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RESEARCH ARTICLE

Markov Switching Model of Philippine Stock Market Volatility

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A Markov-switching model was used to analyze the monthly return of the Philippine Stock Exchange, based on data from January 2000 to July 2017, to estimate the regime-switching behavior of the equity market. The study identified two states of the market: one characterized by positive mean return and low volatility, and another with negative mean return and high volatility. The high-volatility periods of the exchange were linked to various political and economic events. Results showed that the Philippine stock market reacted to domestic political issues that changed or challenged the country's leadership. Economic events such as the Asian financial crisis, the country's rapid currency depreciation, and the global financial crisis also prompted the local bourse to switch to a high-volatility state.

Keywords: Markov switching, stock return volatility

JEL classification: G10; G14

The Philippine Stock Exchange Composite Index, or PSEi, is a selection of 30 common stocks of listed companies that are used as a benchmark to represent the performance of the Philippine stock market (PSE Academy, 2011). Based on data from EIU Financial Services and Forecasts (2017), the Philippine economy has been expanding steadily, with GDP growth averaging at 5.61% over the last 10 years. Consequently, the Philippine stock market also flourished as the PSEi's average closing price increased from 2,071 in January 2000 to 7,935 in July 2017 (The Wall Street Journal, n.d.). This is very much expected as stock market performance is positively and robustly correlated with economic growth (Levine & Zervos, 1998). The Philippine stock market is likely to develop further as the International Monetary Fund (2017) saw the country to be among the fastest growing economies in the world, with growth outlooks amounting to 6.8% in 2017 and 6.9% in 2018. However, despite its high growth performance and potential, the Philippines, being an emerging market, remains to be characterized by high risk relative to developed markets. Therefore, investing in this market would still require higher returns (Bekaert & Harvey, 2017).

This paper tracks the periods when the Philippine stock market switched to a high-volatility state, and identifies the events that can be linked in the change in regime. This provides insights in understanding the market movement, which is helpful in risk management and asset pricing. The study employs the Markov switching model (also known as the regime-switching model), which was popularized by Hamilton (1989). As empirical pieces of evidence have shown that economic and financial variables may demonstrate different patterns over time, the Markov switching model captures these changes as it employs two or more models to represent these variations in patterns. These models are then combined through a Markovian switching mechanism (Kuan, 2002). This model permits the variance of stock returns to interchange across different states, taking into consideration any change in the variance over the study period (Moore & Wang, 2007). The Markov-switching model has been employed in various financial and economic studies to analyze the shifting trend of different variables. In Western cases, the model was used to study the U.S. business cycle by analyzing the country's real GNP data (Hamilton, 1989); the volatility persistence in the monthly excess returns of the three-month treasury bill vis-à-vis one-month Treasury bill (Cai, 1994); the implied stock market volatilities which were tested in predicting the volatility index (VIX) compiled by the Chicago Board Options Exchange (Dueker, 1997); and the volatility in the stock markets of Czechia, Hungary, Poland, Slovenia, and Slovakia (Moore & Wang, 2007). In Asia, Wang and Theobald (2007) studied the regime-switching pattern in the stock market volatility of Indonesia, Korea, Malaysia, Philippines, Taiwan, and Thailand by using data from 1970 to 2004.

In Philippine studies, the model was utilized in the analysis of the country's business cycle by using GDP data (Bautista, 2002), and the time-varying betas of select stocks (Yu, Goyeau, & Bautista, 2011. Bautista (2003) also tracked the regime-switching behavior of the Philippine stock market by using a regime-switching ARCH model on weekly stock return data from February 1987 to October 2007. This research extends that study by also using a regime-switching model on data from January 2000 to July 2017. Unlike the model used by Bautista (2003), the model in this study does not include an autoregressive term, and utilizes monthly returns instead of weekly returns; both of which are discussed in the succeeding sections.

Model Specification

The return model assumes the basic Markov switching model discussed by Timmermann (2000) in the form of:

$$y_t = \mu_{s_t} + \sigma_{s_t}\varepsilon_t \tag{1}$$

where y_t represents the monthly return of the Philippine stock market, ε_t is an i.i.d. random variable with mean 0 and variance σ^2; and s_t is an unobserved state indicator which only assumes integer values {1, 2, …, k}, following a k-state Markov process. Similar to Bautista (2003), this study also classifies the regimes of the Philippine stock market into two: low-volatility state, and high-volatility state. This means that s_t will either be 1 or 2. Consequently, the regime-switching mean μs_t will take on the value μ_1 to represent the mean return for regime 1, and μ_2 to denote the mean return for regime 2. At the same time, the regime-switching volatility σ_{st} will equate to σ_1 to show the volatility of regime 1, and σ_s to present the volatility of regime 2. This model is consistent in the discussion in Timmermann (2000) in comparing the mean return and volatility between two states of a stock market.

The value that s_t takes on depends only on the most recent value s_{t-1}. Hamilton (1994) showed that the probability that s_t takes on some value j is equal to:

$$P\{s_t = j \mid s_{t-1} = i, s_{t-2} = k, \ldots\} = P\{s_t = j \mid s_{t-1} = i\} = p_{ij} \tag{2}$$

The transition probability for the two-state Markov chain, $\{p_{ij}\}_{i,j=1,2}$, , gives the probability that state j will follow after state i. For any k-state Markov chain, the transition probabilities will have the following relationship:

$$p_{i1} + p_{i2} + \cdots + p_{ik} = 1 \tag{3}$$

The transition probabilities can be presented in a transition matrix. For a two-state process, the corresponding transition matrix will be:

$$\mathbf{P} = \begin{bmatrix} p_{11} & p_{21} \\ p_{12} & p_{22} \end{bmatrix} \tag{4}$$

Because of equation (3), equation (4) can be restated as:

$$P = \begin{bmatrix} p_{11} & 1 - p_{22} \\ 1 - p_{11} & p_{22} \end{bmatrix} \quad (5)$$

According to Timmermann (2000), the higher the value of is, the longer will the process remain in regime , as the duration of a regime is equal to $\frac{1}{1-p_{ii}}$ (Bautista, 2003). If $p_{11} = 1$, then there is no possibility of switching to state 2 once the process enters state 1. This renders state 1 as an absorbing state (Hamilton, 1994).

Hamilton (1989) discussed a basic filter which allows for a probabilistic inference about the stock market state s_t based on the historical observations on y. Given the joint conditional probability as input:

$$P\{s_{t-1}, \ldots, s_{t-k} \mid y_{t-1}, y_{t-2}, \ldots, y_0\} \quad (6)$$

the basic filter arrives at the output:

$$P\{s_t, \ldots, s_{t-k+1} \mid y_t, y_{t-1}, \ldots, y_0\} \quad (7)$$

The notation $\{y_t, y_{t-1}, \ldots, y_0\}$ denotes the complete history of observed over the period t. This results from adding y to $\{y_{t-1}, y_{t-2}, \ldots, y_0\}$. On the other hand, $\{s_t, \ldots, s_{t-k+1}\}$ shows the k most recent values of s. This basic filter is an iterative process, and the updating algorithm is discussed in detail in Hamilton (1989).

The basic filter provides inference about the state s_t based on the currently available information (Hamilton, 1989). Equation (7) allows us to determine the probability of which state the stock market is in. Modifying the formula used by Bautista (2002) to apply in a two-state model, the filtered probability is determined by:

$$P\{s_t \mid y_t, y_{t-1}, \ldots, y_0\} = \sum_{s_{t-1}=1}^{2} \cdots \sum_{s_{t-k+1}=1}^{2} P\{s_t, \ldots, s_{t-k+1} \mid y_t, y_{t-1}, \ldots, y_0\} \quad (8)$$

Equation (8) determines the probability that the stock market is either in state 1 or 2 conditional to information available at time t. The two possible values for each period t sum up to 1. On the other hand, the smoothed probability determines the probability of being in a state s_t based on the full sample up to time T:

$$P\{s_t \mid y_T, y_{T-1}, \ldots, y_0\} = \sum_{s_{t-1}=1}^{2} \cdots \sum_{s_{t-k+1}=1}^{2} P\{s_t, \ldots, s_{t-k+1} \mid y_T, y_{T-1}, \ldots, y_0\} \quad (9)$$

The smoothed probability is considered more accurate because it utilizes the full sample, which means that this probability is conditional on more information (Bautista, 2002). Therefore, the analysis in this study will be based on the smoothed probability.

Data and Estimation Results

The dependent variable is equal to the monthly returns of PSEi. The publicly available information was obtained from the website of The Wall Street Journal (n.d.). Monthly return was computed as follows:

$$y_t = \log(PSEi_{closing,t}) - \log(PSEi_{opening,t}) \quad (10)$$

wherein y_t is the market return for month t, $PSEi_{closing,t}$ is the closing PSEi value on the last trading day of month t, and $PSEi_{opening,t}$ is the opening PSEi value on the first trading day of month t.

The study period is from January 2000 to July 2017, resulting in a total of 211 observations. Table 1 shows the data's descriptive statistics. The positive mean confirms the bullish run of the Philippine market over the study period. Based on the Jarque-Bera test (JB test) result, the null hypothesis that the monthly return follows a normal distribution is rejected.

According to Wang and Theobald (2007), using monthly frequency limits the presence of noise, which is commonly present in data with higher frequencies such as daily data. Noise present in higher frequency data can make it difficult to isolate cyclical variations, which can blur the analysis of factors causing the switching behavior.

Data were subjected to the augmented Dickey-Fuller test to assess stationarity. The null hypothesis that there is a presence of a unit root in the data is rejected. Therefore, the time series variable of monthly return is stationary. Based on the Q-statistics, no lag observation will be used to explain the observation in y_t. This explains why a Markov switching model with no autoregressive term is used in this study.

From the estimated parameters in Table 2, regime 1 is characterized by positive mean return and low

Table 1. *Summary Statistics of the Philippine Monthly Return From January 2000 to July 2017*

Mean	Median	Max.	Min.	Std. dev.	Skewness	Kurtosis	JB test
0.005297	0.011212	0.154217	-0.27727	0.058783	-0.67756	5.355226	64.91***

, **, and * denote significance at 10%, 5%, and 1% levels, respectively*

Table 2. *Estimated Parameters of the Model*

μ_1	m_2	σ_1	σ_2
0.014883***	-0.026596**	0.045848***	0.0810232***
(0.003833)	(0.013239)	(0.058996)	(0.109965)

, **, and * denote significance at 10%, 5%, and 1% levels, respectively. Standard errors are enclosed in parentheses under the parameter estimates.*

Table 3. *Regime Transition Probabilities*

p_{11}	p_{22}	p_{12}	p_{21}
0.987184	0.966214	0.012816	0.033786

volatility, whereas regime 2 shows negative mean return and high volatility. This implies that market conditions are unfavorable when it enters regime 2 as the return is unattractive and risk is higher in this state. Section IV identifies the periods when the market switched to regime 2, and the events that can be associated with that change in state. The residuals of the estimated model were subjected to JB test, and the null hypothesis that they follow a normal distribution is rejected. Based on the transition probabilities in Table 3, the duration of regime 1 is 78.03 months, and of regime 2 is 29.60 months.

Discussion of Results

The Philippine stock market was in state 2 in the following ranges in the study period: January 2000 to September 2002 and November 2007 to December 2008. These were the periods when the smoothed probability that equals to 2 is at least 0.50. The corresponding movement of the monthly market return and smoothed probability that s_t has the value of 2 are shown in Figures 1 and 2. Figure 2 shows that the high-volatility state of the market from 2000 to 2002 can be attributed to the domestic political unrest during that period, whereas the market regime in 2008 can be explained by the global financial crisis. Details of these events are discussed further in this section.

The high-volatility state of the market from 2000 to 2002 can be attributed to various political and economic events during this period. The presidency of Joseph Estrada, which lasted from June 1998 to January 2000, was marred with various scandals of corruption and economic mismanagement. It was reported that he amassed about US$82 million in kickbacks and payoffs during his term (Brown, 2001). Consequently, the Asian financial crisis and the persistence of its effects also occurred within his term, compounding the people's dissatisfaction in his leadership. Thus, in January 2001, Joseph Estrada was overthrown through a political protest in the form the second EDSA Revolution. He was replaced by the Vice-President in his administration, Gloria Macapagal-Arroyo. This revolution was the beginning of a politically turbulent climate for the Philippines that year. In April 2001, Joseph Estrada was arrested by the Sandiganbayan for plunder. This arrest caused an uprising among his followers, which prompted them to gather around the EDSA Shrine to form a protest similar to the two previous EDSA Revolutions in the country. This rebellion, however, was unsuccessful as they were unable to unseat Gloria Macapagal-Arroyo from the

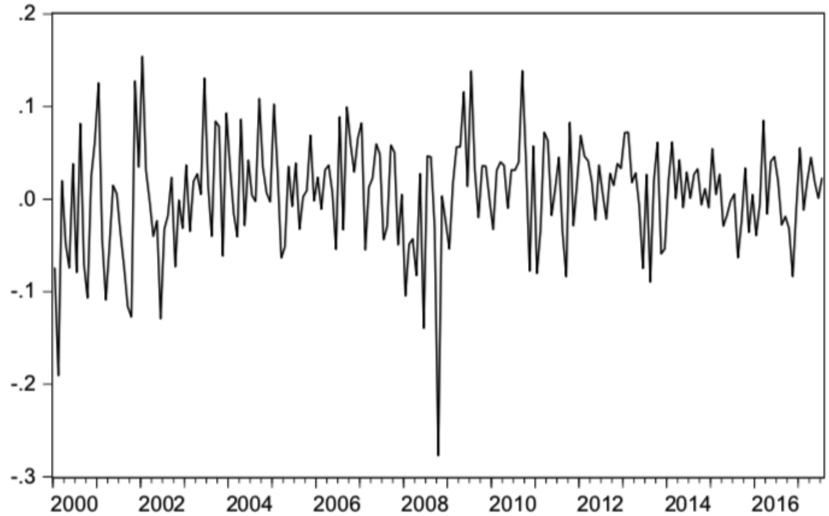

Figure 1. Monthly return of the Philippine stock market from January 2000 to July 2017.

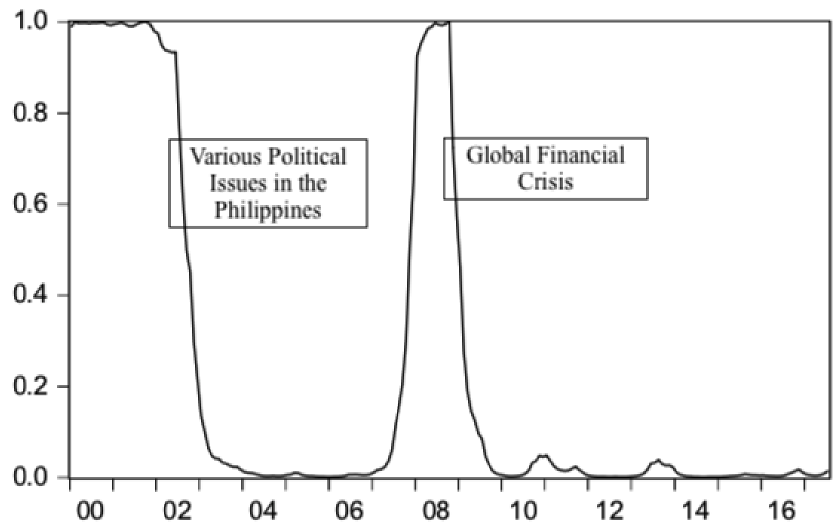

Figure 2. Smoothed probability that $s_t = 2$ from January 2000 to July 2017.

Table 4. *End-Period Exchange Rate of Philippine Peso Against the U.S. Dollar (PHP/USD)*

Year	1998	1999	2000	2001	2002	2003	2004
Exchange Rate	39.06	40.33	50.00	51.40	53.10	55.57	56.27

Source: EIU Financial Services and Forecasts (Online)

presidency. During the same period, the Philippine peso also depreciated against the U.S. dollar, especially from 1999 to 2003, as shown in Table 4.

On the other hand, the Philippine stock market entering regime 2 in 2008 can be attributed to the global financial crisis, which was mainly driven by the U.S. subprime mortgage market. During this year, the PSEi closing value ranged from 1,704 to 3,617, with the declining closing values on the last trading day of each month shown in Table 5 (The Wall Street Journal, n.d.). As it was a time of heightened risk aversion and uncertainty, both domestic and foreign investors unloaded their stocks or stayed in the sidelines to wait for conditions to improve. Raising fresh capital through the stock market slowed down during this period (Guinigundo, 2010).

Table 5. *PSEi Closing Value on the Last Trading Day of Every Month in 2008*

Month	PSEi Closing Value
January	3,266
February	3,130
March	2,985
April	2,750
May	2,827
June	2,460
July	2,577
August	2,688
September	2,570
October	1,951
November	1,972
December	1,873

Source: The Wall Street Journal (n.d.).

After Joseph Estrada, the presidents who succeeded him during the study period—Gloria Macapagal-Arroyo, Benigno Aquino III—had their share of political scandals. Rodrigo Duterte, who succeeded Benigno Aquino III and is just in the first year of his term in the study period, is just as controversial. However, it should be noted that none of the political events linked to these presidents caused the Philippine stock market to switch to a high-volatility state. The Philippine market also did not switch to a high-volatility regime during the national election seasons within the study period, which occurred in 2001, 2004, 2007, 2010, 2013, and 2016. Based on the evidence, it could mean that gravity is necessary for political issues to have an impact on the stock market. From the results of this study, the political events that explained the high-volatility state of the Philippine stock market were characterized by mass demonstrations that changed or challenged the country's leadership. This is consistent with the results of Bautista (2003) as the relevant political events he cited in his study were the many coup attempts which hounded the presidency of Corazon Aquino from 1987 to 1990.

Conclusion

By employing a Markov-switching model, the study determined the periods when the Philippine stock market entered states of high volatility. From there, various political and economic events, both domestic and international, were identified to explain the market's high-volatility regimes during the study period. Most events linked to the high-state of the stock market were economic in nature. These events include the lingering effects of the Asian financial crisis, the country's sharp currency depreciation, and the global financial crisis. In terms of domestic political issues, only the country's change and the challenge of leadership in 2001 affected the local bourse's volatility. The stock market did not switch to a high-volatility state amid other political controversies during the study period. This signifies that gravity of a political event may be necessary to affect the volatility of the stock market, which is consistent with a previous study.

This study provides a guide to fund managers and various investors in analyzing and understanding the movement of the stock market better. Specifically, it offers insights about the nature of political events that can statistically change the nature of the stock market volatility. This is important in risk management and asset pricing brought by exposure to an emerging market like the Philippines, especially because similar markets are usually characterized by political instability.

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