International Journal of Academic and Applied Research (IJAAR)
ISSN: 2643-9603
Vol. 7 Issue 8, August - 2023, Pages: 7-9

Application of Nonparametric Sign and Wilcoxon Sign Rank Control Maps on Animal Feed Data of PT. Japfa Comfeed Indonesia, Tbk

Iswan Rahman[1], Erna Tri Herdiani[2], Anna Islamiyati [3]

[1,2,3] Departement of Statistics, Hasanuddin University, Makassar, 90245, Indonesia
iswan.rahman@gmail.com

Abstract*: Control maps are used to see the performance of a process. Nonparametric control maps are present to overcome processes with unknown distribution patterns. This paper will show the application of nonparametric control maps using the Sign Test and Wilcoxon Sign Rank Test on the Animal Feed data of PT. Japfa Comfeed Indonesia, Tbk. The results show that the Wilcoxon Sign Rank control map has the same effectiveness as the sign control map.*

Keywords—Sign test; Wilcoxon sign test; nonparametric; control chart

1. INTRODUCTION

Statistical process control (SPC) is a tool in monitoring a process parameter. A well-known tool in SPC is the shewhart control map. One example of a control map is the Shewhart control map, cumulative sum, and exponential weighted moving average. In general, these three control maps have distribution assumptions that must be met, namely normal distribution. Whereas in reality there is often a data that is not normally distributed. This nonparametric control map itself has actually been developed for a long time including, in the book mentioned [1].

This book is about inverting nonparametric statistics. This book is often used as a reference for writers who use nonparametric statistics as their test statistic. Other researchers who discuss nonparametric statistics are as follows. [2] first introduced the EWMA *Sign* nonparametric control which serves to detect relatively small average process shifts in data that do not meet the assumption of normality [3] developed the consistency and limits of the t-test with sign and wilcoxon sign rank test. [4] developed wilcoxon signed rank and wilcoxon mann-whitney ranksum. [5] introduced WSR as a hypothesis test that can be applied to one-sample data or two-sample paired data. [6] discussed rank-based and nonparametric methods. [7] applied sign rank to the normal approximation that different distributions have zero median. [8] they wrote the EWMA statistic based on the sign nonparametric control map to monitor the process deviation from the target. [9] the researchers designed the EWMA sign nonparametric control map based on the sampling technique on rank and applied it in the industrial field and proposed a control map without distribution assumptions to monitor the median of a process based on the sign test statistic.

Therefore, this paper will discuss the sign test and Wilcoxon sign rank control maps whose results will be applied to the livestock sector, namely, animal feed products at PT. Japfa Comfeed Indonesia, Tbk Makassar Unit.

2. SIGN TEST CONTROL MAP

Control map is one of the statistical quality control tools that graphically displays an overview of the behavior of a process. The function of control maps in the industrial world as a tool to monitor a production process in order to remain in statistical quality control so as to maintain the quality level of a product. The control map is composed of control lines, namely the center line which shows the average value of quality characteristics, *Upper Control Limit* (UCL) and *Lower Control Limit* (LCL) which are used as the basis for measurement to detect *out of control* signals when there is a shift in the average production results [10].

Based on the data used, control maps are classified into 2 types, namely [11]:

1. Attribute control maps are control maps for monitoring quality characteristics that are classified by product properties such as defects and non-defects.
2. Variable control map is a control map to monitor product quality characteristics obtained from measurements. The data required for the application of this control map is variable data such as length, weight, volume, and others.

Making a control map requires a *mean* value (μ) that can be known or unknown. The previously known μ value is a value that has been set by the company to be used as a quality measurement standard. But in practice, most of the μ values are unknown so that first an estimation is made to get the μ value. If $\bar{X}_1, \bar{X}_2, \bar{X}_3, \dots, \bar{X}_n$ is the average of each of the 1st, 2nd, ... , n samples, then the value of μ can be estimated from the average of all samples $\bar{\bar{X}}$ which is calculated by:

$$\mu = \bar{\bar{X}} = \frac{\bar{X}_1, \bar{X}_2, \bar{X}_3, \dots, \bar{X}_n}{n} \qquad (1)$$

With n being the number of samples [12].

Shewhart *sign* control map is a Shewhart control map using a nonparametric method formed from *sign test* statistics to overcome data that does not meet the assumption of normality. Suppose X_j is the observation data from each sample (i) of size n and μ is the *mean* value of all samples. The initial procedure

International Journal of Academic and Applied Research (IJAAR)
ISSN: 2643-9603
Vol. 7 Issue 8, August - 2023, Pages: 7-9

for making a shewhart *Sign* control map is to perform a sign test statistic defined by the following equation [13]:

$$SN_j = \sum_{j=i}^{n} sign(X_j - \mu_0) = \begin{cases} 1;\ if\ X_j - \mu_0 > 0 \\ 0;\ if\ X_j - \mu_0 \le 0 \end{cases} \quad (2)$$

SN_j is binomially distributed with parameter n and $p = \{X_{ij} > 0\} = 0.5$ for a controlled process. The points of the Shewhart *sign* control map plot are expressed by the following equation:

$$T_i = \frac{SN_j + n}{2} \quad (3)$$

The control limits of the Shewhart *sign* control map are defined as follows [14]:

$$UCL = n - b\left(\frac{\alpha}{2}, n, \frac{1}{2}\right) \quad (4)$$

$$CL = \frac{n}{2} \quad (5)$$

$$LCL = b\left(\frac{\alpha}{2}, n, \frac{1}{2}\right) \quad (6)$$

with;

$b\left(\frac{\alpha}{2}, n, \frac{1}{2}\right)$: the probability value of the binomial distribution forming the control limit

α : significance level of 0.0027

n : sample size

3. WILCOXON SIGN TEST CONTROL MAP

Suppose X_j is the data of each sample of size n and μ is the mean of a sample.

Further defined:

$$M_j = X_j - \mu \text{ and } I_j = \begin{cases} 1;\ if\ M_j > 0 \\ 0;\ if\ M_j \le 0 \end{cases} \quad (7)$$

Suppose $|R_i|$= the rank of $|X_j - \mu|$, with i= 1, 2, … ,n

Therefore:

$$R^+ = \sum_{i=1}^{n} I_j R_i \quad (8)$$

[15] wrote that the Wilcoxon sign rank test statistic has the following exact distribution:

$$Z = \frac{R^+ - \frac{n(n+1)}{4}}{\left[\frac{n(n+1)(2n+1)}{24}\right]^{1/2}} \quad (9)$$

Has a distribution alien to the normal distribution with mean 0 and variance 1.

Based on [16].

$$E(R^+) = \frac{n(n+1)}{4}, and \quad (10)$$

$$Var(R^+) = \frac{n(n+1)(2n+1)}{24} \quad (11)$$

The control map for R+are.

$$-Z_{\propto/2} < Z < Z_{\propto/2} \quad (12)$$

$$-Z_{\frac{\propto}{2}} < \frac{R^+ - \frac{n(n+1)}{4}}{\sqrt{\frac{n(n+1)(2n+1)}{24}}} < Z_{\frac{\propto}{2}} \quad (13)$$

if ∝= 0,0027, then $Z_{\propto/2}$= 3, so

$$-3 < \frac{R^+ - \frac{n(n+1)}{4}}{\sqrt{\frac{n(n+1)(2n+1)}{24}}} < 3 \quad (14)$$

$$-3\sqrt{\frac{n(n+1)(2n+1)}{24}} < R^+ - \frac{n(n+1)}{4} < 3\sqrt{\frac{n(n+1)(2n+1)}{24}} \quad (15)$$

$$\frac{n(n+1)}{4} + 3\sqrt{\frac{n(n+1)(2n+1)}{24}} < R^+ < \frac{n(n+1)}{4} - 3\sqrt{\frac{n(n+1)(2n+1)}{24}} \quad (16)$$

so,

$$UCL = \frac{n(n+1)}{4} + 3\sqrt{\frac{n(n+1)(2n+1)}{24}} \quad (17)$$

$$CL = \frac{n(n+1)}{4} \quad (18)$$

$$LCL = \frac{n(n+1)}{4} - 3\sqrt{\frac{n(n+1)(2n+1)}{24}} \quad (19)$$

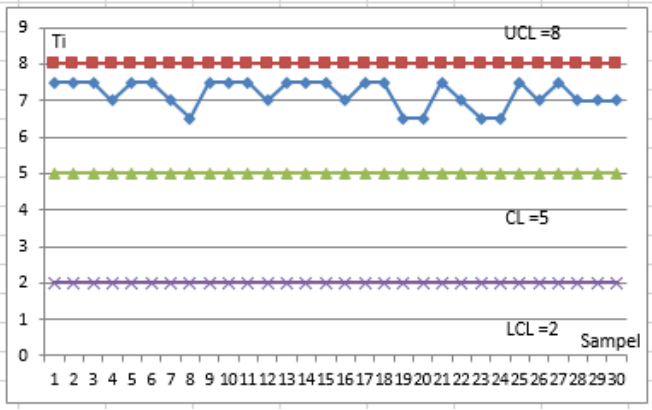
4. CASE STUDY

In the case data of animal feed products at PT Japfa Comfeed Indonesia, Tbk Makassar Unit. The inspection data for animal feed products used is variable data on the percentage of fat content in animal feed products from December 2021 to January 2022. The data consists of 30 samples of sacks of animal feed products with 10 observations of the fat content contained in each product sample, so that the total observation data used is 300 data.

The shewhart sign control map of this animal feed data using equations (4), (5) and (6) will be obtained as follows:

UCL = 8
CL = 5
LCL = 2

As for all the resulting observations, based on Figure 1, they are within the control limits, thus this Control map can be directly used as a control map for further monitoring data.

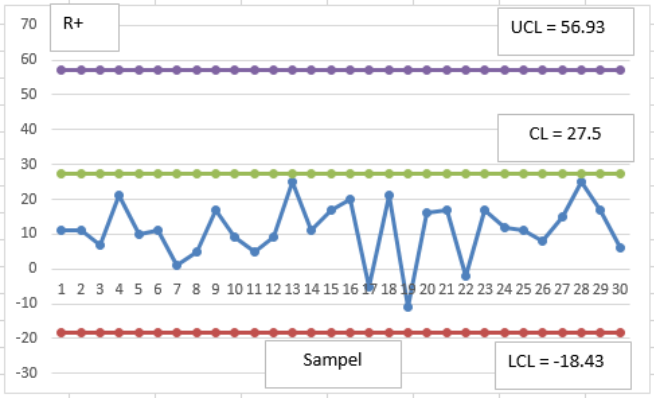


Picture 1. Shewhart sign test control map

The Wilcoxon Sign Rank control map of this animal feed using equations (17), (18) and (19) will be obtained as follows:

UCL = -18.43
CL = 27.5
LCL = 56.93

As for all the resulting observations, based on Picture 2, they are within the control limits, thus this Control map can be directly used as a control map for further monitoring data.



Picture 2. Wilcoxon sign rank test control map

Based on these two control maps, it can be concluded that the fat content of animal feed products of PT. Japfa Comfeed Indonesia, Tbk Makassar Unit is very well controlled..

5. CONCLUSION

The sign and Wilcoxon sign rank control maps have the same effectiveness for application to animal feed product data at PT Japfa Comfeed Indonesia, Tbk and the production process based on both control maps is concluded to be in good control process.

6. REFERENCES

[1] Gibbons, J. D. & Chakraborti, S. (2003*). Nonparametric Statistical Inference (4th ed).* New York: Marcel Dekker
[2] Yang, S. F., Lin, J. S., & Cheng, S. W. (2011). A new nonparametric EWMA Sign Control Chart. *Expert Systems with Applications*, *38*(5), 6239–6243.
[3] Imam, A., Usman, M., & Chiawa, M. A. (2014). On Consistency and Limitation of paired t-test, Sign and Wilcoxon Sign Rank Test. *Journal of Mathematics Volume 10, Issue 1 Ver. IV, PP 01-06*
[4] Harris, T., & Hardin, J. W. (2013). Exact Wilcoxon signed-rank and Wilcoxon Mann–Whitney ranksum tests. *The Stata Journal (2013) 13, Number 2*, pp. 337–343.
[5] King, A. P., & Eckersley, R. P. (2019). *Statistics for Biomedical Engineers and Scientists.* 119-145: Academic Press
[6] Wilcox, R. R. (2003). *Applying Contemporary Statistical Techniques*. PP 557-608. Los Angeles:
[7] Riffenburgh, R. H. (2006). Statistics in medicine (2th Ed). *Basic of Rank, 16(1), 281-303*.
[8] Raza, M. A., Nawaz, T., Aslam, M., Bhatti, S. H., & Sherwani, R. A. K. (2020). Anew nonparametric double exponentially weighted moving average control chart. *Quality and Reliability Engineering International*, *36*(1), 68–87.
[9] Ali, S., Abbas, Z., Nazir, H. Z., Riaz, M., Zhang, X., & Li, Y. (2020). Ondesigning non-parametric EWMA sign chart under ranked set sampling scheme with application to industrial process. *Mathematics*, *8*(9),1-20.
[10] Abbasi, S. A. (2010). On sensitivity of EWMA control chart for monitoring process dispersion. *WCE 2010 - World Congress on Engineering 2010*, *3*, 2027–2032.
[11] Montgomery, D. C. (2009). Introduction To Statistical Quality Control. In *Plastics and rubber international*,*10*(1), 419-428.
[12] Putri, k. i. k. (2011). Bagan Kendali Exponentially Weighted Moving Average Untuk Mean Proses. *Universitas Indonesia : Skripsi*.
[13] Amin, R. W., Reynolds, M. R., & Bakir, S. (2014). Nonparametric quality control charts based on the sign statistic. *Communications in Statistics - Theory and Methods*, *24*(6), 1597–1623.
[14] Park, H.-I. (2013). A Note on the Median Control Chart. *Communications for Statistical Applications and Methods*, *20*(2), 107–113.
[15] Ronald, L. I. (1974). Use of a t-Statistic as an Approximation to the Exact Distribution of the Wilcoxon Signed Ranks Test Statistic. *Western Michigan University*
[16] Gibbons, J. D. & Chakraborti, S. (2010). Nonparametric Statistical Inference (5th ed). Boca Raton: CRC Press