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Investigating the Relationship between Japanese Stock Market and International Stock Markets Using Logistic Smooth Transition Regression Model

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Abstract
This study seeks to investigate the nonlinear influences in relationships between international stock returns, and study of their behavior in the two phases of the financial market, "bull" and "bear" markets. To this aim, eight stock markets were chosen from the developed countries such as, United States, United Kingdom, Germany, Japan, India, Hong Kong, Singapore and South Korea. This research utilized logistic smooth transition regression (LSTR) model with the world market return as the transition variables for smooth asymmetric response of Japanese stock returns (Nikkei). The results showed that the important factor in determining the asymmetric behavior of Japan's stock returns was US stock returns (S&P500). Furthermore, stocks returns were found to stay longer in the up-market than in the down-market, therefore it was riskier for investors to keep portfolios when the market was at bull phase. In this respect, the results further indicated that, Japan was able to recover quickly from the effect of the shocks.

Keywords: Logistic Smooth Transition Regression model, Stock market, Bull and bear market, Financial market, JMulTi

Introduction

The stock market index is regarded as an important indicator by the investors; this can be used as a benchmark by which the investors or fund managers compare the returns of their own portfolio. Numerous studies have been done on Japanese stocks. With regards to Ravi *et la*. (1998), in Japan, the stocks formed a small percentage of the total value of the financial assets. Becher and Finnarty (1989) found the relationship between US (S&P500) and Nikkei. Ghosh*et al.* (1999) investigated the integration between Japanese and US stock market and Asian-pacific stock markets. Chan and Felmingham (2003), discussed about the interdependence of share markets in the developed economies of East Asia (Singapore, Korea, Japan, Taiwan and Hong Kong). Rajavat and Joshi (2013) investigated that stock market of India (BSE) is highly correlated with NSE(98%), Nikkei (64%) and HANGSEN (82%).
In this work, we investigate the relationship among the stock indices and deploy the LSTR to assess the transition between the two regimes. Results are compared with those of the US, UK, Germany and Asian indices. In US stock market, we have S&P500; There are two European markets (FTSE100 and DAX) and four Asian (HSI, KOSPI, STI and BSE). The Japanese stock market (Nikkei) is then compared with these markets based on the description of indices and estimation in the LSTR model.
The Logistic Smooth Transition Regression (LSTR), which is a generalization of a particular switching regression model in the work of Bacon and Watts (1971) is chosen as the best model to solve the problem at hand. This model is known to possess the possibility of allowing for smooth and continuous transition between regimes which has been proposed by Granger and Teräsvirta (1993) and Teräsvirta (1994).

The Logistic Smooth Transition Regression (LSTR) Model

The logistic smooth transition regression (LSTR) model is a nonlinear economic model that can be used in both macroeconomic and financial modeling. It dose nest a linear model that researchers choose a linear model as their starting point and then consider an nonlinear extension should they turn out to be necessary. The switching regression model, Markov switching model and the smooth transition regression model are the examples of the models that belong to this category.
Using the Logistic Smooth Transition Regression (LSTR) model given by,

$$y_t = \phi' z_t + \theta' z_t \frac{1}{1 + \exp\left(-\gamma(s_t - c)\right)} + u_t \tag{1}$$

For the first order LSTR (LSTR1) and,

$$y_t = \phi' z_t + \theta' z_t \frac{1}{1 + \exp\left(-\gamma(s_t - c_1)(s_t - c_2)\right)} + u_t \tag{2}$$

For the second order LSTR (LSTR2) with $\gamma > 0$ in both models.Where $y_t = (y_{1t}, \dots, y_{kt})$, is the dependent stock/portfolio, $z_t = (w_t', x_t')$ is a vector of exogenous variables, $x_t = (x_{1t}, \dots, x_{kt})$, and lagged variables of $y_{t-1}, \dots, y_{t-p}, x_{t-1}, \dots, x_{t-r}$, that *p* is the optimal lag of endogenous variables and *r* is the optimal lag of exogenous variables. $\phi = (\phi_0, \phi_1, \dots, \phi_m)'$ and $\theta = (\theta_0, \theta_1, \dots, \theta_m)'$ are $((m+1) \times 1)$ parameter vectors and $u_t \sim \text{iid } N(0, \sigma^2)$ is error terms. The transition function (F(.)) contains γ as slop value to determine the speed of transferring between regimes (states) and also measures the degree of nonlinearity. A high value of the nonlinear parameter implies an instantaneous switch between the market states 'bull' and 'bear' while a low value of the parameter implies a slow transiting between the market phases;[1] The$c$ as threshold value and s_t as the transition variable that changes of the series are based on the values of this variable. The LSTR classifies the market into a 'bear' phase when $s_t < c$ and in a 'bull' phase when $s_t > c$.

Econometric Methodology

A step-by-step procedure for specifying the Smooth Transition Regression (STR) model was provided by Teräsvirta (1994), which contains three stages, specification, estimation and evaluation. The specification stage is the important component of LSTR model that controls linearity against LSTR model. To this end, Sikkonnen, Kuukkonen and Träsvirta (1998) suggested to apply Taylor series linear approximation to the logistic transition function in the STR model. The Taylor expansion function is mathematically expressed as follows,

$$y_t = \beta_0 + \beta_1 z_t s_t + \beta_2 z_t s_t^2 + \beta_3 z_t s_t^3 + u_t, \text{for } t = 1, 2, \dots, T \qquad (3)$$

That β_0 and β_i are the dimension column vectors of stock\portfolio. The null hypothesis then becomes, $H_0: \beta_1 = \beta_2 = \beta_3 = 0$. The acceptance of null hypothesis provides a warning that identification of two regime parameter is not possible. If the null hypothesis is rejected, then we proceed to estimating the nonlinear LSTR model using the nonlinear least square method. The test statistic is an asymptoticχ^2-distributed with *3q* degree of freedom, but the corresponding F-staitstic is recommended instead, with (3q ,T-4q-1) degrees of freedom, that *q* is the number of the exogenous variables.

The transition function is derived from the auxiliary regression as shown in (3). The following tests must be performed to discriminate between LSTR1 and LSTR2, to choose an appropriate STR model.

$H_{04}: \beta_3 = 0 H_{03}: \beta_2 = 0 \mid \beta_3 = 0 H_{02}: \beta_1 = 0 \mid \beta_2 = \beta_3 = 0.$

The choice between LSTR1 and LSTR2 models can be based on the auxiliary regression. The coefficient vectorsβ_j, $j = 1, 2, 3$, in (3) are functions of the parameters in (1) and (2).In the special case$c = 0$, it can be shown that $\beta_2 = 0$when the model is an LSTR1 model, whereas $\beta_1 = \beta_3 = 0$when the model is an LSTR2 model.

The estimation of the LSTR model follows the nonlinear least squares and then the chosen model can then be evaluated to test of no remaining nonlinearity, no autocorrelation and parameter constancy.

The Data, Empirical Results and Discussion

The data used in this study, come from Yahoo Finance[2] and they are the monthly Japanese stocks (Nikkei), American stocks (S&P500), European stocks (FTSE and DAX) and Asian stocks (KOSPI, HSI, STI and BSE) indices. The data span form February 1998 to December 2012 giving a total of 179 data points. Almost all of these markets increase and decrease volatility, especially around the attacks of September 11, 2001 and financial crisis of 2007-2008, and also they have reached their peak point around February 2008.

As can be seen in TABLE 1, all stock indices are trended and non-stationary at level, hence the prices need to transform to returns by taking the differences of the logarithm of the stock prices ($\Delta \log(y_t) = \log(y_t) - \log(y_{t-1})$). This is carried out for all the eight series and TABLE 2 presents the descriptive measures.

[1]Financial markets have been classified to be in the period of 'up' and 'down' market phases which implies 'bull' and 'bear' market, respectively.

[2]. http://finance.yahoo.com/

Table1.Augmented Dickey-Fuller (ADF) Test Results for Unit Roots

Index	Nonzero mean[1]		Time trend[2]	
	Level	First Differences	Level	First Differences
S&P500	-2.5646(6)	-5.1470(5)*	-2.5570(6)	-5.1305(5)*
FTSE	-2.3746(5)	-4.9277(5)*	-.2.3564(5)	-4.9227(5)*
DAX	-1.8455 (1)	-5.1282(5)*	-2.1184(1)	-5.1408(5)*
BSE	-0.5560(1)	-10.0960(0)*	-2.4120(1)	-10.0744(0)*
KOSPI	-2.4613(3)	-6.5549(2)*	-3.9999(7)	-6.5673(2)*
STI	-1.3733(7)	-4.5165(6)*	-2.1976(7)	-4.5201(6)*
Nikkei	-1.8732(1)	-10.3169(0)*	-2.0862(1)	-10.2919(0)*
HIS	-2.1973(3)	-6.7454(2)*	-2.0816(5)	-6.7274(2)*

[1]The critical values for ADF test statistic are -3.43, -2.86 and -2.57 for 1%, 5% and 10% respectively
[2]The critical values for ADF test statistic are -3.96, -3.41 and -4.13 for 1%, 5% and 10% respectively

Table 1 reports the results of the Augmented Dickey-Fuller (ADF) unit root test for the eight stock indices, with the selected lag length of VAR process for each stock index (according to Akaike Information Criteria (AIC)), for all levels and the first differences of the natural log values. Interestingly all stock indices under consideration are non-stationary in their levels (even at 1% level), and they become stationary when they are first differenced.

Table 2.Descriptive measures on the returns series of stocks

	Mean	Min	Max	SD	Test-Statistic	p-value (χ^2)	Skewness	Kurtosis
S&P500	0.0018	-0.228	0.113	0.0428	189.5381	< 0.001	-1.2475	7.3967
FTSE	0.0003	-0.2003	0.099	0.039	137.1602	< 0.001	-1.1660	6.6132
DAX	0.0028	-0.22	0.129	0.058	55.7243	< 0.001	-0.9869	4.9019
BSE	0.0097	-0.279	0.193	0.067	31.1854	< 0.001	-0.6571	4.5740
STI	-0.005	-0.724	0.26	0.094	2888.0476	< 0.001	-2.8148	21.9132
Nikkei	-0.003	-0.28	0.14	0.053	119.5866	< 0.001	-0.8742	6.6149
HIS	0.0042	-0.255	0.18	0.062	21.8029	< 0.001	-0.3433	4.5711
KOSPI	0.007	-0.225	0.208	0.071	5.3772	0.0680	-0.2195	3.7296

From the summary statistics in table 2, Indian stock market (BSE) gave the highest returns during the 14 years. The values of standard deviation (SD) were observed to be very close to one another. The lowest SD belongs to the United Kingdom, hence FTSE is the most reliable and stable stock market among these international markets, whereas Singapore is the most risky stock market (with the highest SD value). The normality test for stock returns shows the signs of lepokuricity and as well negatively skewed. The p-values of Jarque-Bera test (normality test) are rejected for all stocks except Asian Hang Seng.

Table 3. Saikkonen and Lütkepohl (S&L) Co-integration Test

Hypothesis	Test statistic	Critical values		p-value
		10%	5%	
None	159.47	147.04	152.59	0.0186
At most 1*	101.93	114.84	119.77	0.3903
At most 2	80.43	86.64	90.95	0.2308
At most 3	52.30	62.45	66.13	0.4201
At most 4	29.23	42.25	45.32	0.6892

The S&L co-integration test is perfect for the financial series with structural breaks, and in fact the trend breaks are ignored by this type of co-integration test (Lütkepohl&Krätzig, 2004).The main idea of this test is, using the data to estimate the future returns.The result indicates the presence of one co-integration relation ($\mathbf{r = 1}$). In other words, there is a long-run co-movement among these eight stock indices. Also the S&L co-integration test can be performed for each possible pair of stock returns. The results indicate that there are several long-run relationship among the stock indices (at 5% level). The significant pairs for long-run relationship are: (Germany, UK), (Japan, Hong Kong), (Japan, South Korea), (India, Hong Kong),(India, South Korea), (South Korea, Singapore) and (South Korea, Hong Kong), (Germany, Hong Kong).

The next step consists in testing whether or not a nonlinear model (LSTR) would be appropriate for this dataset. To this aim in JMulTi, we select stock returns of BSE, DAX, HSI, STI, KOSPI, FTSE and S&P500 as candidate transition variables.

Table 4.The P-value of Linearity Test

Hypothesis	P-value						
	BSE	DAX	HIS	STI	KOSPI	FTSE	S&P500*
F-statistic	0.225	0.029	0.612	0.583	0.667	0.245	0.025
H_{04}	0.471	0.129	0.47	0.566	0.626	0.718	0.034
H_{03}	0.342	0.153	0.757	0.227	0.724	0.107	0.07
H_{02}	0.163	0.073	0.348	0.804	0.325	0.259	0.444
Suggested model	Linear	LSTR1	Linear	Linear	Linear	Linear	LSTR1

* US stock return (S&P500) is suggested by JMulTi as the transition variable.

In table 4, F-statistic presents the results of linear model against LSTR model. As it is observed, the null hypothesis of linearity is strongly rejected for all return series except S&P500 and DAX. The results show that all p-value of the tests for S&P500 are almost less than the corresponding values for DAX, therefore between these two variables, S&P500 would be a better choice for transition variable. Not surprisingly, because the investigations show that S&P500 has a great impact on Nikkei index even for future overnight returns and also there is a high correlation between the open to close return for the US stocks and the Japanese stock market in the same period (Becher*et al.*, 1990) and also Tokic (2003) found that there is a long-term relationship between US stock markets and Japanese stock market.

Table 5. Estimated STR Model for Stock Returns (Nikkei)

Variable	Stock index	Estimate	Standard Deviation	T-statistic	p-value
		Linear Part			
Constant	-	0.104	0.0560	1.851	0.066
India	BSE	-0.867	0.633	-1.37	0.173
Germany	DAX	-0.428	0.346	-1.236	0.218
Hong Kong	HSI	0.956	0.556	1.718	0.088
Singapore	STI	0.114	0.07	1.635	0.104
South Korea	KOSPI	0.796	0.499	1.595	0.113
UK	FTSE	0.564	0.498	1.132	0.259
US	S&P500	0.846	0.536	1.58	0.116
		Nonlinear Part			
Constant	-	-0.104	0.056	-1.851	0.066
India	BSE	0.939	0.636	1.476	0.142
Germany	DAX	0.739	0.361	2.049	0.042
Hong Kong	HSI	-0.903	0.564	-1.6	0.112
Singapore	STI	-0.136	0.083	-1.643	0.102
South Korea	KOSPI	-0.692	0.502	-1.377	0.171
UK	FTSE	-0.396	0.527	-0.75	0.454
US	S&P500	-0.759	0.563	-1.347	0.18
Gamma	-	16.312	27.568	0.592	0.555
C_1	-	-0.061	0.006	-10.734	0.000

According to the table 5, the estimated the parameters in first order of LSTR model for Nikkei index is written as the following equation.

$$\begin{aligned} Nikkei_t = {} & 0.104 - 0.867(BSE_t) - 0.428(DAX_t) + 0.956(HSI_t) + 0.114(STI_t) + 0.796(KOSPI_t) \\ & + 0.564(FTSE_t) + 0.846(S\&P500) \\ & + [-0.104 + 0.939(BSE_t) + 0.739(DAX_t) - 0.903(HSI_t) - 0.136(STI_t) \\ & - 0.692(KOSPI_t) - 0.396(FTSE_t) \\ & - 0.759(S\&P500_t)](\frac{1}{1+\exp\{-16.312(S\&P500_t + 0.061\}}) \end{aligned} \quad (4)$$

The results in table 5 report a high value of the slope parameter, 16.312. Hence, it could be concluded that, the returns in the Japanese stock market are characterized by asymmetric cycles with a relatively high degree of transition between regimes determined by the S&P500 returns. The values of S&P500 stock returns are plotted versus the corresponding values for the transition function $G(16.32\,, -0.061\,, S\&P500_t)$. In mathematical terms, the transition function in model (4) is interpreted that as $S\&P500_t$ increases, the magnitude of exponential part decreases to *zero* and it can be ignored thus naturally the denominator of the transition function tends to *one* (bull market), $\lim_{S\&P500 \to +\infty}(\frac{1}{1+\exp\{-16.312(S\&P500_t+0.061)\}}) \approx 1$and mutually, as $S\&P500_t$ decreases, the magnitude of exponential part increases, and the denominator of the transition function tends to *zero* (bear market), $\lim_{S\&P500 \to -\infty}(\frac{1}{1+\exp\{-16.312(S\&P500_t+0.061\}}) \approx 0$.This result is confirmed in FIGURE 1 that shows a rapid transition between bull and bear markets.

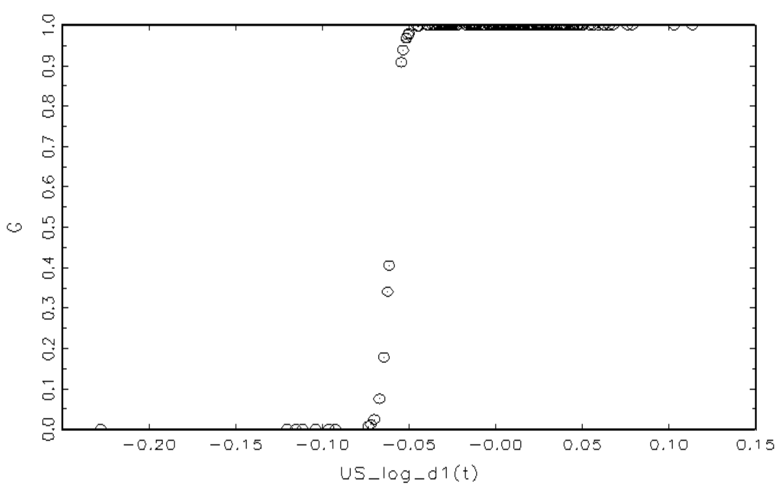

Figure 1. Plot of Transition Function ($S\&P500_t$) of First Order Parameter Nonlinear Smooth Transition Regression (LSTR1) for Nikkei

Since the most observations lie in the up-market in this plot, we can claim that the possibility of the risk in the up-market is usually lower than risk in the down-market. And also the claim that volatility increases with duration in bear markets.

Concluding Remarks and Discussion

This study considers the Japanese stock market with other foreign markets in America, Europe and Asian. The first order of LSRT of Teräsvirta (1994) is used. We obtain results which strongly confirm the existence of the two phases of markets: ‘bull’ and ‘bear’ in our data. The Peak period detected in the model coincides with the period of global financial crisis (2007-2008). In the LSTR1 model, S&P500 is selected as the transition variable for Nikkei returns and the high speed of transition between bull and bear markets indicates that Japanese stock return is able to recover quickly from the world’s finance returns. And also according to the Fama’s classification about Efficient Market Hypothesis (EMH), Nikkei is an efficient and strong market in the world. Furthermore the possibility of risk in the bull market is lower than in the bear market, that is because of this reason that, stocks returns are found to stay longer in the up-market than in the down-market, therefore it is riskier for investors to keep portfolios when the market is at bull phase.

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