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Ascertainment Of Rice Yield In The Northern Thailand With CUSUM Control Chart

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Abstract

The objective was this work was to apply the cumulative sum (CUSUM) control chart in agriculture. The CUSUM parameters were usefully regulated to ascertain the shift in rice yield in the northern Thailand. The result of work presented an increasing positive deviation of CUSUM statistic since 2010 to 2013. That meant, there was an inclination of significant expansion of rice yield of the northern Thailand specifically during 2010-2013.

Keywords: Rice yield, the northern Thailand, CUSUM control chart

Mathematics Subject Classification: 62-07, 62G35

INTRODUCTION

Thailand is one of Asian countries which have rice be the most staple food. Rice is not only a significant portion of the Thai economy and labor force [1] but also an important main Thai export. Its rice exports surged from around 6.2 million ton in 1995 to 8.9 million ton in 2010 and grew at about 4% per year in 2005-2010 [2]. One-third of the land areas of Thailand appeared in the northern section. The total rice land in the northern part is about 20%. Presently, there are a lot of works focused on the rice yield by using various statistical techniques.

Control chart is one of the statistical process control (SPC) tools. It was popularly and widely utilized in detecting the abnormalities of manufacturing processes [3], [4], [5]. The cumulative sum or CUSUM control chart is favorably applied for detecting small change of process in various fields besides the manufacture such as environment [6], [7], or fishery [8], [9], [10], [11], etc. Both of two positive and negative deviation statistic values of CUSUM are figured against the sample order or the time into the chart displaying the center line (CL.) and the upper and lower control limits (UCL and

LCL). This work then practically exemplified demonstrating the CUSUM control chart in detecting the rice yield in the northern Thailand by adjusting two CUSUM parameters in accordance with [12].

MATERIALS AND METHODS

Office of Agricultural Economics, Ministry of Agriculture and Cooperatives supplied the rice yield in the northern Thailand in the amount of tons per year since 2001 to 2013 [13]. Data of rice yield in the northern area was just systematically collected in a few decade so the parameters of in-control state, mean and standard deviation, were assumed from a preliminary work or a reference period.

Suppose a sequence of rice yield x_t collected at time t; t=2001, 2002,…, 2013. The estimates of mean and standard deviation of rice yield based on the reference period in seven years (2001-2007) were then computed for the in-control state. Four steps of investigating the shift of rice yield in the northern Thailand were as followed.

1. The rice yield was standardized with transformation technique as of Equation 1

$$z_t = \frac{x_t - \bar{x}}{s} \tag{1}$$

Where z_t be the standardization of rice yield at time t, $\bar{x}$ and s be the estimators of mean and the standard deviation of rice yield, respectively.

2. The two CUSUM test statistics were calculated. The one-sided upper CUSUM deviation was the first positive statistic derived from Equation 2

$$S_t^+ = \max[0, S_{t-1}^+ + z_t - k] \tag{2}$$

The one-sided lower CUSUM deviation was the other negative statistic defined as of Equation 3

$$S_t^- = \min[0, S_{t-1}^- + z_t + k] \tag{3}$$

where k be the referenced or allowanced parameter of CUSUM control chart. While the starting value was generally specified as $S_t^+ = S_t^- = 0$

3. The control limits of CUSUM control chart were constructed as of Equation 4 with the decision limit h called the decision interval.

$$\begin{aligned} UCL. &= +h \\ CL &= 0 \\ LCL. &= -h \end{aligned} \tag{4}$$

4. The CUSUM control chart of rice yield in the northern Thailand was displayed by plotting both of positive statistic, S_t^+, and negative statistic, S_t^-.

As a recommendation of [12], two parameters of CUSUM control chart were set up as $k = 1.3$ and $h = \pm 1$. The process would be stated in the out-of-control state if any S_t^+ fell beyond the upper control limit (UCL.) or S_t^- located below the lower control limit (LCL.).

RESULTS

Once the mean and standard deviation for in-control state of rice yield were estimated, the standardization of rice yield, z_t, was computed following Equation 1. Then, the two statistics, S_t^+ and S_t^-, were derived by replacing z_t and k in Equation 2 and 3, respectively. Finally, the CUSUM chart contained the control limits set up followed Equation 4 was pictured in Figure 1 after plotting S_t^+ and S_t^-.

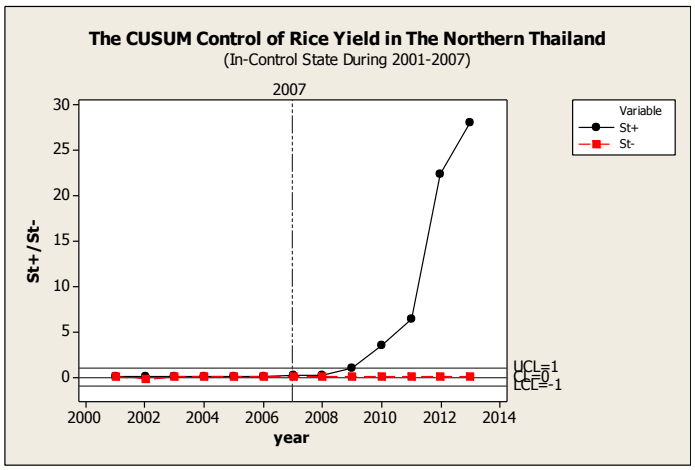

Figure 1: The CUSUM Control Chart of Rice Yield in The Northern Thailand

The CUSUM control chart illustrated the S_t^+ fell above the UCL since 2010 to 2013. However, the S_t^- still maintained within the control limit.

DISCUSSION

The CUSUM control chart is suitably utilized in detecting small shift because both of the positive and negative deviations are equally important considered. Therefore, the CUSUM technique is also usefully assist in agricultural application. For this study, it showed the substantial increase of rice yield during 2011-2013 due to Thailand confronted the major flood crisis in 2011 led to an effect on people certainly in the north provinces. Thai farmers in the northern then brought forward rice plantation ahead in order to protect flood disaster. Also, it was plentiful of water for cultivation in 2012 and it faced a few problems of insect plant pests. Therefore, it caused to enhance the rice yield for overall. These results were in accordance with [14].

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