"VITAL FEW, TRIVIAL MANY"—CHALLENGED

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SUMMARY

Quality leaders are taught to focus on the vital few problems, based on the Pareto principle. However, the Shewhart + Pareto principles together select significantly different vitals than Pareto alone. It is critical to understand the key difference between the two differing results. This new development is likely to change the practice of how problems are prioritized. This is also likely to change the focus of statistical research where the emphasis has been on improvement methods without fully understanding the complexities of physical and statistical phenomena. It may even challenge the belief and application of the widely accepted axiom—*Vital few, trivial (useful) many* (Juran 1995).

KEY WORDS

Pareto chart, problem solving, Shewhart chart

INTRODUCTION

To achieve a desired level of quality, we must control and/or improve an output target and an output consistency based on process actions. Process actions are based on knowledge of processes or based on clues derived from output behavior.

When actions are taken based on expert knowledge, we refer to that as forward thinking (Bajaria and Copp 1991). Forward thinking actions are necessary but not sufficient to achieve optimum output quality. When actions are taken based on the clues provided by output behavior on a control chart, we refer to that as backward thinking (Bajaria and Copp 1991). Forward and backward thinking together create a necessary and sufficient condition to derive optimum solutions. Shewhart and Pareto principles together form a powerful tool to execute the backward thinking.

The Shewhart principle can be stated as follows—"An adequate science of control for management should take into account the fact that measurement of phenomena in both social and natural science for the most part obey neither deterministic nor statistical laws, until the assignable causes of variability have been found and removed" (Shewhart 1931).

The Pareto principle can be stated as follows—When output variability exists due to multiple symptoms, large gains can be made by solving for a vital few symptoms than many trivial ones.

Both principles prioritize the process control and process improvement actions in different ways. The Shewhart principle separates stability problems from variation problems. Furthermore, it states that stability problems will prevent us from successfully investigating variation problems. The Pareto principle separates high-occurrence problems (referred to as vital few) from low-occurrence (referred to as trivial many or useful many) problems without any reference to system stability. We will label stability problems as urgent problems and variation problems as important problems. Thus, the Shewhart principle helps determine the problem-solving sequence (urgent before important) whereas the Pareto principle helps us focus (more important few versus less important many). The Shewhart principle is more science-based whereas the Pareto principle is more management based. Their use together helps us form a new strategy for determining problem priorities and corresponding corrective actions.

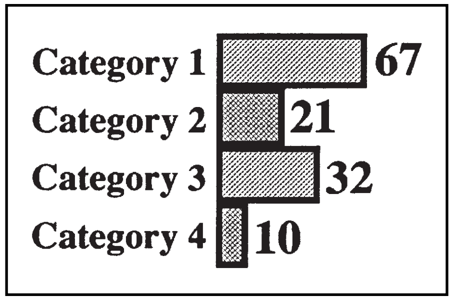


Figure 1. Pareto chart.

Most applications in industries tend to use the Shewhart principle for variable data and the Pareto principle for multisymptom attribute data. Emphasis is placed on using the Shewhart chart to reduce errors α and β when control actions are taken. Thus, primary use of the Shewhart principle has been to reduce process control action errors. In contrast, primary use of the Pareto chart has been to focus on a vital few problems to improve processes.

Instead of using the Pareto chart alone, we should use the Shewhart + Pareto charts together. Such a combined use of Shewhart and Pareto charts would produce an entirely different set of priorities in choosing problems. We would arrive at substantially different corrective actions both in nature and in sequence. We also show gross inadequacies in using the Pareto chart alone.

SELECTING INSTABILITY BEFORE VARIABILITY

Let us look at an example of nonconformances on the Pareto chart in Figure 1. According to this Pareto chart we will consider category 1 as the first priority in solving the problem. Now, let us look at the Shewhart and Pareto charts together for the same set of data in Figure 2.

The Shewhart chart indicates that the data summarized in the Pareto format came from an unstable system. Category 3 appears to be responsible for this instability. Therefore, according to Shewhart's principle we should solve the instability (category 3) before we can solve the variation (category 1). We can see a remarkably different problem-

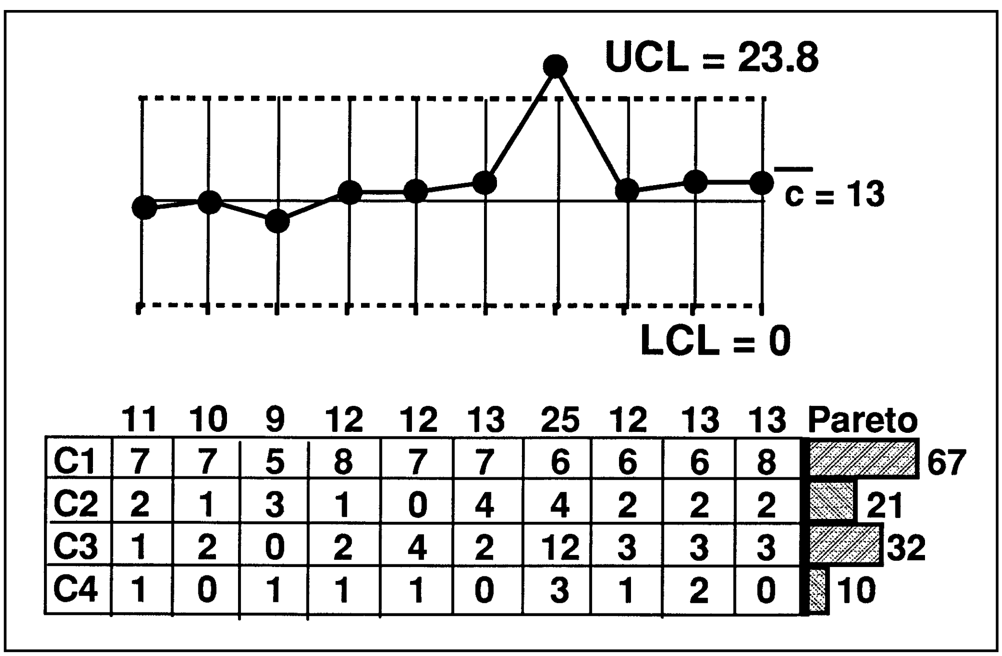


Figure 2. Shewhart and Pareto charts together.

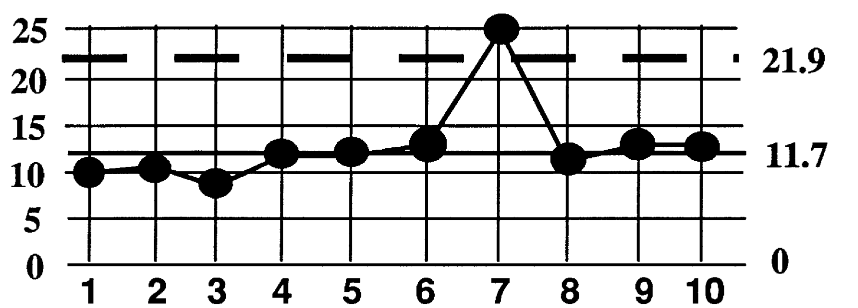
solving priority as we went from using the Pareto chart alone to Shewhart + Pareto chart. The failure to recognize distinction between instability and variation problems in the Pareto chart introduces a class of statistical errors which are neither discussed in quality improvement literature nor are subject of research in statistics. Let us coin the term ξ error for choosing category 1 (variation) before choosing category 3 (instability). The concept of ξ error can potentially make a valuable contribution to the field of statistical and quality sciences.

The following is a real-life example of the ξ error. In a multicavity injection mold machine several attribute defects are observed. Of specific interest is a distortion of the part because it occurs more often than any other defect (similar to C1 in Figure 2) as evidenced on the Pareto chart. However, occasional blips occur on the control chart (Similar to C3 in Figure 2) exhibiting a defect labeled excessive flash. Over a period of time, the excessive flash defects occur less frequently compared to distortion defects. The mold temperature is a common input variable affecting both defects. Correctness of temperature setting is a strong suspect for distortion. On the other hand, temperature differences across the mold surface are strong suspects for the excessive flash condition. Subvariables that can contribute to uneven mold surface temperature could be malfunctioning thermocouples, uneven mold wear, or uneven mold cooling. According to the Pareto chart we can choose part distortion as a priority problem. But according to Shewhart + Pareto chart we should choose excessive flash condition as the first priority. The Pareto guided choice would send us in the direction of determining the best temperature setting. On the other hand, the Shewhart + Pareto guided choice would suggest that we first investigate temperature instability. From a physics perspective, it will be meaningless to talk about temperature setting especially when temperature is fluctuating in an unstable manner.

In this instance, the company was spending its valuable resources in solving distortion problems by using design of experiments to determine the best temperature setting. Needless to say, the problem-solving team could not produce any useful conclusions about the best temperature setting. In other words, it committed ξ error.

SEPARATING MULTIPLE CAUSE SYSTEMS

There is one other possibility of making an error when choosing a problem-solving priority based on the Pareto chart alone. This happens when a single symptom contains both instability and variation problems. Let us examine Figure 3. In this case, based on either the Pareto chart or the Shewhart + Pareto charts, we will choose category 3 because it represents instability as well as majority. However, the key difference comes into play when we attempt to solve the category 3 problem. The Pareto chart will make us believe that there is a single cause system responsible for the category 3 problem since the Pareto chart cannot separate the variation from instability in a single category. In contrast, the Shewhart + Pareto chart would lead us to believe that there are multiple cause systems present.



	10	11	9	12	12	13	25	12	13	13	Pareto
C1	4	6	3	6	5	5	4	4	4	6	47
C2	2	1	3	1	0	4	4	2	2	2	21
C3	3	4	2	4	6	4	14	5	5	5	52
C4	1	0	1	1	1	0	3	1	2	0	10

Figure 3. Shewhart + Pareto chart.

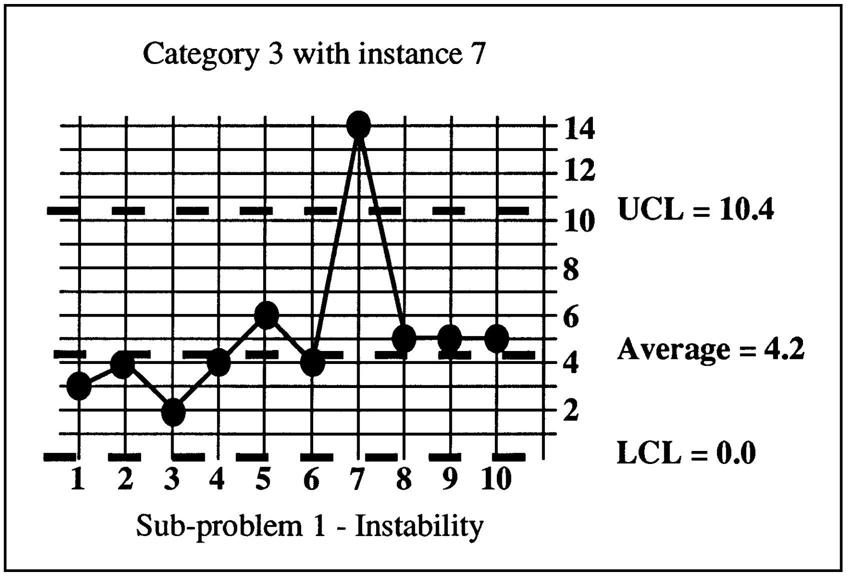


Figure 4. Category 3 data plotted with instance 7 showing instability.

One cause system affects instability and the other affects variation. This can be readily seen if we break down category 3 problem into two subproblems. Figure 4 illustrates instability and Figure 5 shows variation.

Therefore, an error is committed when using the Pareto chart alone because it makes us think that there is a single cause system when, in fact, there are at least two cause systems. We will coin the term for this error as the Ψ error.

Here is an example of the Ψ error. A corrugator process is experiencing a glue joint strength problem. The strength value at times is lower than expected. A peel test is used to determine the product acceptance or rejection. The test data is an attribute form (pass/fail). Here, instability and variation both are built into a single symptom called *peel test failure*. Subgroup 7 exhibiting instability had 14 peel test failures. This instability is assignable to the glue buildup on the rollers where the paper rides. If this buildup is not periodically cleaned, the paper rides on the roller in a concave shape rather than flat. This evidently contributes to peel test failure. Even without the subgroup 7 instability, peel test failures naturally varied between 0 and 10.4. This variation is due to the fact that interactions among paper moisture, temperature, and speed variables are not well-understood. This lack of understanding is evidenced

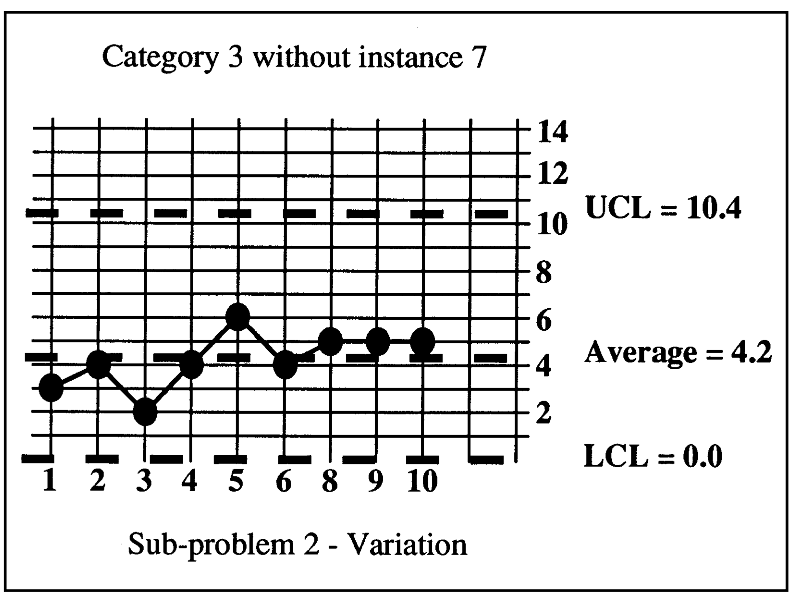


Figure 5. Category 3 data plotted without instance 7 showing variation.

by continuous play with temperature and speed variables by the operators. The end result is the peel test failure. On the Pareto chart both of these failure phenomena show up as a single symptom.

In this instance, the company was focusing on finding the optimum values of temperature and speed to counter the moisture variation in the paper. The company was not focusing on solving the glue buildup problem, which prevented it from learning about the moisture-temperature-speed interactions. In this case, the problem-solving team committed Ψ error.

POSSIBLE ERRORS WHILE WORKING ON PROCESS CONTROL AND PROCESS IMPROVEMENT

Errors when dealing with a single symptom.

α error—When correction is made because a variation problem is thought of as an instability problem. This error is primarily due to decisions based on specification limits rather than control limits.

β error—When instability is not corrected when it should be. This error is also primarily due to decisions based on specification limits rather than control limits.

Errors when dealing with multiple symptoms.

ξ error—When the problem category incorrectly chosen as "vital few" represents a variation problem when another problem category showing instability is present. This happens primarily due to the use of the Pareto chart without the accompanying control chart.

Ψ error—When the problem category chosen as "vital few" is incorrectly assumed to exist due to a single cause system when multiple cause systems exist. This also happens primarily due to the use of the Pareto chart without accompanying control chart.

WHY HAVE ξ AND Ψ ERRORS NOT BEEN RECOGNIZED?

ξ *Error*

The main reason for this error is the inadequacy of the Pareto chart when used singularly to separate the symptom that indicates instability from the symptom that indicates variation.

Ψ *Error*

There are at least two reasons for this error. The first is the fact that engineers/problem solvers heavily rely on symptoms to provide clues rather than statistical problem conditions. Therefore, they do not separate the problem symptom into instability and variation.

The second reason is that data on the Pareto chart disregard the system stability issue. The teachings of the Pareto principle do not emphasize the fact that the system has to be stable in order for *vital few, trivial many* to be utilized for problem focus.

CONCLUSION

We have introduced two new concepts: ξ error and Ψ error. These errors challenge the widespread practice of using *vital few, trivial many* (Pareto principle) to prioritize problems. The primary challenge comes from the use of the Pareto principle as a guiding tool when system instability is not detected. We established the fact that the Shewhart principle determines the sequence in which problems must be solved—*instability before variation*. We basically agree with the fact that the Pareto principle creates a focus—*vital few versus useful many*. However, to form a strategy of selecting problems we need sequence and focus both. Thus, application of the Shewhart + Pareto charts offers a strategy which is shown to produce substantially different priorities compared to the Pareto chart alone.

I suggest the change in axiom from *vital few, trivial (useful) many* to *urgent before vital few, useful many*.

Not only should we change the name of the axiom, we should change our starting point of solving problems from quality characteristics to quality performance. Much bigger opportunities lie in using performance problems downstream as a starting point rather than in controlling characteristics upstream. This suggestion is based on problem-solving experience in many industries over the last 20 years. Many companies focus upstream with an unfounded belief that if upstream is okay then downstream is okay. Many inherent problems remain unresolved as a result. It is my earnest hope that this paper will contribute toward changing the strategy of assigning problem-solving priorities across all disciplines and will produce dramatically better results.

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