SOME POSSIBILITIES OF THE ANALYSIS OF THE COSTS OF SPC BY CONTROL CHARTS

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This contribution deals with the possibilities of using of Shewhart control charts for the analysis of the costs of the statistical process control and for the decision making based on this analysis. We start by the description of the basical understanding of the control charts, based on the definition of the common and special causes of variation. Afterwards we present the application of the control charts in the problem of the analysis of the costs of statistical process control and of the decision making based on the results of this analysis.

Príspevok je venovaný možnostiam využitia Shewhartových regulačných diagramov na analýzu nákladov na štatistickú reguláciu procesu a na riešenie problémov rozhodovania na báze výsledkov tejto analýzy. Na úvod uvádzame základnú koncepciu chápania a formulácie regulačných diagramov, založenú na definovaní náhodných a vymedziteľných príčin variability. Nakoniec uvádzame príklad aplikácie regulačných diagramov pri riešení uvedených problémov.

There is variation in all aspects of our lives. Household expenses, time required to travel to work all vary over time.

There is variation among people. The ability to perform a task, intelligence, all vary from person to person.

According to (1) there are four major issues that must be addressed if statistics is to become an integral part of management:

- Managers must understand why they need to possess statistical knowledge.
- Current and future managers must develop this knowledge.
- Measures must be taken to ensure that the knowledge is effectively applied.
- The payoff from the knowledge and its application must be assessed.

Principles of statistical thinking

Statistical thinking has its roots in the work of W.Shewhart. Statistical thinking could be understood (1) as the thought that all work is a series of interconnected processes, that all processes are variable, and that a reduction in variation provides improvement opportunities should not frighten anyone.

Rational subgrouping. One of the importent principles of statistical thinking contributed by Shewhart is rational subgrouping. To minimize variability, the sources of variation must be identified and eliminated. Data must be collected in a manner that will enable measurement of the variability in the process.

Plot the data. Graphical disolays are an excellent tool for quickly communicating large quantities of information. It is important that people plot the data and use the plot.

Managers can benefit from using graphical displays to understand the process and , consequently, the predictive power this understanding offers. The predictive power comes from knowing the amount of variation reduction that will occur when some of the sources of variation are minimized or eliminated.

Common - and special - cause variation. We constantly make decisions in our daily lives based partly on our interpretation of the variation that we encounter. The decision is often based on whether we think that the variation we observe is indicative of a change or simply random variation that is no different from that which has occurred in the past.

Managers have to be able to determine whether the patterns of variation that are observed are indicative of a trend or of random variation that is similar to what has been observed in the past. This distinction between patterns of variation is necessary to minimize the losses resulting from the misinterpretation of these patterns. According to (10), typical losses resulting from misinterpretation are:

. Blaming people for problems beyond their control

. Spending money for new equipment that is not needed

. Wasting time looking for explanations of a perceived trend when nothing has changed

. Taking other actions when it would have been better to do nothing.

The concepts of common and special causes of variation can be used to help minimize these and other losses resulting from misinterpretation of variation.

Indicators of the performance of any process or system can be identified and measured. These indicators will be called quality characteristics.

A fundamental concept for the study and improvement of processes and systems developed by Walter Shewhart is that the variation in a quality characteristic has two types of causes:

Common (chance) causes: thouse causes that are part of the process (or system) hour after hour, day after day and affect everyone working in the process.

Special (assignable) causes: those causes that are not part of the process (or system) all of the time or do not affect everyone, but arise because of specific circumstances.

A process (or a system) that has only common causes affecting the outcomes is called a stable process or said to be in a state of statistical control.

Exactly, a process is in control (is stable) if and only if the distributions of all of its measurable characteristics are constant over time.

In a stable process, the cause system for variation remains essentially constant over time. This does not mean that there is no variation in the outcomes of the process , that the variation is small, or that the outcomes meet the requirements set by the customer . A stable process implies only that the variationin the outcomes is predictable within statistically established limits.

A process, whouse outcomes are affected by both common causes and special causes is called an unstable process. An unstable process does not necessarily have large variation. It is called unstable because the magnitude of the variation from one time period to the next is unpredictable.

The view of variation based on common and special causes is in contrast to the view of variation based on classification of performance of the process as good or bad (10).

The „good or bad“ view of variation forms the basis for checking of products or services. It does not provide any information about the causes of variation. It does not provide useful information for improvement.

As the special causes are identified and removed, the process becomes stable.

Shewhart Control Charts and Statistical Process Control (SPC)

Shewhart also provided a method to determine whether variation in the process is dominated by common or special causes. This method is the Shewhart control chart.
The control chart is the means to operationally define the concept of a stable process. It consists of three lines and points plotted on a diagram (Figure 1).
A control chart is constructed by obtaining measurements of some quality characteristic of the process such as delivery time, viscosity, temperature, cost, number of errors, volume of sales, forecast error etc.

The individual data or some descriptive statistic such as average, range, or percent is plotted on the chart. The horizontal axis is the number or other identifier of the subgroup and the vertical axis is a scale for the statistic.

The control limits bound the variation in the statistic due to common causes.

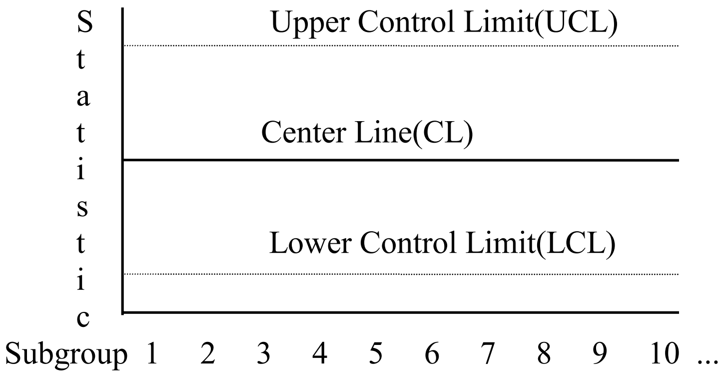

Figure 1. Control chart

According to (14) , the rational for the continued use of Shewhart control limits can be summarized as follows:

- The limits have a basis in statistical theory.
- The limits have proven, in practice, to distinguish between special and common causes of variation.
- In most cases, use of limits will reduce the total cost due to overreaction and underreaction to variation in the process.
- The limits protect the moral of workers in the process by defining the magnitude of the variation that has been built into the process.

Points outside the limits are indications of the existence of special causes. The control limits are not to be confused with specifications or other targets values for the process. They are simply a prediction of the variation that will occur due to the system, that is, due to common causes.

Control charts are a tool of Statistical Process Control (SPC). According to (13), Statistical process control is a collection of tools, mostly statistical, which help us to understand what is going on in any process that generates products, services or informations. It helps us to attain insight into the inherent behavior of those processes. Understanding how a process behaves enables us to find the reasons why it behaves that way, enables us to excercise control over that process , and serves also to assist in the redesign and improvement of the process.

The reader can find the interesting view on SPC also in (4), (5), (6), (7), (11), (12), (16), (17).

Analysis of the Costs of SPC

Generally, costs of SPC = costs of taking the sample+costs of investigation and correction of special causes+ costs of nonconforming output.

The costs of taking the sample include the out-of-pocket expenses of inspectors and technicians salaries and wages, the costs of any necessary test equipment and in the case of destructive testing, the unit cost of the item sampled.

The costs of investigation and correction of special causes include the costs associated with investigating an out-of-control signal and with the repair or correction of any assignable causes found.

The costs of nonconforming output consist of typical failure costs - that is, the costs of rework or scrap for internal failures, or replacement or repair costs for units covered by warranties in the case of external failures.

We would like to know if we can consider the increasing of the costs as a special case and look for any special causes of its increasing.

We have the following data (Table 1).

Table 1

month number	1	2	3	4	5	6	7	8	9	10	11	12	13
reported costs	112	114	112	125	152	156	152	154	163	156	158	164	182
estimated costs	110	110	115	120	155	155	155	160	160	160	160	160	160

The first possibility is the using of the simple statistical diagram, like in the figure 3, when the reported and the estimated data are compared.

In the figure 1 we can see an important difference between reported and estimated data in the last month, but on the basis of this simple diagram we cannot judge if this difference could be taken as a special situation, if there are any special causes.

The better tool of analysis in this situation is the using of a control chart. The appropriate control chart in this problem is the control chart for individual measurement (more details about control charts for individual measurements are for example in (8)

We can use the individual measurements for example of the following indicator C:

$$C = \frac{\text{reported costs} - \text{estimated costs}}{\text{estimated costs}} \cdot 100\%$$

and we have the indicator of the cost deviation in %.

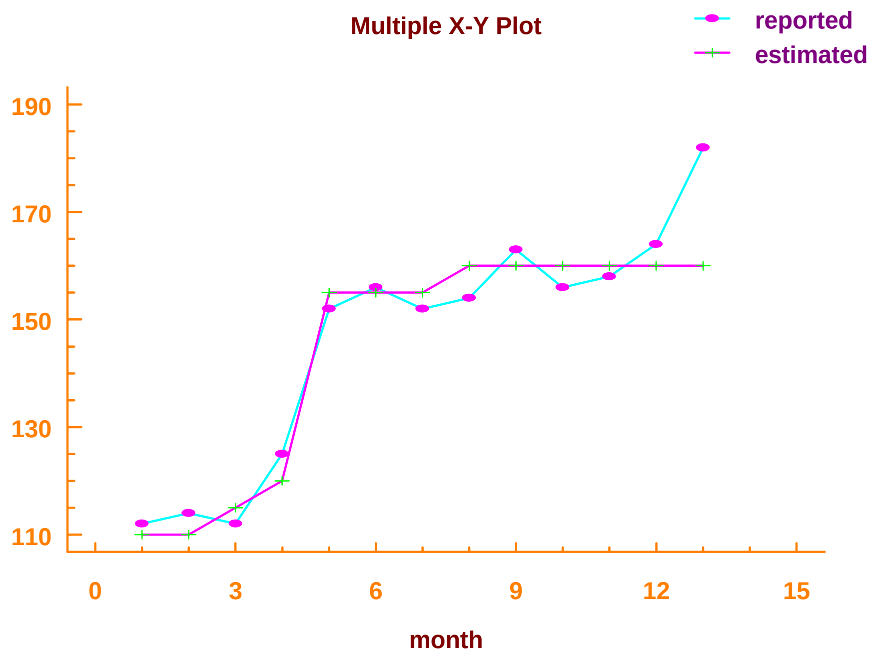

Figure 2. Simple statistical diagram

We suppose the independence of observations and normality of the random variable C.

Really on the basis of the value of indicator C we can formulate two types of control charts:

a) for the moving range $MR_i = |\ C_i - C_{i-1}\ |$
b) for the individual observations.

In figure 4 in the control chart for individual observations we can see, that actual observation is out of control limits.

This fact indicates that any special causes of variability of the costs of SPC exist and we can investigate the kind of these special causes .

Generally, for the most learning and least disruption when special causes occur, a reaction plan should be established. Often a flowchart of steps is useful. The reaction plan should consider that it is useful to learn from the special cause and to take action to eliminate its effect.

Figure 3. Control chart for individual observations and for moving range

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