Testing for Special Causes

You've learned how to construct individual and moving range, or I and MR, charts. Most variables control charts come in pairs. For the I and MR chart, the top chart is used to plot the averages and to show the range of variation in individual measurements that you can expect if the process is stable. The bottom chart is used to plot the within-subgroup variability.

Remember that this chart plots the moving range between consecutive points. For an example, we use the Cleaning data. In this scenario, you measure the cleanliness of parts after a cleaning process. The Post-Cleaning measure of the particulates on the parts is of interest. You select one part per hour, for 50 hours, and study the process variation using an I and MR chart.

First, you use a normal quantile plot to check for normality, and you find that the distribution is approximately normal. Here are the individual and moving range charts, and the control limit summaries. Let's take a closer look at these control charts. Our primary focus is the individuals chart. There aren't any points outside the control limits. But can we safely conclude that this process is stable or free of special causes?

A control chart can result in two types of errors. The chart can fail to signal or detect a special cause. In statistics, this is called a false negative.

Or the chart can erroneously signal a special cause when there is only common cause variation. This is called a false positive or a false alarm.

Until now, we have discussed only one type of special cause: when a point falls outside the control limits. If your data are normally distributed, and the process is stable, this will happen only 0.27% of the time by chance alone. This is pretty rare. So, if you see a point outside the control limits, you have a pretty good indication that this is a special cause, especially if the point falls far beyond one of the control limits.

Here's another example. The process variable is acid concentration. On this individuals chart, one point is pretty far beyond the upper control limit. This is clearly a special cause. Notice that the moving ranges for this point on the moving range chart are above the upper control limit! This one special cause is producing signals in both charts.

There are other types of special causes, and these might not be as easy to detect. Shewhart control charts are insensitive to small shifts and might take many time periods to signal after a change has occurred.

To make a Shewhart control chart more sensitive to detecting special causes, we can test a number of rules. The most common rules are the set of eight Western Electric Rules. These rules were developed at the Western Electric Company in the 1950's. Tests for these rules are conducted by dividing the intervals between the overall average and the control limits into zones, where each zone is one standard deviation wide. Each test looks for the occurrence of points in the different zones, signaling if something unlikely, or special, has occurred. Here are the rules as they are documented in the JMP Support Files. Test 1 is the familiar test for one point outside the control limits.

Let's consider Test 2. This tests for nine points in a row on the same side of the center line.

The center line is the overall average of the observations. If nothing special is occurring, you would expect to see points randomly scattered on either side of the center line. Getting nine points in a row on one side would be like getting nine heads in a row when flipping a coin. The probability of this happening by chance alone is very small. If the control chart signals a violation of this rule, it's very likely that the process mean has shifted. Most of the tests identify patterns in the data that are unlikely to occur unless something in the process has changed. However, some of the tests are used to identify potential issues with the rational subgrouping or sampling.

For example, take Test 4: 14 points in a row alternating up and down. If alternating points are collected from two shifts, for example, a signal from this test might indicate that there are systematic differences between the two shifts.

For the Acid data, three of the rules are violated. It is easy to see the one point outside the control limits. This is a violation of Rule 1. We also see violations of Rules 5 and 6. These are both indications that there might have been a shift in the process mean. In fact, it looks like there was an upward trend in the data until row 13. After that, it appears that the mean stabilized.

In a problem-solving context, you'd want to research these special causes to identify what exactly caused the changes. Depending on what you learn, you might want to take action. For the upward trend, you might need to take steps to prevent the process mean from drifting in the future. The mean stabilized, or leveled out, starting with row 14. If this new level is desired, you might want to take steps to ensure that this level of performance is sustained. But first, you'd need to identify what caused this change.

Note that you don't need to run every test for every control chart. In fact, if you run all tests, you might get a false alarm, or a false detection of a special cause. Ultimately, for a problem-solving team, special causes point to potential changes in the process that should be investigated, understood, and controlled.

In this video, you've learned how to identify special causes of variation in a process. Remember that it can take many time periods for a Shewhart chart to signal that a special cause has occurred. There are other types of control charts, such as Exponentially Weighted Moving Average (EWMA) and CUSUM (Cumulative Sum) charts, that are particularly effective at detecting small shifts in the process. For more information on these control charts, see the Read About It for this module. In the next video, you see how to conduct tests for special causes in JMP.

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