CHAPTER 3

Methodology

3.1 General

The aims of this study is to obtain the Hurst exponent of the Thai natural rubber price, then the fractal properties and dynamic characteristic could be gained as well. This study uses the single fractal to analyze the Thai natural rubber price by using the Rescaled Range analysis.

3.2 Rescaled Range Analysis

This study employs the method R/S analysis which was presented by Hurst (1951). The rescaled range is a statistical method for measuring the variability of a tome series, which was introduced by British hydrologist Harold Edwin Hurst. The technique was used to forecast Nile River flooding of the Aswan High Dam which plays the roles both of storing of water during drought and distributing the flood. Hurst aimed to find the hidden long-term trend of the Neil River to build a better dam for Egypt. Nevertheless, this method provides an estimate of how the apparent variability of a series changing with the length of the time period. The R/S analysis a widely used non-parametric statistical method applied in fractal analysis. The procedure is as follows:

The time series $\{R_t\}$ of length N must be divided into A (integer) groups of continuous subseries. Subseries of length n are labeled as I_a (a=1, 2, 3, ..., A) . The data of the subseries are $R_{k,a}$ (k = 1,2,3,...,n). After finding the mean (e_a) of the subseries, the cumulative deviation of internal elements from the mean in each part is then calculated:

$$X_{k,a} = \sum_{i=1}^{k}(R_{i,a} - e_a),\ k = 1,2,3,\ldots,\quad n \qquad (2)$$

The range (R_a) is obtained from:

$$R_a = max\ (X_{k,a}) - min\ (X_{k,a}) \qquad (3)$$

The standard deviation of each subseries is later calculated:

$$S_a = \sqrt{\left(\frac{1}{n}\right) \sum_{k=1}^{n} (R_{k,a} - e_a)^2} \quad (4)$$

The mean value of the rescaled range is estimated from all of the subseries:

$$(R/S)_n = (1/A) \sum_{a=1}^{A} (R_a/S_a) \quad (5)$$

R/S analysis, a statistical technique, is designed to estimate the variability of data over time. Then, this process has been used to test and assess the persistence and randomness of time series data in financial markets, which suggests the proper investment strategies.

3.3 Hurst Exponent

The Hurst exponent is called as self-affinity index or a scaling exponent, which can be employed to explain the fractal properties. Meanwhile, the Hurst exponent is a parameter that normally appears in time series and explains the dependence in the time series. The Hurst exponent value is in the range between 0 and 1. (Mandelbrot et al., 1997) The Hurst exponent is defined by:

$$(R/S)_n = C * n^H \quad (6)$$

in which *R/S* is the rescaled range, *n* is the length of the time intervals, *C* is a constant, and *H* is the Hurst exponent.

To get the Hurst exponent *H*, the logarithm is taken for both sides of (6), i.e.

$$\log(R/S)_n = \log C + H \log n \quad (7)$$

The slope of linear regression between $\log(R/S)_n$ and $\log_n$ then yields the Hurst exponent *H*.

The correlation function between the present on the future prices in the time series can be expressed in terms of the Hurst exponent:

$$CR = 2^{2H-1} - 1 \quad (8)$$

According to (8), when $H = 0.5$, $CR = 0$. The time series is thus completely uncorrelated. When $H = 1$ and thus $CR = 1$, the time series has a perfect positive correlation. If $H \in (0.5,1)$, CR>0, indicates that there is a positive relationship among each increment. On contrary, $H \in (0,0.5)$, $CR < 0$, which implies that the time series has anti-persistence with negative correlations.

Consequently, it can be summarized as follows that:

1) If H = 0.5, then there is no relationship between past, present, and future in whole time series and it is a random and uncorrelated one.

2) If 0.5< $H \leq 1$, the time series has a continuity characteristic. Moreover, the time series have a persistent process with long-term memory, which proves that the fluctuation of analyzed time series in every period of past, present, and future has a positive correlation with each other. The trend of the movement will be stronger and stronger when H keeps moving closer to 1 or the continuity of time series is stronger too.

3) If 0≤ H <0.5, the time series have an anti-continuity characteristic or anti-persistent memory with negative correlations. The closer H is to 0, the stronger the anti-continuity is at the same time.

3.4 V-Statistics

To calculate the memory circulation, the V-statistics was used through the R/S analysis field by Harold Edwin Hurst, after that, the scholars developed this method to calculate the circulation of aperiodic memory. Moreover, the V-statistics was determined as:

$$V_n = \frac{(R/S)_n}{\sqrt{n}} = \frac{C * n^H}{\sqrt{n}} = C * n^{(H-0.5)} \qquad (9)$$

(1)If H=0.5, the whole process is a random walk, the increments are independent, so, the diagram of $Vn - \log(n)$ is a level line.

(2)If 0<H<0.5, the process is anti-persistent, the movement of R/S is slower than $\sqrt{n}$ (the square root of time), hence, the diagram of $Vn - \log(n)$ downward inclined.

(3)If the 0.5< H< 1, there is long-term memory exhibiting in the process, the movement of R/S is faster than $\sqrt{n}$, in that the diagram upward inclined.

Furthermore, when the shape of $Vn - \log(n)$ plot is changed, in other words, when meet the first turning point on the diagram, which indicates that the memory ends right away.

3.5 Data

In order to estimate the Hurst exponent of the Thai natural rubber price with fractal model, 2272 observations of daily Thai natural un-smoked rubber price from 21 April

2003 to 7 July 2014 are used (the un-smoked rubber is one of the main natural rubber species). The data is obtained from TRA. So, this study will use the un-smoked rubber price taking place of the whole Thai natural rubber price.