An Investigation on Supplier Delivery Performance by using SPC Techniques for Automotive Industry

Soroush Avakh Darestani [1], Md Yusof Ismail [2], Napsiah bt Ismail [3], Rosnah bt. Mohd. Yusuff [4]

[1.] Department of Mechanical and manufacturing engineering, Universiti Putra Malaysia, 43400, Malaysia, soroushavakh@yahoo.com,Tel: +60172986210
[2.] Department of Manufacturing engineering, Universiti Malaysia Pahang, 26300, Malaysia
[3] Department of Mechanical and manufacturing engineering, Universiti Putra Malaysia, 43400, Malaysia
[4] Department of Mechanical and manufacturing engineering, Universiti Putra Malaysia, 43400, Malaysia

Abstract: As about 60% of finished price of goods are allocated to raw material and purchased parts by suppliers in the chain of automotive industry, the importance of supplier management and its performance is an ongoing problem. Moreover the need of monitoring of supplier performance has been emphasized in Quality Management System of automotive industry ISO/TS16949. To meet standard requirement and also continuous improvement in business, companies need to monitor their supplier performance. Delivery and quality are two of the most important indicators of supplier evaluation. This paper introduces a statistical approach to monitor supplier performance over time by using control charts. To monitor supplier delivery performance, a statistical control chart is developed based on conceptual model of how to implement in industry. Normality test is done on data and upper and lower control limits are calculated. Data gathered from supplier of a tier 1 company and out of control signals are recognized on chart. All out of control signals are removed from control chart and updated "In control" is obtained with improved mean and standard deviation. It can be employed in the industry and should result in improvement in supplier performance over time. [Journal of American Science 2010;6(4):5-11]. (ISSN: 1545-1003).

Key words: Delivery Performance, Statistical Monitoring, Quality Management System (QMS)

1-Introduction:

SPC has its origins in the 1920s. Dr Walter A. Shewhart of the bell Telephone laboratories was one of the early pioneers of the field. SPC is a set of problem-solving tools may be applied to any process. The control chart is the most powerful of the SPC tools (Montgomery et al., 2007). SCM performance, supplier selection, SCM quality, Customer satisfaction and so on are the most researched area in the scope of supply chain management since 1980. Many studies have been done in the scope of supplier selection and evaluation. Nowadays, automotive industries are one of the industries which have implemented On time delivery system for their suppliers. Just in Time is a production system in which the movement of goods during production and deliveries from suppliers are carefully timed so that the right parts, in the right quantities are provided at the right time. The success of JIT approach depends on the capability of the company's suppliers to meet several criteria on quality quantity and delivery performance (Alwan, 2000).

From QMS approach in automotive industry, the ISO/TS 16949 was jointly developed by the IATF members and coupled with customer-specific requirements defines quality system requirements for use in the automotive supply chain(IATF, 2002). Based on QMS, the organization shall evaluate and select the suppliers based on their ability to supply products in accordance with the organization's requirements.

2- Literature review:

Supply Chain Management can be seen as the process of strategically managing the procurement, movement and storage of materials, parts and finished inventory and also related information flows through the organization and its marketing channels in such a way that current and future profitability are maximized through the cost effective fulfillment of orders (Rahul andAltekar, 2005). As stated in BMW supplier Quality Management System (BMW, 2008), they are looking for suppliers who are best in "Product Quality", "Life Time Cost" and "Delivery Process Capability and On-time Delivery".

PSA PEUGEOT CITROËN stated in their supplier Quality Principles in 2006 that the quality of their vehicles depends directly on the quality of the external supplies that represent over 70% of the manufacturing cost of a vehicle(PSA PEUGEOT CTROEN, 2006).

A study also has been conducted in PROTON on determining what supplier development programs are being undertaken by PROTON as Malaysian car-manufacturing firm. PROTON establishes supplier rating schemes which track supplier performances in terms of management, financial, technical capability, quality, delivery, services, price, etc(Abdullah et al., 2008).

Supplier linkage and internal departmental linkage have significant effect on overall SCM performance where the supplier linkage is the most important significant on SCM overall performance(lee et al., 2007). On time deliveries, reducing response time, determining customer future needs were also highly ranked on SCM performance (Tan et al., 2002). Process management has been about improving the linkages between internal processes and supply chain management has been about improving the linkages between firms(McAdam and McCormac, 2001). Supply chain performance is significantly affected by the strategic nature of the purchasing function (Paulraj et al., 2006).

Traditionally, purchasing was considered as a clerical function, where the relationships between suppliers and buyers tended to be adversarial. However, many organizations are now moving towards a more collaborative approach (Humphreys et al., 2001). Many manufacturers embraced the concept of supply chain management to improve product development, quality and delivery goals, and to eliminate waste.

An insufficient level of communication between internal customer and supplier could be among the reasons conceivable for the situation detected. Issues that give rise to criticism or dissatisfaction are either not articulated clearly enough to be understood or are not perceived, realized or accepted as a source of improvement(Large andKonig, 2009).

There is always a need for a tool to select potential suppliers and continually monitoring and assessing the performance of the suppliers. What manufacturers are doing is to establish dynamic trading relationships. However, it needs a tool to select potential suppliers with the capability of continually monitoring and assessing the performance of their suppliers (Liu et al., 2000). The prioritization of suppliers for development depends upon, for example, the supplier's quality performance and the importance of the product supplied. Supplier performance shall be monitored through delivered product quality and delivery schedule performance. Moreover, the organization shall promote supplier monitoring of the performance of their manufacturing processes. The organization shall determine, collect and analyze appropriate data generated as a result of monitoring and managing from other relevant sources such as suppliers (ISO, 2002). Moreover, Performance measurement describes the feedback or information on activities with respect to meeting customer expectations and strategic objectives (Lehtonen, 2001).

The aim of any type of data analysis is to gain understanding from data. When we collect process performance data we see that it varies. The information in this variation is important to the understanding of how the process is performing and statistical process control (SPC) is primarily the tool for understanding variation(Stapenhurst, 2005). A large number of statistical tools and methods are applied in manufacturing and service firms. Statistical process control (SPC) includes a number of them. Shewhart introduced control charts (CCs) in the beginning of the 1930s and currently it is one of the most widely discussed statistical techniques(Xie andGoh, 1999).

SPC is not really about statistics or control, it is about competitiveness. Organizations, whatever their nature, compete on three issues: quality, delivery and price if the quality is right, the chances are the delivery and price performance will be competitive too(Oakland, 1999). It was found that control charts could be adapted to monitor the supplier/retailer interface and that the results could potentially be used to monitor and manage the buyer/supplier relationship effectively. Moreover, SPC is one of the techniques used in quality assurance programs and/or Total Quality Management (TQM), for controlling, monitoring and managing a process either manufacturing or service through the use of statistical methods(Anthony et al., 2000).

SPC is a technique of investigating of the dynamics of failing supplier's performance. A good perspective can be obtained by considering three basic market perspectives(Crichton et al., 2003). A well established quality principle is that strategies that lead to improving supplier performance should be based by the first instance on improving supplier capability; and, in the second instance on moving the average performance towards the overall target performance required by the customer(Besterfield, 1994). To achieve this, the use of SPC control charts seems to offer a simple solution to establishing problem-solving dialogues between buyers and suppliers. An exploratory investigation done in food multiple retailers on their suppliers performance monitored using SPC techniques has demonstrated the value of SPC in consistently monitoring performance; of presenting this information in an understandable format; of using this information to stimulate buyer/supplier problem solving activities; of focusing on process consistency; and, of linking measurement protocols throughout the supply network. Both SPC and conventional statistical analysis can contribute to this paradigm. It was found that these control charts could be adapted to monitor the supplier/retailer interface and that the results could potentially be used to monitor and manage the buyer/supplier relationship effectively(Morgan and Dewhurst, 2008).

Most investigation and research have been done on method of supplier selection and performance evaluation and few researches have been done on supplier monitoring and tools of monitoring of suppliers. The performance monitoring is one of the important clauses in the standard.

This paper employed SPC Control Charts for monitoring of supplier performance in the automotive industry in a Quality Management System environment. Based on the literature, Figure 1 is depicted to employ SPC as monitoring tool to cover the need of supplier monitoring in both ISO/TS and SCM environments.

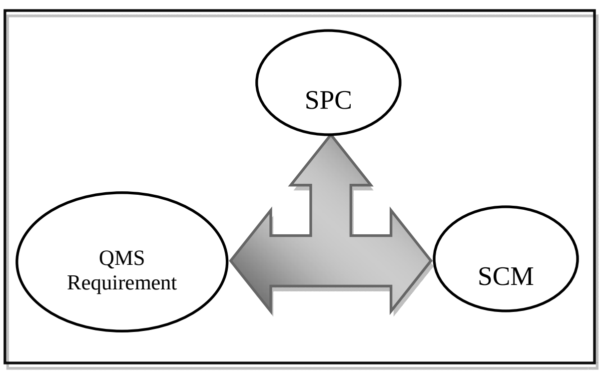

Figure 1, Relation between three main scope of thesis

3- Methodology

From the literature, delivery is performance is selected through investigation by statistically controlling of supplier's performance.

Hereby, a conceptual model has been proposed (Figure 2) and it shows the consecutive steps to develop the statistical analysis.

To develop the control chart, the first step is to post preliminary data to the chart along with the control limits and central lines. The next step is to adopt standard values with the available data. If an analysis of the preliminary data shows good control, then central lines can be considered as representative of the process and these become the standard values. Good control can be briefly described as that which has no out-of-control points, no long runs on either side of the control line, and no unusual patterns of variation (Besterfield, 2009).

The delivery measures by On Time Delivery (OTD) indicator on a monthly basis has been defined by automotive supply chain according to below:

$$OTD = \frac{\text{The number of on time delivered parts}}{\text{The number of ordered parts}} \times 100$$

For employing mean and range chart, the OTD indicator should be defined according to the literature of statistical process control philosophy. Suppose the supplier supplies m lots in specific time (weekly, monthly, and quarterly). If the gathered data approximates normal distribution, individual mean OTD and moving range can be employed otherwise, to deal with normality assumption on data, Central limit theorem should be applied with $n \geq 4$ and the proposed control chart will be substitute with OTD mean and range according to:

$i = 1, 2, \dots\dots, n$ and $j = 1, 2, \dots\dots, m$

n = sample size of supplier's OTD

m = the number of OTD samples for establishing control chart

OTD = the percentage of On – Time Delivery

R_i = range of the ith OTD's subgroup

$\overline{R}$ = average of the OTD's subgroup ranges

A_2, D_3 and D_4 factors for computing central lines of X bar and R chart (Besterfield, 2009)

Where:

$$\overline{OTD}_i = \frac{\sum_{j=1}^{m} \overline{OTD}_j}{m},$$

$$\overline{OTD} = \frac{\sum_{i=1}^{n} \sum_{j=1}^{m} OTD_{ij}}{n \times m},$$

$$UCL_{OTD} = \overline{OTD} + A_2\overline{R}, \quad LCL_{OTD} = \overline{OTD} - A_2\overline{R}$$

$$UCL_R = D_4\overline{R}, \qquad UCL_R = D_3\overline{R}$$

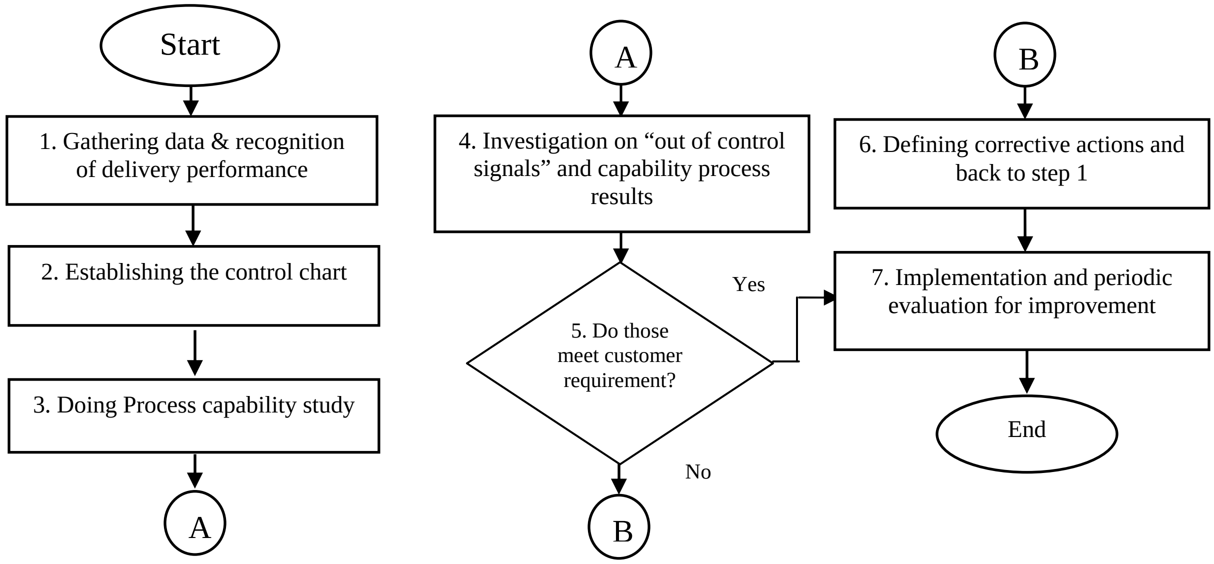

Figure 2, Conceptual model for monitoring of delivery Performance

4- Case study:

Based on the equations and according to the proposed conceptual model, an automotive vendor was selected as case study. This company is a Tier 1 for automotive industry. The OTD was measured for 88 arrival lots according to Table 1.

According to the propose methodology, the distribution of data approximated to small extreme value in 1% significant level according to figure 3. To establish the control chart, the data should show normal distribution. In this situation, the research used central theorem limit to meet this assumption where $n \geq 4$. All calculations and charts have been produced by using Minitab software version 15.1.0.0.

Table 1, Basic statistics of supplier delivery performance

Variable	count	mean	St. Dev	variance	minimum	maximum	skewness	kurtosis
Supplier OTD	88	74.31	17.81	317.11	9	97	-1.18	1.45

Delivery mean and range chart is depicted in Figure 4. According to gathered data 22 points were drawn on OTD mean and range chart and 13 points from mean chart and 5 points from range chart were out of control. It shows caused signal on data. The test on data also demonstrates that data have clustering caused signal as well. The upper control limit of OTD chart is obtained as 91.23 where it may be 100 in a perfect situation.

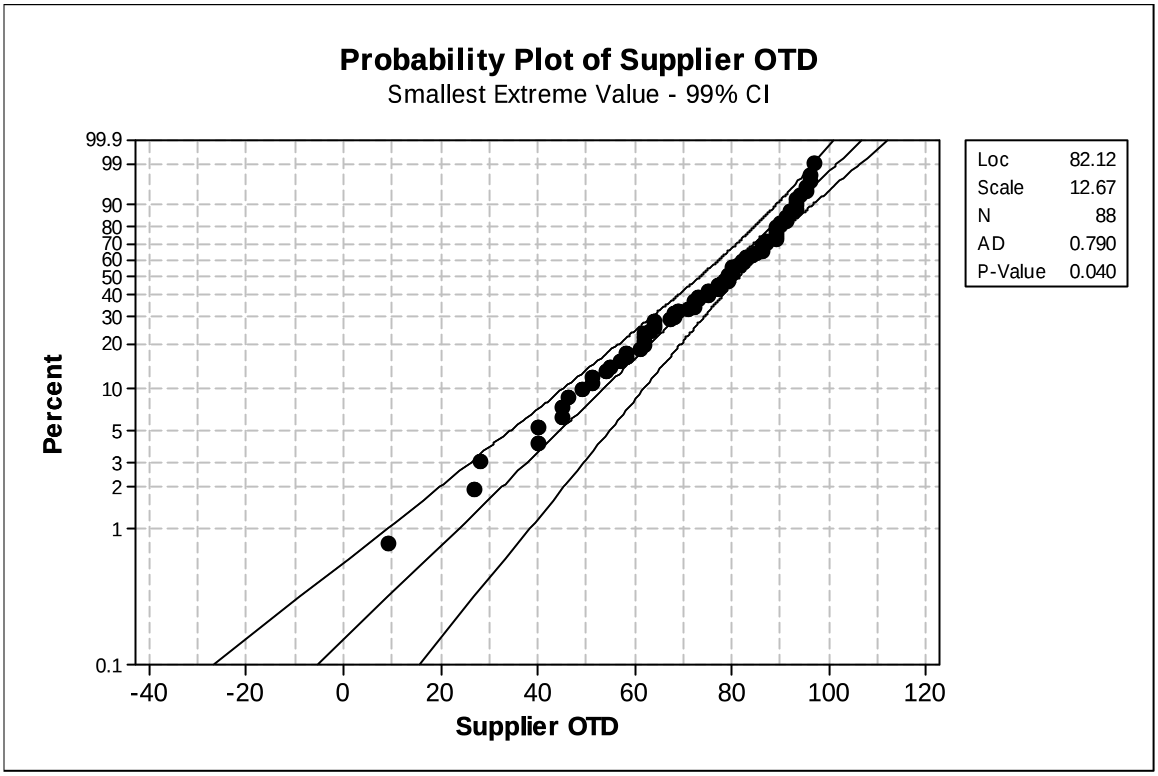

Figure 3, Probability Plot for Delivery performance data

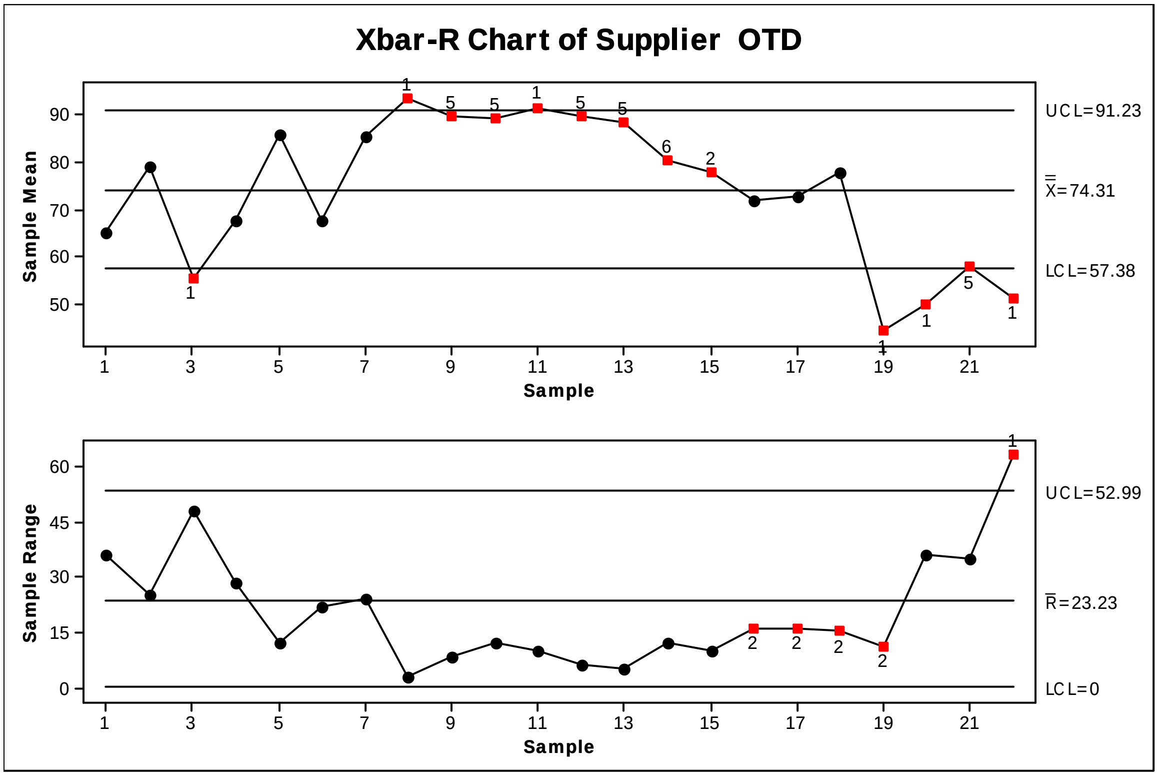

Figure 4, Deliver mean and range chart for n=4

To see whether the observed delivery performance meet customer expectation, the gathered data should be examined with upper and lower specification limit (USL and LSL of delivery by customer). It is required by customer that the lower limit is 75 and the upper limit should be 100. Capability study has been done based on approximated data to smallest extreme value distribution in 95% confidence interval.

For OTD's lower that 75, it can be stated that it does not meet customer expectation. Based on the capability study equation according to:

$$P_p = \frac{Min\left\{\left(USL - \bar{X}\right), \left(\bar{X} - LSL\right)\right\}}{3S}$$

$$PPU = \frac{USL - \bar{X}}{3S}$$

Hereby, a delivery capability study has been done and result depicted in figure 5. The Target defined 90 out of 100. As suppliers try to deliver the lots on time with same ordered quantity, it is obvious that the histogram has right skewness and majority of data has kurtosis to upper delivery limit. The minimum delivery capability is defined by customer 1 where the result shows that both $P_p = 0.23$, $PPU = 0.79$ have not met minimum customer expectation and corrective actions are required to increase delivery performance.

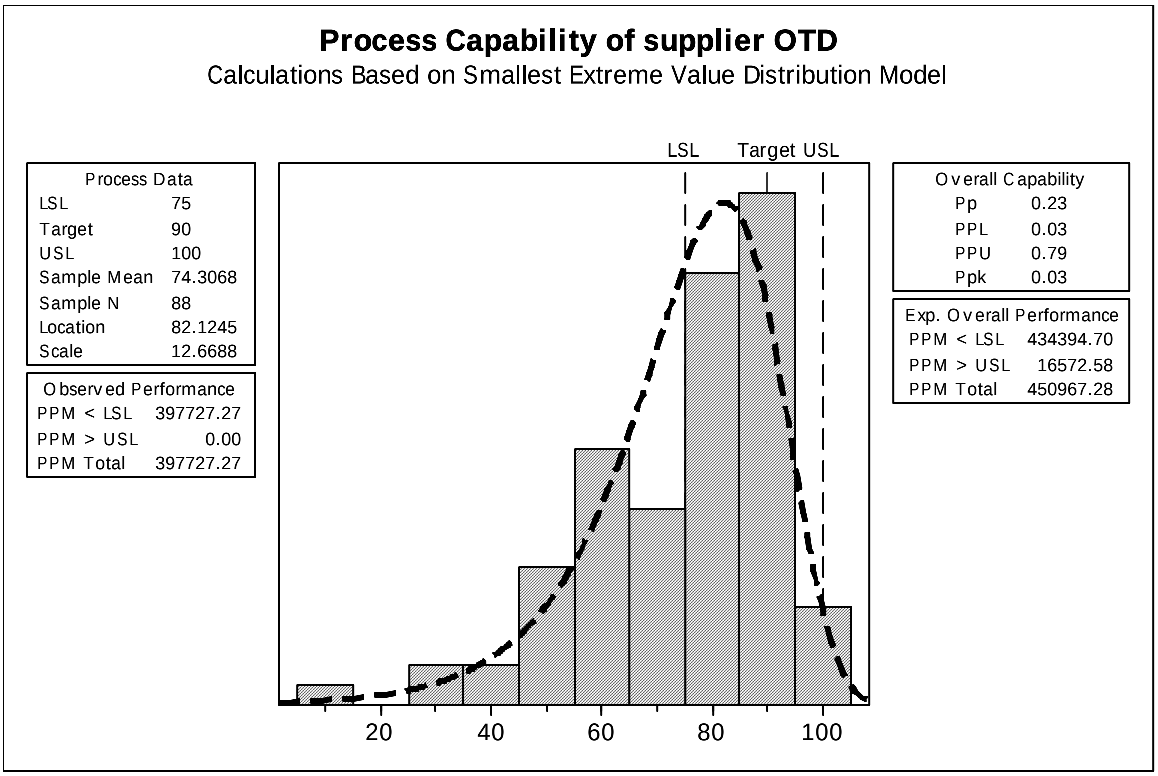

Figure 5, Delivery capability study

5- Result:

Investigation on delivery performance shows that it can be modeled for monitoring by control chart. Out of control and caused signals pattern may be recognized on supplier on time delivery data. It is important to identify the distribution of data before any action. It can work nicely when the numbers of arrival lots are in continuous supply.

For the low rate of arrival, short run chart may be used in this respect. The result shows that OTD data approximates to smallest extreme value distribution. It is because the data tend toward upper specification limit and supplier trying to deliver right quality with right ordered quantity "on time' to customer. The low delivery capability was because of two major issues.

Firstly, the target was appointed 90 out of 100 by customer where the mean of the OTD was 74.31 and it makes a bias from target and results in lower capability. Secondly, due to extensive standard deviation, as the overall process capability is based on overall standard deviation, a centralized standard deviation will achieve a higher delivery capability.

The corrective action by supplier can lead to improvement on two phases. First, by reducing the deviation and range of deliveries and second by adjusting the mean with target and improve mean of delivery. According to SCM literature, for a long term partnership both supplier and customer effort is needed in this respect to obtain good result.

6- Conclusion

From the literature, delivery performance is one of the most important indicators of supplier performance. This paper intended a model "on time delivery" using control chat. It is shown that control charts can be used to monitor delivery performance. It also may help organizations to enhance their supplier performance monitoring via corrective actions and improvement on caused signals patterns. When the rate of lot arrival is low, standardized or individual chart also recommended.

References

1. Abdullah, R., Lall, K. L., & Tatsuo, K. (2008). Supplier development framework in themalaysian automotive industry. International journal of economicsand management, 2(1), 29--58.
2. Alwan, L. C. (2000). Statistical Process Analysis (first ed.): McGraw-Hill.
3. Anthony, J., Balbontil, A., & Taner, T. (2000). Key ingredients for the effective implementation of statistical process control. Integrated manufacturing system, 49, 242-247.
4. Besterfield, D. H. (1994). Quality controll (4 ed.): Prentice Hall, Englewood.
5. Besterfield, D. H. (2009). Quality Control (8 ed.): Prentic Hall.
6. BMW. (2008). Supplied Part Quality management.
7. Crichton, G., Zammit, V., Hughes, J., & Vammen, S. (2003). Connecting purchasing and supplier strategies to shareholder value: emerging trends for executive action, (Executive report of the future purchasing alliance): Charted inistitute of purchasing andsupply
8. Humphreys, P. K., Shiu, W. K., & Chan, F. T. (2001). Collabrotive buyer-supplier relationship Hong Kong manufacturing firms. Supply chain management journal, 6(4), 152.
9. IATF. (2002). ISO/TS16949:2002. 2009, from http://www.iatfglobaloversight.org/
10. ISO. (2002). Quality management system-Particular requirement for the application of ISO9001:2000 for automotive production and relevant service part organizations (2 ed.): ISO copyright office.
11. Large, R. O., & Konig, T. (2009). A gap model of purchasing internal service quality: Concept Case and internal survey. Journal of purchasing and supply management, 24-32.
12. lee, C. W., Kwon, I.-w. G., & Severance, D. (2007). Relationship between supply chain performance and degree of linkage among supplier internal integration. Supply chain management: An international journal, 12(6), 444-452.
13. Lehtonen, T. W. (2001). Performance measurement in construction logistics. International journal of production economies, 69, 107-116.
14. Liu, J., Ding, F. Y., & Lall, V. (2000). Using data envolement analysis to compare suppliers for supplier selection and performance improvement. Supply chain management: An international journal, 5(3), 143-150.
15. McAdam, R., & McCormac, D. (2001). International business processes for global and supply chain management. Business process management journal, 7(2), 114.
16. Montgomery, D. C., Runger, G. C., & Hubele, N. F. (2007). Engineering Statistics (4 ed.): John Wiley & Sons, Inc.
17. Morgan, C., & Dewhurst, A. (2008). Multiple retailer supplier performance: An exploratory into using SPC techniques. International journal of production economies, 111, 13-26.
18. Oakland, J. (1999). Statistical process control (4 ed.): Butterworth Heinemann Oxford.
19. Paulraj, A., Chen, I. J., & Flynn, J. (2006). Level of strategic purchasing: Impact on supply chain integration and performance. Journal of purchasing and supply management, 12, 107-122.
20. PSA PEUGEOT CTROEN. (2006). Supplier Quality Management Principles. Retrieved Dec, 2006
21. Rahul, V., & Altekar. (2005). Supply chain management: Printice Hall.
22. Stapenhurst, T. (2005). Mastering Statistical Process Control (1 ed.): ELSEVIER.
23. Tan, k. C., Lyman, S. B., & Wisner, J. D. (2002). Supply chain management a strategic perspective. International journal of operation and production management, 22(6), 614-631.
24. Xie, M., & Goh, T. N. (1999). Statistical techniques for quality. The TQM magazine, 11, 238-242.

Submission date: 28 November 2009