Cause-classified Control Chart and its application

Yan Xu

Department of Information and Systems Management, Hong Kong University of Science and Technology, Hong Kong

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Abstract

Traditional statistical tools are subject to certain constraints when they are applied to quality control in industries where the number of faults per working day is limited. An effective quality monitoring and analyzing tool is therefore needed to meet the specific requirements of these industrial sectors. Proposes a so-called "Cause-classified Control Chart", based on fieldwork in the Nanchang Telecommunications Office of China. Trial results from several posts and telecommunications offices in China in recent years have positively shown that the Cause-Classified Control Chart is an effective tool for quality enhancement in these specific industrial sectors.

Introduction

In some industrial sectors, especially in the service industry, the number of quality faults per working day is limited. For example, the number of faults is usually less than six in a regular working day at a middle-sized post office of China. However, this does not necessarily imply that quality control is not important for these industrial sectors. On the contrary, quality control is extremely critical for most of these sectors, especially the service sector, as customers will be directly affected by the fault and, in consequence, the business and corporate image will be seriously damaged. In the telephone service provision, for example, a mistake in bill invoice could be a strong incentive for a customer to switch to another operator, as the telecommunications market is highly competitive and a customer can easily make a choice over service providers. Thus, it would not be extravagant to claim that any ignorance of quality might lead to critical business losses.

However, as will be discussed in the next section, traditional statistical tools are subjected to certain limitations when they are applied for the purpose of quality control in the above industrial sectors. To improve quality, innovative and effective quality monitoring and controlling tools are therefore in demand.

This paper proposes a more effective quality control chart that is specifically applicable to occasions where the number of faults is limited. It resulted from this author's fieldwork in Nanchang Telecommunications Office of China when the author was invited to establish an effective mechanism of monitoring the quality of telegram delivery. Before the fieldwork, the Department of Telegraph of

this telecommunications office had tried almost every traditional quality control tool. However, none of them seemed effective in reducing the number of faults in telegram delivery. After a period of close cooperation and communication with this department, this author proposed the so-called "cause-classified control chart". Early trial results from several posts and telecommunications offices in China during past years have positively shown that the Cause-classified Control Chart is an effective instrument to enhance quality in the above-mentioned industrial sectors.

Limitations of traditional statistical tools

Traditional statistical tools are subjected to a certain limitations when they are applied for quality control in industrial sectors where only few quality faults occurred.

The Shewhart Control Chart, which was created by Shewhart in 1924, has been one of the most popular statistical tools for quality control. According to Shewhart, every process exhibits some degree of variation due to the existence of chance cause variation and assignable cause variation. The purpose of the Shewhart Control Chart is to monitor the assignable cause variation which occurs and to take relevant procedures accordingly (Swift *et al.*, 1998).

For industrial sectors concerned in this paper, the most commonly used Shewhart control chart is the *pn* Control Chart (see Figure 1). In this case, the upper control limit (UCL) and lower control limit (LCL) of the control chart are relevant to the size of the sample *n*, which makes the chart plotting a complex process, and employees are very reluctant to plot the chart on a daily basis (Zhang, 1984). Normally, the *pn* chart is used in occasions where the sample size is equal. However, for service industries, the amount of production depends on demand, which is out of the control of operators. For example,

the amount of letters which is delivered by the post office is different everyday. In this case, it is hard to apply the *pn* chart in these industrial sectors.

Another commonly used tool for quality control is the Cause and Effect Diagram, or Fishbone Diagram (Hakes, 1991). Its primary purpose is to show the relationship between a given effect and all identified causes of that effect. As the Fishbone Diagram is one of the basic tools for quality control (QC), many quality circles in China analyze the possible causes of the faults with its help. However, due to the lack of quantitative records of these faults and their causes, all the possible causes that might lead to the effects are raised by members of the quality circle during their monthly meeting. Consequently, all the diagrams are more or less the same month after month. Finally, the application of fishbone chart becomes a useless routine business due to its failure in identifying specific causes behind the specific faults in a specific month. Figure 2 shows the Fishbone Diagram that was consistently presented by a QC group in a photocopy store month after month, which hardly tells which cause should be dealt with first (Zhang, 1991).

The Pareto chart is usually used for separating the important from unimportant causes once quantitative data is available (see Figure 3). Accordingly steps can then be taken once the main cause for faults is recognized (Goetsch and Davis, 1995). However, for the sake of data accumulation, the analysis is usually conducted not so timely, hence improvement steps could not be taken in time and fluctuations within the month are concealed.

The above shortcomings of traditional statistical tools have frustrated the incentives of industries to apply them in practice. As a result, many of the Chinese posts and telecommunications offices plot the number of faults on a simple statistical chart on a monthly basis (see Figure 4). In other words, there are only 12 plotted points on the chart over a year. Such a chart only provides monthly statistics of faults and is not helpful at all for quality control, as it can neither give out a timely warning nor tell any information behind these faults.

Figure 1
pn Shewhart control chart

Cause-classified Control Chart

It is obvious that a more effective tool is needed to meet the specific characteristics of the concerned industrial sectors. In 1986, when this author conducted a field study in Nanchang Telecommunications Office of China, employees in the frontline raised the above concerns when applying traditional statistical tools in their QC practice. Based on a comprehensive study about all the traditional tools, both their advantages and disadvantages, this author proposed the so-called “Cause-classified Control Chart” (see Figure 5).

The Cause-classified Control Chart consists of three parts. The first part, or the

Figure 2
Fishbone Diagram

lower part, is a regular statistical chart. The function of this chart is to monitor the fluctuation of faults on a daily basis. Above it, on the top left, is the second part. It is a statistical table which records the number of individual causes that has led to the faults. The third part, the part on the top right, is a histogram chart and is used to illustrate the main causes in a perceptive way of presentation.

In practice, there are three steps to implement this chart (see Figure 5). The first is to plot the total number of faults within a specific day on the statistical chart. For example, on the first day of the month, there are two faults, then, above the date "1", plot a point at the level of "2". Similarly, on day two, there is only one fault, then, above the date "2", plot a point at the level of "1".

After plotting the point, an immediate analysis should be conducted, and causes that have led to the faults should be identified. The Fishbone Diagram might be used at this stage if necessary. Once the causes were found, they should then be recorded in the statistical table. For example, cause 1 and cause 2 are the two causes that have led to the two faults in the first day, then, above date "1", the number "1" should be recorded in the two cells corresponding to cause 1 and cause 2 respectively. Similarly, on day five, two of the faults were caused by cause 2 while one of the faults was caused by

cause 5, then, above date "5", the number "2" and number "1" should be recorded in the cells corresponding to cause 2 and cause 5.

The last step is to draw the histogram chart. For every cause recorded, it should be reflected in the histogram chart by extending one-unit-long length of the bar accordingly. For example, cause 3 was the cause for the one fault on day two, then, after marking "1" in the statistical table, a one-unit-long length should be added to the bar that corresponds to cause 3. The total length of each bar can perceptively tell which cause is the main cause for the faults, and, to solve the problem, appropriate actions can then be taken accordingly.

All the three steps should be taken every day. As they are relatively simple, it will not create much extra work for employees.

Advantages of the Cause-classified Control Chart

Compared with traditional statistical tools, and in the context of the industrial sectors being discussed in this paper, the Cause-classified Control Chart has the following advantages:

- Compared to the *pn* Shewhart Control Chart, the Cause-classified Control Chart is simple and easy to use. All the employees can understand the principles of Cause-classified Control Chart in a few minutes and apply it to their routine operation without any difficulty. This can strongly stimulate their enthusiasm for participating in the process of total quality management (TQM). Or, in other words, the Cause-classified Control Chart enabled the TQM to become a reality in the concerned industrial sectors.
- Compared to the Fishbone Diagram, the Cause-classified Control Chart can tell the main causes more accurately as it is based on quantitative evidence. In this case, appropriate steps can be taken to solve the core problems, then the whole process of production can be easily under control.
- Compared with the Pareto chart, the Cause-classified Control Chart achieves real-time quality control more easily. As the histogram chart included in Cause-classified Control Chart is renewed everyday, the latest information regarding the main cause can be presented. Immediately, effective steps can be taken to solve the problem. As a result, the overall quality is very well controlled in a dynamic way. For example, in Figure 6, cause 2 was the main cause in the first five days of that month. After

Figure 3
Pareto chart

Figure 4
Monthly-based statistical chart

Figure 5
Cause-classified Control Chart (1)

immediate reaction to this, faults resulted from cause 2 were considerably reduced while cause 4 has risen as the main cause afterwards (see Figure 6).

The application of the Cause-classified Control Chart

The Cause-classified Control Chart has been widely used in many industrial sectors in China since it was proposed in 1986. The achievements have positively shown that this control chart is an effective tool in enhancing quality in certain industrial sectors.

The first application case was in Nanchang Telecommunications Office. The Cause-classified Control Chart was used to control the service quality of telegraph department during the period from July to December 1986. This department was mainly responsible for the termination of telegraph, the seal of the envelope and the delivery of telegram to each individual household and company. The commonly met faults include wrong text translation, time delay in delivery and mistake in emergency degree classification. The application of the Cause-classified Control Chart in this department was very successful. Compared with the

Figure 6
Cause-classified Control Chart (2)

period January to June of the same year, the faults were reduced by 70, a decrease of almost 30 per cent (Deng, 1987).

Another case was in Wuxi Posts and Telecommunications Office. The Cause-classified Control Chart was used to control the internal process of confidential documents delivery service. With the help of this chart, they achieved the benchmark of “zero faults in one million documents delivery” (Pu, 1991).

Figure 7 provided an example on how a post office in China applied a Cause-classified Control Chart to control the quality in its mail sorting department. Before the application of this chart, the sorting department occasionally conducts a general

quality analysis with a traditional quality control tool such as a fishbone chart. The main cause cannot be highlighted and no solution has been conducted accordingly. When this department applied the Cause-classified Control Chart in 1989, they immediately realized that the placement of mail in wrong sorting cells is the main cause of the fault. Accordingly, they improved the sorting box by highlighting the label for each cell with different bright color and enlarged the destination name. They also conducted the extensive training for staff on how to view the address completely within the limited time, as incomplete address viewing is the number two major cause for faults in mail sorting. After three months of applying

Figure 7
Cause-classified Control Chart in application

the Cause-classified Control Chart, the faults in service dropped dramatically (Xu, 1989).

Conclusion

This paper has introduced a relatively more effective statistical tool for quality control. It overcomes the limitations of several traditional control tools when they are used in industrial sectors where the number of faults is limited. Compared with the Shewhart Control Chart, the Cause-classified Control Chart is simple and easy to use.

Compared with the Fishbone Diagram, this chart can tell the real causes that have led to the faults in a quantitative way. The advantage of Cause-classified Control Chart over Pareto chart is that it can show the main cause in a dynamic way so real-time quality monitoring and controlling is possible. Practical application has shown that quality can be improved significantly if the Cause-classified Control Chart is applied properly. Additionally, the simplicity of this new control tool would encourage more employees to participate in the process of quality control, hence the goal of TQM can be

achieved in a relatively easy way, and the resistance of inertia avoided.

This technique has applications outside that of industrial production quality control, and may easily be modified for use in internal and managerial auditing. It has the advantage of both simplicity and economy of effort, as well as enabling a rapid response to issues and problems, and pinpointing where action is required, and who bears the responsibility.

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