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Investigation of Sugar Cane Yield in the Northeast of Thailand with CUSUM Control Chart

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ABSTRACT

BACKGROUND: The northeast of Thailand has the tropical largest land which is suitable for cultivating sugar cane. The report of Kasetsart University, Kamphaeng Saen Campus also notified that Thailand could produce sugar cane in a large amount so its sugar cane exports in 2013 created huge income approximately two hundred thousand million baht. Finding a method of investigating sugar cane yield then becomes essential to an authorized government department for future planning and policy making to control the production of sugar cane in the northeast of Thailand. **OBJECTIVE:** Constructing the Cumulative sum or CUSUM control chart with tuning up two parameters, $k = 1.3$ and $h = \pm 1$, in order to investigate the sugar cane production in the northeast of Thailand. **RESULTS:** The one-sided upper CUSUM deviation, S_t^+ , were plotted beyond the UCL since 2011 to 2013 while the one-sided lower CUSUM deviation, S_t^- , maintained along the CL. That means, the sugar cane yield in the northeast of Thailand was increasing from 2011 to 2013. **CONCLUSION:** The CUSUM control chart is an efficient method for investigating the sugar cane production because it is capable to detect a small mean shift as clearly seeing of an increasing one-sided upper CUSUM. The Thai sanctioned government agent then will use these findings for forthcoming control the production of sugar cane in the northeast of Thailand.

INTRODUCTION

Thailand is an agricultural country so there are versatile economic crops cultivated throughout the country; i.e. rice, cassava and rubber, etc. Sugar cane is also the one of main crucially commercial crops of Thailand. Thailand can produce sugar cane in a large amount so its sugar cane exports in 2013 created huge income approximately two hundred thousand million baht. Kasetsart University, Kamphaeng Saen Campus (2014). The northeast of Thailand contained 15 provinces; Kalasin, Khon Kaen, Chaiyaphum, Nakhon Phanom, Nakhon Ratchasima, Buriram, Maha Sarakham, Mukdahan, Roi Et, Loei, Sakon Nakhon, Surin, Nong Khai, Udon Thani and Ubon Ratchathani, covers 160,000 km². It has the tropical largest land which is suitable for cultivating sugar cane. An authorized government department should find a potential direct or indirect way for investigating the sugar cane production.

Either statistical model, regression analysis, or mathematical model, artificial neural network, is often utilized to forecast the sugar cane production. The regression and artificial neural network models are

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corresponding to many variables. The objective of this study is to investigate the sugar cane yield which is relating to only one variable therefore both models are not appropriately employed here. The control chart, one of seven magnificent tools in statistical process control (SPC), is then an alternative method usually chosen for exploring a single variable in manufacturing process.

The cumulative sum or CUSUM control chart discovered by Page is widely applied in examining small mean shift: Page (1961). Also, CUSUM control chart is useful in diverse fields besides the manufacturing process: Montgomery (2005), Whetherill and Brown (1991) or Derman and Ross (1997), like in environment: Saithanu and Mekparyup (2015), Saithanu *et al.* (2015) or in marine science: Nicholson (1984), Scandol (2003), Scandol (2005), etc. Petitgas presented to tune up the parameters of CUSUM control chart according to the real practice: Petitgas (2009). For these reasons, this study then uses CUSUM control chart to investigate the sugar cane yield. Additionally, the one related cause the study results for future planning or policy making of sugar cane yield in the northeast of Thailand.

MATERIALS AND METHODS

Office of the Cane and Sugar Board, Ministry of Industry provided the sugar cane yield per year in Thai unit called rai or 1,600 square meters in the northeast of Thailand since 2002 to 2013: Office of the Cane and Sugar Board (2011). The production of sugar cane in the northeast sector was just well organized presently hence two parameters of in-control periods, mean (μ) and standard deviation (σ), were presumed from a preliminary study or a reference period.

Suppose a sequence of sugar cane yield (x_t) measured at time t ; $t=2002, 2003, \dots, 2013$. The estimates of mean and standard deviation of sugar cane yield related on the reference period in five years (2002-2006) were then gauged for the in-control period. The procedure for investigating of sugar cane yield in the northeast of Thailand then performed as following these four steps.

1. Standardized the sugar cane yield as of Equation 1.

$$z_t = \frac{x_t - \bar{x}}{s} \quad (1)$$

where z_t be the standardization of sugar cane yield at time t , $\bar{x}$ and s be the respective estimators of mean and the standard deviation of sugar cane yield for the in-control period.

2. Calculated two statistic values of CUSUM control chart as of Equations 2 and 3.

The one-sided upper CUSUM deviation which is the positive statistic derived from Equation 2.

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

The other negative statistic value or the one-sided lower CUSUM deviation defined from Equation 3.

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

where k be the allowed parameter of CUSUM control chart. The starting value was usually set up as $S_t^+ = S_t^- = 0$.

3. Constructed the control limits of CUSUM control chart as the upper control limit, $UCL = h$, the lower control limit, $LCL = -h$, and center line ($CL = 0$) where h be the decision limit called the decision interval. Petitgas (2009) suggested for the real situation with the values of $k = 1.3$ and $h = \pm 1$.

4. Illustrated the CUSUM control chart of sugar cane yield in the northeast of Thailand by plotting both of two statistic values, S_t^+ and S_t^- . If any S_t^+ was placed above the UCL or S_t^- fell below the LCL, it indicated the process was out-of-control.

Results:

As of measuring a sequence of sugar cane yield, the parameters for in-control period were respectively estimated with 127.79 and 19.956 rai for the mean and standard deviation of sugar cane yield. Then, the standardization of sugar cane yield (z_t) and two statistic values (S_t^+ and S_t^-) were obtained in Table 1.

Table 1: The statistic values of CUSUM control chart for the sugar cane yield in the northeast of Thailand

t	z_t	S_t^+	S_t^-
2002	1.19733	0.00000	0
2003	0.86961	0.00000	0
2004	-0.54851	0.00000	0
2005	-1.18140	0.00000	0
2006	-0.33704	0.00000	0
2007	1.95701	0.65701	0
2008	1.13319	0.49020	0
2009	0.85358	0.04378	0
2010	2.02466	0.76843	0
2011	1.99910	1.46753	0
2012	1.89337	2.06090	0
2013	1.92043	2.68132	0

Simultaneously, S_t^+ and S_t^- were plotted against time t containing the predefined control limits as mentioned above. The CUSUM control chart was then finally displayed in Figure 1.

Fig. 1: The CUSUM Control Chart of Sugar Cane Yield in The Northeast of Thailand

As of Figure 1, it indicated all S_t^- stayed along the CL. meanwhile some of S_t^+ were placed above the UCL. since 2011 to 2013.

Conclusion And Discussion:

Cumulative sum or CUSUM control chart is applied for examining the sugar cane production in the northeast of Thailand since 2002 to 2013. The mean and standard deviation of sugar cane yield was consecutively presumed with 127.79 and 19.956 rai under the in-control period. The values of k and h are adjusted in practice as a suggestion of Petitgas with $k = 1.3$ and $h = \pm 1$. Once both statistic values were located in a sequence of time on the CUSUM control chart. It demonstrates the one-sided upper CUSUM deviation, S_t^+ , were plotted above the UCL. since 2011 to 2013. The CUSUM control chart is then able to clearly illustrate that sugar cane yield in the northeast of Thailand was increasing from 2011 to 2013. The CUSUM control chart here is still a potential tool in SPC particularly in investigating small process change as seeing of an increasing one-sided upper CUSUM. It distinctly indicates that there is a valuable enlargement of sugar cane yield in the northeast of Thailand especially in 2013 complying with the report of Kasetsart University and Kamphaeng Saen Campus (2014). The Thai sanctioned government agent then will use these study results for future planning and policy making to control the production of sugar cane in the northeast of Thailand.

Future Research:

Other control charts, like Moving average (MA) or Exponentially weighted moving average (EWMA), which can also efficiently detect the small mean shift will be considered in discovering the sugar cane production for future study.

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REFERENCES

- Derman, Cand S., M. Ross, 1997. Statistical aspects of quality control. London: Academic Press.
- Kasetsart University, KamphaengSaen Campus, 2014. National Conference on Cane and Sugar 2014. Retrieved May 3, 2015 from web site: <http://esd.psd.kps.ku.ac.th/sugar2014%20/detail/detail1.html>
- Montgomery, D.C., 2005. Introduction to statistical Quality Control (5th ed.). New York: John Wiley & Sons, Inc.
- Nicholson, M., D., 1984. Some applications of CUSUM techniques in fisheries research. *Int. Counc. Explor. Sea*, CM 1984/D: 5, p: 10.
- Nicholson, M.D., 1984. Some applications of CUSUM techniques in fisheries research. *Int. Counc. Explor. Sea*, CM 1984/D: 5, p: 10.
- Office of The Cane and Sugar Board. 2011. Report of sugarcane cultivated area in Thailand. Retrieved 29 March, 2015 from web site: <http://www.ocsb.go.th/th/cms/detail.php?ID=923&SystemModuleKey=journal>
- Page, E.S., 1961. Cumulative sum control charts. *Technometrics*, 3: 1-9.
- Petitgas, P., 2009. The CUSUM out-of-control table to monitor changes in fish stock status using many indicators. *Aquatic Living Resource*, 22: 201-206.
- Saithanu, K and J. Mekparyup, 2015. Apply CUSUM Control Chart To Monitor Amount of Municipal Solid Waste In Bangkok. *Global Journal of Pure and Applied Mathematics*, 11(1): 431-435.
- Saithanu, K., P. Phodjanawichaikul and J. Mekparyup, 2015. Investigation of Municipal Solid Waste Quantity in Chiang Mai Municipality with CUSUM Control Chart. *Global Journal of Pure and Applied Mathematics*, 11(1): 409-413.
- Scandol, J.P., 2003. Use of cumulative sum (CUSUM) control charts of landed catch in the management of fisheries. *Fisheries Research*, 64(1): 19-36.
- Scandol, J.P., 2005. Use of quality control methods to monitor the status of fish stocks. In: Kruse, G.H., Gallucci, V.F., Hay, D.E., Perry, R.I., Peterman, R.M., Shirley, T.C., Spencer, P.D., Wilson, B., & Woodby, D. (eds.), *Fisheries Assessment and Management in Data-Limited Situations*, Alaska Sea Grant College Program, University of Alaska Fairbanks. pp: 213-233.
- Whetherill, G.B and D.W. Brown, 1991. *Statistical process control: theory and practice*. London: Chapman & Hall.