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Common Cause versus Special Cause Variation

In a previous video, you learned about common and special causes of variation.

A pioneer in the field of quality, and a peer of Walter Shewhart, was W. Edwards Deming. According to Deming, most opportunities for improvement are driven by the system.

These are the result of predictable sources of variation, or common causes.

Only a small proportion of the problems are the result of unpredictable influences in the system, which are driven by special causes of variation.

A special cause, for example, might be due to an equipment issue, to a part wearing out, or to a power failure.

As you have learned, a stable, or in control, process is one in which only common causes of variation are present.

If a process is in control and on target, trying to improve the performance of the process by 'tweaking' machines or work methods generally makes things worse.

These efforts to improve a stable process, without knowledge of cause and effect, are known as tampering.

To illustrate the effects of tampering to managers, Deming used a demonstration called the Funnel Experiment. The demonstration involved a funnel, a stand for the funnel (to lift it off the ground), a ball or a marble, and a target.

A volunteer was selected from the audience and was asked to drop a ball through the funnel.

The ball's final resting position was marked, and this was repeated 50 times. The goal was to get the ball to come to rest on the target. The critical measurement for the process was the distance from the target to the ball's final resting position.

The volunteer was given different adjustment rules, or strategies, to try to improve the performance of the process.

Rule 1 is no adjustment. Leave the funnel fixed and aimed at the target.

Rule 2 is Exact Compensation. After the ball lands a certain distance from the target, move the funnel an equal and opposite distance from its last position.

Rule 3 is Overcompensation. After the ball lands a certain distance from the target, move the funnel an equal and opposite distance from the target.

Rule 4 is Consistency. After the ball lands a certain distance from the target, aim the funnel right over the spot where it came to rest.

Which adjustment strategy do you think is the best?

We'll conduct our own funnel experiment using the demoFunnelExperiment script. This script is available in the Sample Scripts Directory under Help, Sample Data.

The graph on the left shows the view of the target from above, marked by a circle. We start by clicking Rule 1. Fifty successive balls are dropped, without changing the position of the funnel. The final position of each ball is marked, and the distance from the center of the target is plotted on the I and MR chart.

Most of the points are close to the target. The points appear to be randomly scattered in the individuals chart, with no points outside the control limits. This is a process with only common cause variation.

We apply the other adjustment rules to see if we can improve the process.

Under Rule 2, exact compensation, the funnel is moved to the exact opposite position of the last drop. So if the ball's final resting position was 3 inches north of the target, the funnel is moved 3 inches south of this position.

This rule is based on the idea of making adjustments to meet a target on the next production run. A common example in a machining operation is applying an offset adjustment or adjusting to zero. Another example is when an operator overreacts to common cause variation and makes unnecessary adjustments.

Let's look at the graphs. The process has become more variable than if we had left the process alone. In fact, if we apply this rule long term, the process will be 40% more variable.

Notice that the moving range chart shows more variability, with more points beyond the upper control limit. Also notice the pattern in the individuals chart. Many of the points fall close to either the upper or lower control limit.

Under Rule 3, overcompensation, the funnel is moved to the opposite position from the target.

The goal of this rule is to average out to the target level. This strategy is often used in resource planning, inventory management, and managing budgets, lead times and production levels.

Now the process is moving farther and farther away from the target with each drop, on either side of the target.

Under Rule 4, the funnel is moved over the resting position for the previous drop.

The strategy for this rule is consistency. One of the most common examples of this rule is on-the-job training. In an application with dyes or paints, an example would be color-matching based on the last swatch or batch.

Under this rule, we see somewhat of a random walk. The balls come to rest farther and farther away from the target.

The funnel experiment demonstrates that well-intended efforts to improve a stable process, without knowledge of cause and effect, can make things much worse. If you react to common cause variation as though it is special cause variation, you might actually increase variation, drive the process off target, or create other problems.

Common cause variation is inherent to the process. The variation in the output of a process is a function of many input variables, or x's.

To reduce common cause variation, you need to understand the process and use data and statistical tools to manage the sources of variation.

Special cause variation is external to the process. To eliminate special cause variation, you need to identify the special cause, understand what changed, and take action to prevent the change from happening again in the future.

In this video, you learned more about common and special cause variation, and about the impact of tampering on a process.

In the next video, you learn about tests for detecting special causes.

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