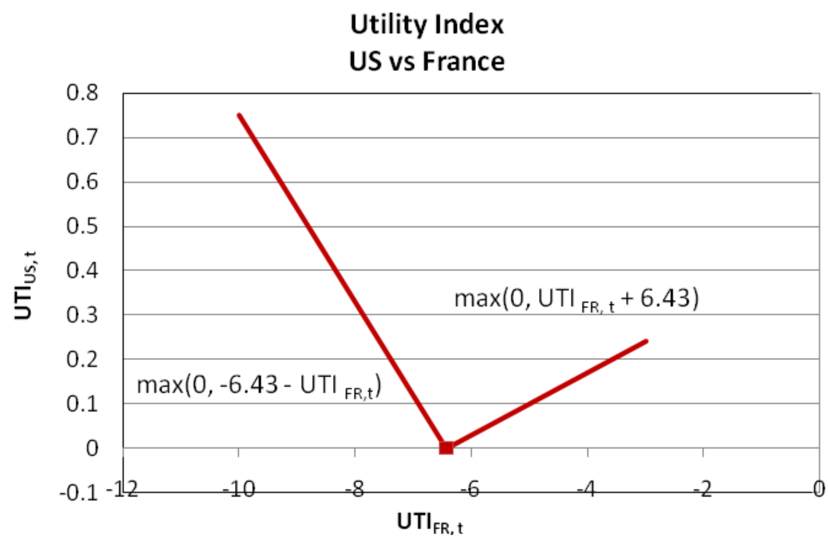

Figure 1. Asymmetric effects of France on U.S. in utility index.

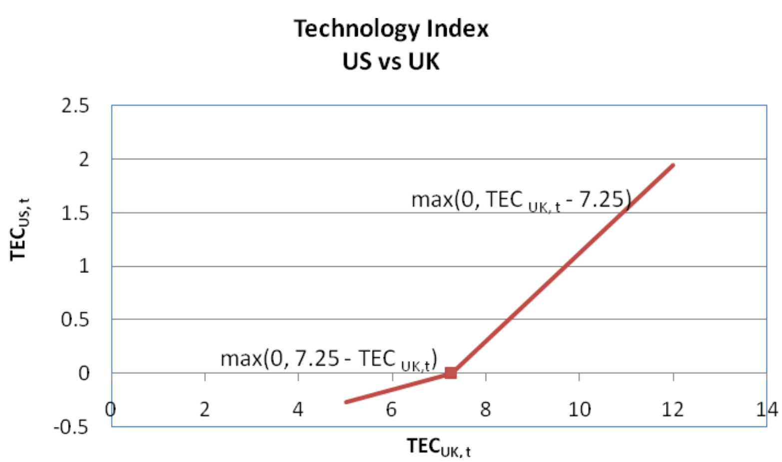

Figure 2. Asymmetric effects of UK on U.S. technology index.

excessively volatile and also identified the difference between the impact of positive and negative extreme price movements for each sector index.

The MARS model showed utility sector in France ($UTI_{FR,\,t}$) is expected to influence the utility sector in US ($UTI_{US,\,t}$) by -0.21 when $UTI_{FR,\,t}$ is less than -6.43 (19 times) and by 0.07 when $UTI_{FR,\,t}$ is greater than -6.43 (2542 times). This indicates that an extreme negative shock in the utility sector in France improved US utility sector strongly while the relationship is weakly positive in general. The MARS model showed technology sector in UK ($TEC_{UK,\,t}$) is expected to influence the technology sector in US ($TEC_{US,\,t}$) by 0.41 when $TEC_{UK,\,t}$ is greater than 7.25 (24 times) and by 0.12 when $TEC_{UK,\,t}$ is less than 7.25 (2669 times). This indicates that the UK technology sector has a very strong positive impact on the US technology sector during times of extreme positive shocks; however, the magnitude of impact is much less during normal times. The MARS model showed the healthcare sector in France ($HTH_{FR,t}$) is expected to influence the healthcare sector in US ($HTH_{US,t}$) by 0.13 when $HTH_{FR,\,t}$ is greater than 1.19 (569 times) and 0.10 when $HTH_{FR,\,t}$ is less than 1.19 (2109 times).

This indicates that the healthcare sector in France is linked with the US health care sector in a very consistently positively manner. The MARS model showed the energy sector in France ($ENG_{FR,t}$) is expected to influence the energy sector in the US by 1.06 when $ENG_{FR,\,t}$ is less than -5.10 (19 times) and 0.12 when

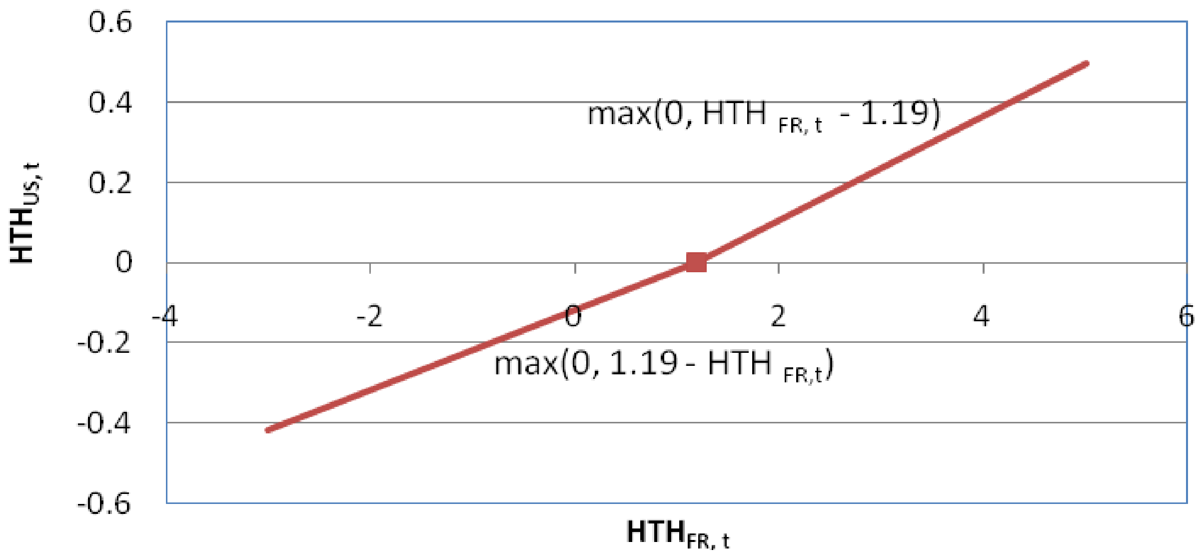

Figure 3. Asymmetric effects of France on U.S. in Healthcare index.

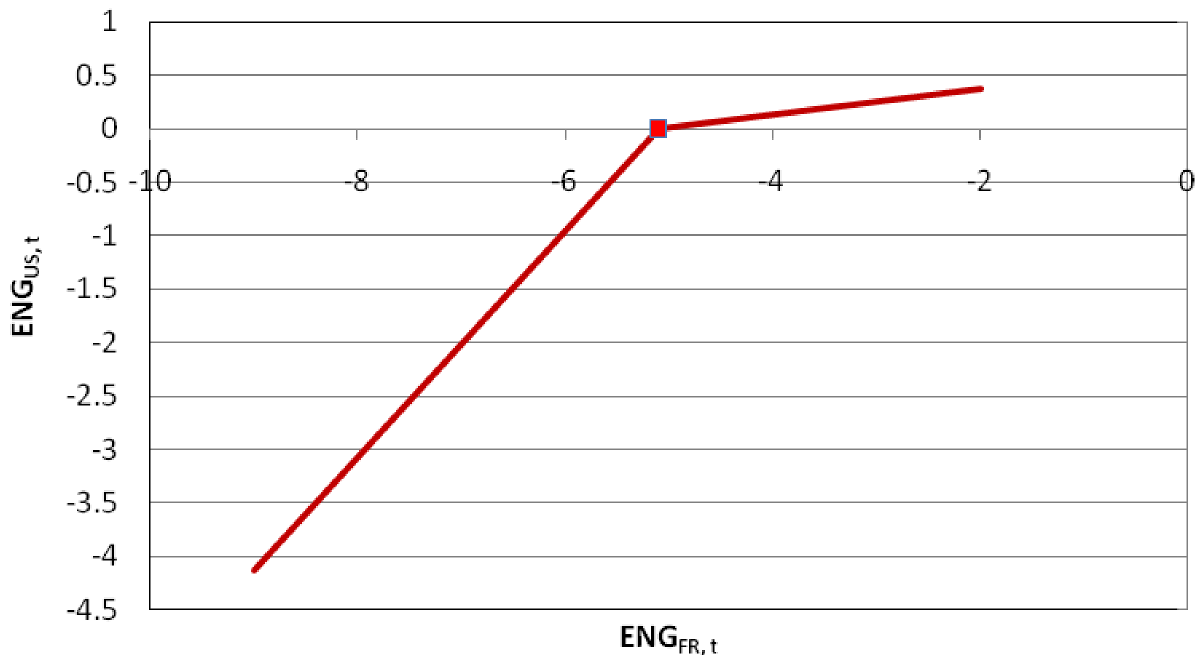

Figure 4. Asymmetric effects of France on U.S. energy index.

$ENG_{FR,\,t}$ is greater than -5.10 (2653 times).

This indicates an extreme negative shock in the energy sector in France which strongly influences the energy sector in US while the relationship is weakly positive in general. This shows that the US energy sector is highly linked with France's energy sector in the presence of negative news in France.

DISCUSSION

This study investigated the transmission of daily stock market returns for four countries (Japan, U.K., France, and Canada) to the U.S. The MARS model was applied to examine this relationship at the broad-based as well as industry specific levels. The study revealed that the U.S.

trading session was significantly influenced by the market which closed just prior to its own opening. Typically, the previous market's price movement had even a stronger influence than U.S.'s own market's lagged data. This is most likely due to the fact that U.S.'s own lagged price movement was neglected to capture the more current information which was included in the previous market's trading session.

The results from this study also provided supportive/ corroborative evidence of asymmetric influence from the previous market from both extreme positive and negative price movements. The nonlinear aspect of the MARS model was able to provide valuable additional detailed information with its unique ability to capture and highlight the asymmetric nature of international financial markets. The sector specific MARS study results revealed the strong linkages when markets were excessively volatile and also identified the difference between the impact of positive and negative extreme price movements with great detail. This paper revealed the advantages of applying the MARS model to international financial markets as its results revealed very specific information which may be helpful for managing risk and hedging portfolios.

The findings of this study can benefit international portfolio managers in many ways. First, the results should alert managers to the existence of price comovements in international stock markets and help them be aware of the possible limitations of international diversification. Second, the results from the inter-sector study should cause the portfolio managers to consider diversifying international portfolios on a sector basis as well as by country. Third, through the utilization of the MARS model, a portfolio manager can receive very specific information on how to rebalance and/or hedge their portfolio after an extreme price movement in the market which traded just prior to its own open. A study which includes the influence of international financial markets on other countries as well as the U.S. would provide portfolio managers with valuable additional information for risk management.

Also, given the shake-up in the global economy due to the 2008 subprime mortgage debacle, the current Middle East turmoil, and the tragic earthquake and tsunami disaster that affected Japan, future studies which incorporate the latest data and utilize an appropriate volatility model should provide some interesting and useful research outcomes.

REFERENCES

Masih AMM, Masih R (2002). Propagative causal price transmission among international stock markets: Evidence from the pre- and post globalization period. Global Financ., J., 13: 63-91.

Beine M, Capelle-Blanchard G, Raymond H (2008). International nonlinear causality between stock markets. Eur. J. Financ., 14(8): 663-686.

Bialkowski J, Bohl M, Serwa, D (2006). Testing for financial spillovers in calm and turbulent periods. Q. Rev. Econ. Financ., 46: 397-412.

Eun CS, Shim S (1989). International transmission of stock market movements. J.Financial. Quant. Anal., 24: 241-256.

Evans T, McMillan DG (2009). Asymmetric return patterns: Evidence from 33 international stock market indices. Appl. Econ. Lett., 16: 775-779.

Forbes KJ, Rigobon R (2002). No contagion, only interdependence measuring stock market comovements. J. Financ., 57(5): 2223-2261.

Friedman JH (1991). Multivariate adaptive regression splines (with discussion). Annal. Stat., 19: 1.

Hirayama K, Tsutsui Y (1998). Threshold effect in international linkage of stock prices. Japan World Econ., 10: 441-453.

Hseih D (1991). Chaos and nonlinear dynamics: Application to financial markets. J. Financ., 46(5): 1839-1877.

Jeon BN, Von Furstenberg GM (1990). Growing international comovement in stock price indexes. Q. Rev. Econ. Bus., 30(3): 15-30.

Kim HW, Stern L, Stern M (2009). Nonlinear mean reversion in the G7 stock markets. Appl. Financ. Econ., 19: 347-355.

Lewis PAW, Stevens JG (1991). Nonlinear modeling of time series using multivariate adaptive regression splines (MARS). J. Am. Stat. Assoc., 86: 864-877.

Lin WL, Engle RF, Ito T (1994). Do bulls and bears move across borders? International Transmission of Stock Returns and Volatility as the World Turns. Rev. Fin. Stud., 7: 507-537.

Longin F, Solnik B (2001). Extreme correlation of international equity markets. J.Finan., 66(2): 649-676.

Odier P, Solnik B (1993). Lessons for international asset allocation. Financ. Analyst J., 49: 63-77.

Stokes HH (2009). Specifying and diagnostically testing econometric models.