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What are Common Causes and Special Causes?

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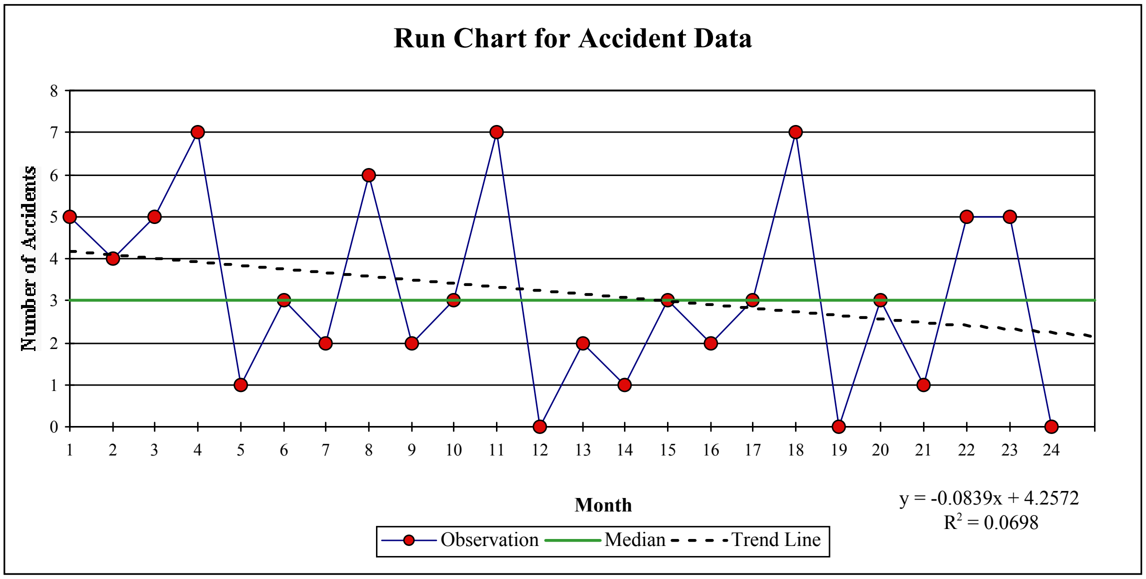
There seems to be some confusion with regard to the classification of the causes of variation. For example, some people believe that, points outside the control limits are always the result of special causes and those inside are the result of common causes. Others believe that control limits should always be set at three standard deviations. Both beliefs are incorrect, but these seem to be common misconceptions. So, since this is an important issue, it makes sense to explore it and see what we can learn.

First, we need to define our terms – specifically what are common and special causes of variation? This is a key to actually understanding this important concept. To paraphrase Dr. Tukey, an observation is classified as being the result of common cause variation if it is uneconomic to search for its causes (Tukey, 1946), or if a search for special causes is unsuccessful. Armed with this definition it is apparent that any observation can be classified as being the result of special causes, if we are able to determine its causes. Further, this definition implies that the practitioner should look for the causes when the cost of searching is less than the expected cost of failing to search.

So, just because a point is outside the control limits does not mean that the observation is due to special causes. It just means that it is highly likely to have been the result of special causes and it probably makes economic sense to search for those causes. The converse is true for points inside the control limits. Control limits and run test rules were established to help the practitioner so that they would not search for causes when it was probably uneconomic to do so. But any observation, whether it violates a control chart stability test rule or not, can be classified as being the result of special causes if it is possible to determine the causes. This is true even if it was uneconomic to have searched for the causes in the first place. Further, the point at which it makes economic sense to search for special causes is not always at three standard deviations from the mean. For example, if it is inexpensive to search for the causes and expensive if the process becomes unstable, then the break-even point can be much less than three sigma).

Now let's see how we might deal with a real world problem where applying our knowledge leads to a different conclusion than conventional wisdom. A recent article by Davis Balestracci in Quality Digest (September 2005) cites an example of a safety committee that had been working to reduce accidents in their manufacturing plant. The author provides the data on a run chart that shows a 46.2% reduction in accidents from 45 in the first year to 32 in the second year. The team achieved this by carefully analyzing each event (i.e., accident) and trying to eliminate its causes.



The author looked at this data and asked, "Is the process that produced the 32 accidents any different than the one that produced the 45?" His answer is no, based on applying three run chart tests for detecting an unstable process (i.e., seven points in a row going downward, or eight above the median in the first year, or eight below the median in the second year). Based on this analysis he states, "The special cause strategy of looking at each accident and attempting to find its causes is wrong." The author apparently thinks that the committee is treating common cause events as if they were special and this, as we all know, can lead to serious problems. But is the author correct?

Let's take a closer look at this argument and see if we agree. As it turns out the regression coefficient (b) for the 24 points in the data set is -.0839 and we can test this value to see if it is significantly different from zero. The test statistic is:

$$t\,(Ho{:}\ \beta = 0) = (b - \beta) * SQRT[(n - 2)s_x^2/s_e^2]$$

If we can reject the null hypothesis that $\beta = 0$, then we would conclude that there has been a reduction in the accident rate. The computed t value is -1.29 and the p-value is .21. This means that there is a 79% chance of rejecting the null hypothesis and concluding that the correlation coefficient $\beta \neq 0$. Yes, typically, we would like to have a p-value of less than .1 or .05, but if you were asked to bet money on whether the accident rate had dropped and the person offered you even money odds, then you should bet that the accident rate declined because you will win 77 times out of 100.

Therefore, I think it is incorrect to characterize the efforts of the safety committee as inappropriate because, on safety issues, the cost of searching for special causes may be much less than the expected cost of failing to search (i.e., serious injury or death and the ensuing litigation). Hence the analysis of many of the accidents was probably reasonable and the actions taken may have actually addressed some real special causes, thus reducing future accidents. Further, in terms of communication, I think we should say that there is insufficient evidence to conclude with a high degree of confidence that their efforts have been effective in reducing the accident rate, but the trend is positive and that they should continue their efforts. We should encourage the team to look for systematic causes and not just respond to accidents in trying to improve the system. Sending the message that they have been wasting their time is surely not the one that we want to communicate as it will undermine their initiative and perhaps end their efforts entirely.

References:

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