VARIATION, MANAGEMENT AND W. EDWARDS DEMING

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Jack and Sarah were preparing for their monthly meeting. Jack, the vice president of sales, wasn't looking forward to it. Sales were down again this month, and he was going to have to confront Sarah, a regional sales manager. He really thought Sarah was doing a good job overall, and the fact that he needed to chastise her periodically frustrated him. But reprimanding Sarah usually improved sales--at least for a month or so.

Sarah wasn't looking forward to the meeting either. Even though she could easily come up with a thousand reasons why sales were down, they were the same reasons she had used many times before and would use many times again: absenteeism, sales force turnover, poor training, lack of product promotions, and a host of other factors that were mostly beyond her control. Even in those months when she was credited with unusually good sales, Sarah was nervous about the monthly meeting because she was never sure of exactly how she had improved sales.

At the meeting, Jack asked Sarah to explain the most recent drop in sales. Sarah gave her reasons. Jack pretended to believe her. He felt obliged to emphasize that her job was to keep sales up. Both felt this meeting was necessary, but both felt they hadn't really solved anything and that the same thing would happen again in subsequent months.

What were these managers doing wrong? Or, rather, what could they have done better? Both were acting in the best interests of the company. Both were competent managers who had risen to high levels in the company. Yet Jack didn't enjoy reprimanding people, and Sarah felt uneasy each time she had to explain drops or rises in the sales figures.

What these managers and millions like them lack is a key piece of the management puzzle, a piece that W. Edwards Deming calls the theory of variation. In Deming's view, the first step is to recognize that variation is a part of everything: supplier goods, temperature, measurement systems, and even people's performance. But the real benefit comes from knowing something about the theory of variation so you can act on it. Understanding the theory of variation enables managers to recognize, interpret, and

react appropriately to variation in the data, figures, performance, and outputs they deal with daily.

Knowledge of the variation theory is one of the most powerful tools a company can develop in its quest for quality. It can improve a manager's effectiveness and create opportunities for continuous improvement. It is part of the foundation of Deming's management philosophy; each of his 14 points is based, in part, on the desire to reduce variation.

Some basics about variation

Variation is not a new concept. Statisticians and scientists have studied it for decades. What's new is that their awareness of variation and how it affects everyday activities is infiltrating the workplace. There are seven concepts about variation that everyone should know:

1. All variation is caused. There are specific reasons why your weight fluctuates every day, why sales go up, and why Maria performs better than Robert.

2. There are four main types of causes. Common causes are the myriad of ever-present factors (e.g., process inputs or conditions) that contribute in varying degrees to relatively small, apparently random shifts in outcomes day after day, week after week, month after month. The collective effect of all common causes is often referred to as system variation because it defines the amount of variation inherent in the system. Special causes are factors that sporadically induce variation over and above that inherent in the system. Frequently, special cause variation appears as an extreme point or some specific, identifiable pattern in data. Special causes are often referred to as assignable causes because the variation they produce can be tracked down and assigned to an identifiable source. (In contrast, it is usually difficult, if not impossible, to link common cause variation to any particular source.) Tampering is additional variation caused by unnecessary adjustments made in an attempt to compensate for common cause variation. Structural variation is regular, systematic changes in output. Typical examples include seasonal patterns and long-term trends.

3. Distinguishing between the four types of causes is critical because the appropriate managerial actions are quite different for each. Without this distinction, management will never be able to tell real improvement from mere adjustment of the process or tampering. In practice, the most important difference to grasp first is the difference between special cause variation and common cause variation.

4. The strategy for special causes is simple: get timely data. Investigate immediately when the data signal a special cause was present. Find out what was different or special about that point. Seek to prevent bad causes from recurring. Seek to keep good causes happening.

5. The strategy for improving a common cause system is more subtle. In a common cause situation, all the data are relevant, not just the most recent or offending figure. If you have data each month for the past two years, you will need to look at all 24 of these points. In-depth knowledge of the process or system being improved is absolutely essential when only common causes are present. This knowledge can come from basic statistical tools, such as flowcharts, cause-and-effect diagrams, stratification analysis (used for measurement data such as process cycle time), and Pareto analysis (used for

count data such as number of accidents). These and other tools can help identify fundamental changes to the system, but they should be tried on a small scale first to see whether results improve. Statistically designed experiments might also be helpful in identifying system innovations. [1, 2]

6. When all variation in a system is due to common causes, the result is a stable system said to be in statistical control. The practical value of having a stable system is that the process output is predictable within a range or band. For example, if a stable order entry system handles 30 to 60 orders a day, it will rarely slip to fewer than 30 or rise to more than 60. If some variation is due to special causes, the system is said to be unstable since you cannot predict when the next special cause will strike and, therefore, cannot predict the range of variation. If the order entry system just described were unstable and subject to special cause variation, its capability might sporadically (and unpredictably) drop sharply below or rise sharply above the 30 to 60 range.

7. How much system variation is present can be determined by performing statistical calculations on process data. Thus control limits can be set. Control limits describe the range of variation that is to be expected in the process due to the aggregate effect of the common causes. Calculating these limits lets managers predict the future performance of a process with some confidence. [3, 4, 5]

These seven fundamental concepts provide the framework for improving managerial effectiveness. The following example shows how.

The pernicious periodic report

Managers often base decisions on data prepared daily, weekly, or monthly by their subordinates. These data are usually displayed in a table. Figure 4.1 is a typical example.

Figure 4.1 – Traditional Presentation of Management Figures

Period 12—1986
Variances

	Actual	Plan	Fav. (Unfav.)	Volume	Usage	Spending	Price
Pulpwood	$131.63	$132.29	$7.66	$	$(1.98)	$	$9.64
Waste	27.18	33.61	6.43		2.36		4.07
Other Raw Materials	28.93	30.74	1.81		1.46		0.35
Labour	30 10	26 14	(3.96)	(1.30)		(2.66)	
Repairs	22.52	24.34	1.82	(1.22)		3.04	
Steam	32.01	35.37	3.36	(0.25)	0.82		2.79
Power	73.79	70.90	(2.89)	(1.76)	(2.20)		1.07
Wrapper	2.99	2.90	(0.09)				(0.09)
Clothing	11.11	10.18	(0.93)	(0.50)	(0.41)		(0.02)
Supplies	7.95	8.37	0.42	(0.42)		0.84	
Other Expenses	3.91	4.33	0.42	(0.22)		0.64	
Mill Burden	66.57	67.67	1.10	(3.38)		4.48	
Mill Depreciation	50.42	48.55	(1.87)	(2.42)	___	0.55	___
Total	$489.11	$502.39	$13.28	$(11.47)	$0.05	$6.89	$17.81

Year-to-Date

	Actual	Plan	Fav. (Unfav.)	Volume	Usage	Spending	Price
Pulpwood	$133.96	$139.24	$5.28	$	$1.91	$	$3.37
Waste	29.84	33.71	3.87		1.41		2.46
Other Raw Materials	27.67	30.40	2.73		0.68		2.05
Labour	28.54	26.39	(2.15)	(0.61)		(1.54)	
Repairs	23.92	24.48	0.56	(0.58)		1.14	
Steam	36.67	41.52	4.85	(0.14)	1.96		3.03
Power	67.97	68.73	0.76	(0.77)	2.45		(0.92)
Wrapper	3.20	2.89	(0.31)				(0.31)
Clothing	11.21	10.41	(0.80)	(0.24)	(1.53)		0.97
Supplies	9.23	8.64	(0.59)	(0.20)		(0.39)	
Other Expenses	3.62	4.33	0.71	(0.10)		0.81	
Mill Burden	63.14	66.06	2.92	(1.50)		4.42	
Mill Depreciation	48.12	48.84	0.72	(1.15)	___	1.87	___
Total	$487.09	$505.64	$18.55	$(15.29)	$6.88	$6.31	$10.65

When asked what they look for in such tables, most managers respond "big negative variances." Like Jack in the opening story, they will focus on the undesirable figures and ask, "What happened? What is being done about it?" They'll say things like: "Manufacturing losses are up this month. Why? What are you doing about it?" "Why have sales gone down two months in a row? What are you doing about it?" "Your project came in more than 10% over budget. Why?"

Look back at the description of what to do in response to special cause variation and common cause variation. Which one most closely describes these reactions? The answer is the strategy for special causes: seek out explanations for that data point and investigate how that point differs from the rest of the data.

Is this the appropriate strategy to follow? Although it is hard to tell without more data,

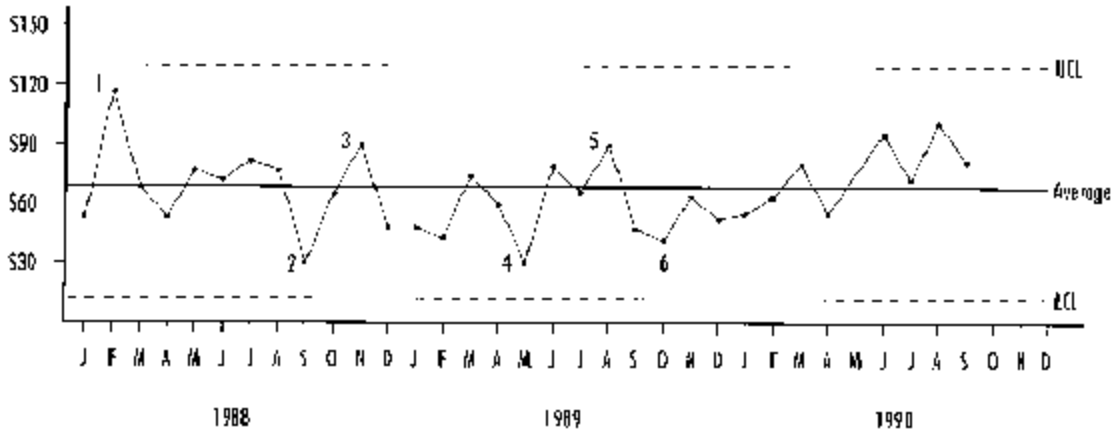
the answer is probably no. Tables such as Figure 4.1 give no clue as to whether the undesired figure arose from a special cause or common cause. However, experience shows that the overwhelming majority of undesirable figures are, in fact, due to common causes. Not only do such tables hinder a manager's ability to determine appropriate action, they also reinforce the human tendency to overreact: if you receive a report, you feel the need to use it.

Yet the responses are characteristic of Western management: treat everything as a special cause. This invariably leads to tampering, which increases variation and makes matters worse, not better. The consequences of tampering can be fully appreciated only when a manager knows the alternatives.

A better way

Managers will do better if they use the theory of variation to react to figures. To use this knowledge, they must first look at the data in a different way. Figure 4.2 shows the monthly sales data for a product line. This presentation is different from Figure 4.1 in two important ways: the data are plotted in time order and the overall average and control limits are indicated on the plot. The resulting chart is a statistical control chart. (A product line with no growth in sales was chosen to simplify the presentation. If there had been a trend in sales--say, a 5% growth per year--the trend would be used as a center line and the control limits would be plotted parallel to that trend line.)

Figure 4.2 – Monthly Sales Data (in $1,000s)



How does such a display help managers? It is immediately evident that all the points fall within the control limits. With a little training, a manager would also recognize that there is no evidence of special causes, patterns, or trends in the data. Thus the graph shows that the variation in this system is most likely due to common causes--it arises from the myriad of ever-present factors, each contributing a small amount to the variation seen each month.

In a system where only common cause variation is present, asking why the sales for a given month are lower or higher than the preceding month is a low-yield strategy, which means you won't get much payback for the time and resources you expended trying to answer the question. Worse, investigating one point will not give you the answers you

need, and the problem will most likely resurface.

There are additional, less obvious costs incurred when variation is ignored or misinterpreted, including:

- attention being diverted from more pressing problems that could be effectively addressed.
- more variation in the system.
- loss of productivity.
- low morale.
- subordinates losing confidence in their manager.
- jobs/careers being put in jeopardy.

Tampering revisited

Despite these costs of inappropriate reactions, treating everything as a special cause is exactly what most American managers are asked to do, and they learn to do it well. An example is shown in Figure 4.3.

Figure 4.3 – Traditional Explanations of Variances

February 1986 report (for those accounts that are ± £ 5,000 from the budget)

Sales Region 1	Actual	Budgeted	Total Variance
	1,137,673	1,465,507	-315,228

Negative Variances		Positive Variances	
-115,000	-ost to UK	+6,200	Kar's, business up
55,205	Stone Branch closed	6,400	Detroit Bay, business up
5,002	Upstate, Ohio plant closed	6,150	Dwyer's, business up
7,702	ABC, lost to XYZ yeast		
11,750	John's		
25,200	Mercer Pastry		
9,300	R Rolls		
15,100	City Bakers		
19,000	Jane's		

Sales Region 2	Actual	Budgeted	Total Variance
	2,328,382	2,969,161	660,079

Negative Variances		Positive Variances	
130,000	Stone Creek, PA, lost to Lotus	(none)	
113,000	Upstate, NY plant closed		
50,000	Upstate, OH lost to overseas		
47,000	Erie, PA, lost to UK		
35,000	Ax's, Ft. Athon, no Feb. order		
10,700	Sarle business down		
10,500	Bittenroom, product-ier shift		
25,200	TH's, business down		
15,000	New Day, new relationship		
72,000	Andrew, new plant delayed		
23,750	CBC, Dayton, lost to overseas		
24,000	Royal, Ore., business down		
13,000	Sarin, lost to UK distributor		
15,500	Lee Foods, business down		
10,500	Benj. Bacon, business down		
6,750	M.N. English, NC, business down		

Sales Region 3	Actual	Budgeted	Total Variance
	3,917,856	3,730,686	+187,142

Negative Variances		Positive Variances	
-17,000	Upstate, Ohio, business down	+6,030	Upstate, business up
8,750	Edna's, lost to UK	5,020	Dickens, business up
8,520	Giant, Chicago, lost to UK	9,030	Friendly's, gained from UK
8,020	West, business down	151,020	Stone Creek gained from UK
9,240	AmBaCo, business down	13,150	Acton, annual promotion ended early
90,020	D. Baking, grain box in repair	33,750	All Oil, gained from UK
8,420	PPSA, Detroit, lost to UK	150,000	CBC, gained from UK
17,620	Wyl Fine, Detroit lost to UK	10,000	Royal, business up
7,020	WWW's, Detroit, business down	10,000	Goodco, new business, new account
6,020	Oldtime, lost to UK	7,200	CBL gained from UK
5,000	H Supply, business down	34,200	CBC, Elderott, gained from UK
6,850	Lane's, N.H. business down	10,500	Hunt's, closed Green Bay, moved to Milwaukee
12,500	Weiss, Roseville, lost to UK	12,500	Tammy's, business up
7,500	NDF, not buying from us in Canada	8,490	MidCoCo bread special in Feb
23,500	Innes' bakery, business down	24,000	Royal, business down from SHAR
19,100	SHAR, 1/2 business to UK		

Here the manager compared the pounds of product he predicted would be sold in a certain month with what was actually sold. As you can see, he came up with explanations for practically every pound of difference between the two numbers. His reaction to these figures was probably to chastise his salespeople for losing business to competitors. The implicit assumption in this reaction is that there are special causes his salespeople could track and eliminate. As displayed, it is impossible to tell which of these figures could, in fact, be credited to special causes. His facts were correct, but his use of them (chastising salespeople) had only marginal benefit.

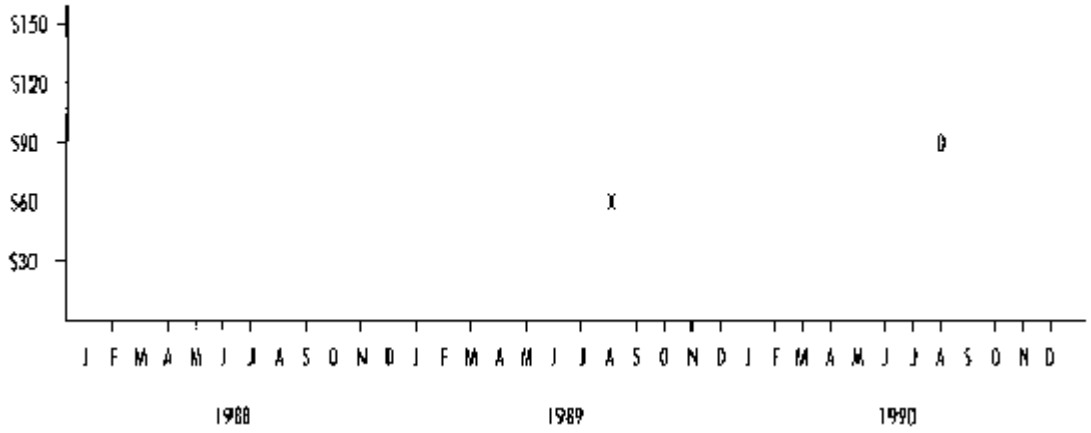
Another example of typical management practices is when managers concentrate on only the most recent data, although sometimes they might compare them with the previous year's. Figure 4.4 (which uses the same data as Figure 4.2) shows the most recent monthly sales figure (indicated by an "o") and the figure resulting from the same calculation a year previously (indicated by an "x").

Compare this plot with the complete chart in Figure 4.2. Which is more useful? Which puts the manager in a better position to plan, predict, and improve?

Again the question of whether these approaches are adequate arises. The answer, again, is no. Figure 4.3 represents a failure to appreciate common cause variation. Like the causes that produced the data in Figure 4.2, the causes that produced the data in Figure 4.3 are most likely the same for all months. Trying to explain the reason for the exact increase or decrease in the latest point will most likely identify false causes and result in false solutions. Time, energy, and money will be wasted treating the wrong disease, exacerbating the situation instead of improving it --a perfect definition of tampering.

Figure 4.4 shows that managers are seriously handicapped if they cannot see all the data displayed on a control chart. Managers can make much sounder decisions that will lead to continuous improvement if they plot all the data on control charts and apply statistical theory to interpret what they see.

Figure 4.4 – Annual Comparisons



Deming has often said that the use of statistical control charts should start at the top, not on the shop floor, to foster an understanding of variation among the leaders of the organization, to aid them in improvement efforts, and, particularly in the early years of a quality improvement effort, to help them reduce their tendency to tamper. Improvements cannot really be made until tampering stops.

Appropriate managerial action

Charts such as the one in Figure 4.2 provide the quickest, surest way to determine the appropriate reaction to variation. They enable managers to quickly distinguish common cause variation from special cause variation. Such plots also help managers predict system capability. For example, using the data in Figure 4.2, it's clear that unless something changes in the system, sales for this product will almost always fall between $10,000 and $130,000 per month.

What recourse does a manager have against common cause variation? If the manager is not happy with the range of variation, he or she would have to improve the system as a whole using basic statistical tools and methods.

Here's where data like those in Figure 4.3 are helpful. With such data, you can get a lot of mileage out of a common cause strategy. For instance, you might lump together the gains and losses over a series of months, not just single out the latest month or a month you don't like. You could look for patterns. You could stratify the data by categories: How much business is being lost to each competitor? How much to plant closings? How much to other factors? How much by region? You could also plot the data for each competitor on separate charts to see whether, over time, there were special causes within any one competitor, which might be masked if just the aggregate data for all competitors were plotted. (This tactic could, for instance, signal that a competitor was using new promotions or introducing new products that were drawing away business.) And you could look for other ways to stratify and desegregate the data.

If the data do signal the appearance of a special cause, you should find out what is unique about the particular month and then take action to prevent future problems. Failure to react in such a special cause situation would be inappropriate and costly.

Many managers say they are already using the common cause and special cause strategies. That's great, but it will only lead to rapid, continuous improvement if it is done systematically, if the focus is always on the appropriate strategy, if the manager reacts to the latest figure only when there is evidence of a special cause, and if employees are not wasting their time trying to explain why each month's figures are up or down. An article by Thomas Nolan and Lloyd Provost provides further background relative to common and special causes of variation. [6] Through numerous examples, the authors demonstrate the value of appropriate reactions to common and special cause variation.

The need for reacting appropriately to variation seems to be relatively easy for managers to accept when the data plotted are for widgets or processes. But what happens when knowledge of variation is applied to something much closer to home: the evaluation of employee performance?

Variation and people:"half below average"

Current managerial strategies used in this country show a lamentable lack of appreciation for simple math and variation. Managers are taught to reward employees who rank highest in groups, work with those employees who perform "below average," and punish those who rank lowest.

An average is simply a number calculated from data. By virtue of how it is calculated, roughly half the people in any group will perform below average, no matter how smart or talented they are. Even if you could improve the performance of those people "below average," as soon as you gathered new data, you'd find that the average had simply been raised and there are still people below the new average. When people are ranked according to performance, someone will always be highest and someone will always be lowest. These are incontrovertible facts. The issue for management is not whether this will happen--it will--but how to deal with this inevitability.

The red bead experiment, popularized by Deming, illustrates this. [7] Five workers draw beads from a box with a paddle that has fifty holes. The box contains both red and white beads: white represents good products, and red represents defective products. All workers use the same procedure for drawing the beads, with the five workers alternating draws until each worker has drawn five paddlefuls. At the end of the demonstration, the two workers who have the largest total numbers of red beads are

fired. Since these workers did nothing different from the workers who were not fired, they are obviously victims of a game of chance. They were the ones who were "below average," yet they did nothing to merit being fired. They were merely working within a system of common cause variation. This scenario does occur in real life and has a demoralizing influence on the entire work force.

But people really are different

You might be saying, "But people really are different." Of course they are. The point is what to do about it.

The concepts of variation can help people understand what they should do when it is their job to guide other employees. Deming says that the manager's job is to learn who, if anyone, performs at a level outside the system of common cause variation. [8] When a manager finds an individual outside the system--that is, above or below the "control limits"--the manager needs to follow a special cause strategy: investigate how this person's case differs from those of others working in the same process or system.

If this employee consistently performs better than anyone else, perhaps he or she uses different equipment or has invented more effective procedures. In that case, it is in the best interests of the company that this person's knowledge and insight be shared among all employees performing this task and that every effort be made to improve methods, equipment, and so forth.

If the person consistently performs worse than others, perhaps he or she was never properly trained or has a physical limitation (height, vision, hearing, dexterity) that impairs his or her ability to perform this particular job. In such a case, the manager owes it to the employee to identify the cause of the difficulty and work to eliminate the source of the difference, if possible.

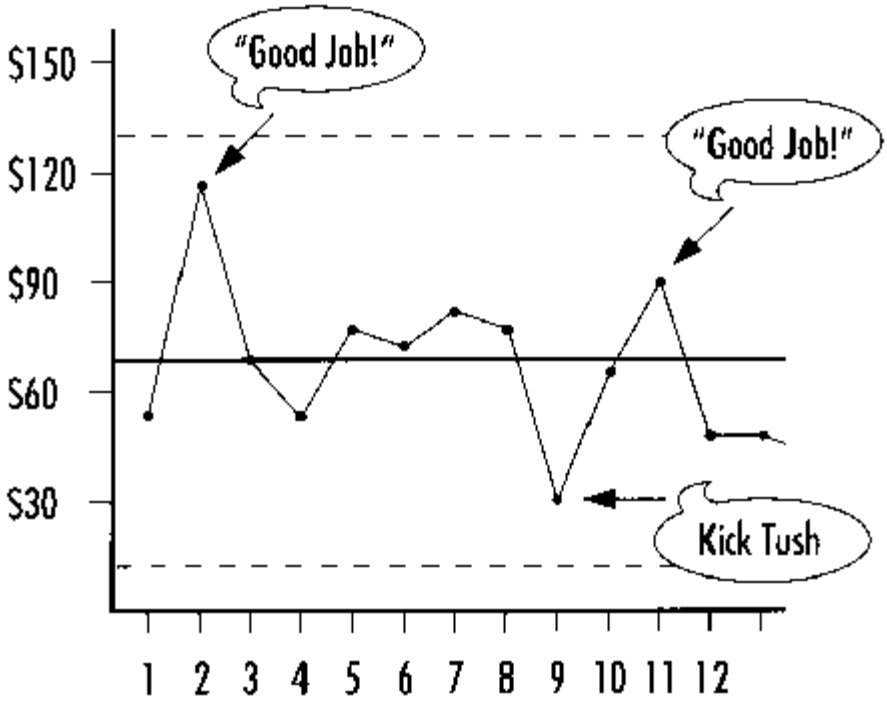
If no one's performance falls outside the system of common cause variation, then the manager needs to work on the system to bring everyone to a higher level of performance with reduced variation. The common cause strategy described earlier is the high-yield improvement strategy in such a situation. Focusing on those who are below average or on the person with the lowest performance rating is not effective and has serious negative psychological effects. (An example of how the theory of variation relates to the supervision of salespeople can be found in the previously mentioned article by Nolan and Provost. [9])

Variation and kicking tush

It is very hard to get managers to apply common cause and special cause strategies to people. Their experience tells them to use what works: punishment and negative feedback. Praise an employee for exceptional work this week, and that employee's performance almost invariably worsens next week. But chastise an employee for poor work, and that employee's performance will probably improve.

The key to the puzzle is the fact that employees are usually functioning in a common cause system. A portion of the data used in Figure 4.2 is reproduced in Figure 4.5. Let's treat the data as if they represent one employee's performance over a 12-week period.

Figure 4.5 – Luella's Sales Over a 12-Week Period



When Luella performs very well one week, achieving high sales, she's unlikely to perform better the following week. In fact, it's likely her sales figure will go down. But if Luella performs badly one week, then she's likely to perform at a higher level the following week. Thus, as many managers have discovered, giving praise for a good week seems to lead to worse results and kicking tush after a bad week seems to lead to better performance. The lesson is "obvious" to those who do not understand variation: kicking tush works better than giving praise! The kick tush approach to managing is just another example of destructive behavior nurtured by ignorance of the theory of variation. [10]

Learning the basic concepts of variation can prevent a lot of tension between managers and the people they lead and can create opportunities for real improvement. Had Jack and Sarah, the people in the opening story, understood the theory of variation, they could have dispensed with their monthly praise-or-blame sessions. Instead, Jack could have been helping Sarah figure out how to study and improve the systems and processes that affected her work and that of her salespeople. He could have helped her identity special causes and shape her tactics for tracking them down and preventing their recurrence. They could have worked on the common cause system to reduce variation and to bring all Sarah's salespeople to improved levels of performance.

In short, Jack and Sarah's working relationship would have changed. Knowledge of the theory of variation alters people's view of the world forever. It influences practically every aspect of how companies are managed. That is why variation is a central theme of Deming's 14 points.

Variation and Deming's 14 points

Deming maintains that management's job is to optimize the enterprise as a whole, creating a win-win situation for customers, shareholders, employees, and suppliers. Think about what this would mean for your company. What would you have to do to make sure customers received high-quality goods and services all the time, shareholders were satisfied with their return, employees looked forward to coming to work, and suppliers worked closely with your employees to ensure the supplied goods were exactly what was needed? What would it take for you to do all this simultaneously?

That's the challenge that Deming presents. An in-depth understanding of variation is central to your ability to meet this challenge.

Point 1. Create constancy of purpose. Having a clear goal that everyone can work toward every day, month after month, allows employees to focus on tasks important to the organization and its customers. Changing the goal from time to time to meet managerial goals and quotas creates serious loss. Forcing a system to produce predetermined figures to delight executives or shareholders is extremely costly in terms of future profits, customer loyalty, and employee morale. Doing so represents a fundamental failure to understand that variation will inevitably be present in any system. Constancy of purpose toward delighting the customer each and every day is far better. It reduces variation because the employees will not have to constantly shift their priorities.

Point 2. Adopt the new philosophy. We are in a new economic age, says Deming. Higher levels of quality at lower costs are possible if you learn to manage differently. Learning to manage differently involves learning how to improve systems in the presence of variation. As previously described, managing differently includes reducing variation in materials, people, processes, and products. Tampering and overreacting to variation, which only increase variation, must end.

Point 3. Cease dependence on inspection. Depending on inspection is like treating a symptom while the disease is killing you. The need for inspection results from excessive variability in the process. The disease is the variability. Ceasing dependence on inspection means you must understand your processes so well that you can predict the quality of their output from upstream activities and measurements. To accomplish this you must have a thorough understanding of the sources of variation in your processes and then work toward reducing the variation. Ceasing dependence on inspection forces you to reduce variability.

Point 4. End purchasing on price tag. Reducing variation requires that you rethink your purchasing practices. Working with a selected supplier on a long-term basis of loyalty and trust reduces variation in incoming material and hence in the finished product. Involving the supplier in the collaborative design of new products further improves quality and reduces variation

Point 5. Improve constantly. You must constantly improve your production and service systems by understanding the causes of problems and seeking to reduce variation. Everyone in the company must participate in a disciplined way using the plan-do-check-act cycle.

Point 6. Institute training. Some of the most insidious sources of variation are the lack of documentation on the best known methods for performing tasks and the lack of standardized training for all employees working on the same function. The best-known methods quickly dissipate without training and retraining. Variation creeps in. Having the last worker training the next is a pervasive source of variation. [11]

Organizations must take action to train employees effectively and consistently. There is variation in how people learn, and training programs must accommodate it. How much training is needed should be addressed using common and special cause thinking. [12] In the words of Eddie "The King" Feigner, the famous fast-pitch softball pitcher who struck out more than 100,000 batters in his career, "Practice makes permanent, not perfect." Once the practice has reduced the variation to the point where only common causes are present, the effect of the training has become "permanent," and further training of the same kind is not likely to be effective. If the results are not good enough, moving to a new job with a fresh start at effective training is usually the best course.

Point 7. Institute leadership. Managers who ask "Why is that point up? Why is this one down?" are not leaders. Managers who merely find fault with their employees or who punish the lowest-ranking employee without knowledge of the system increase variability. According to Deming, a leader is someone who, enlightened with an understanding of variation, helps employees do their jobs better with less effort. Such a person works toward diminishing the differences among people by learning which employees are within the system and which are not and then acting appropriately. A leader also supports the goal of the company, focuses on internal and external customers, functions as a coach, and nurtures pride of workmanship. In doing these things, a leader provides constancy of purpose and helps reduce variation.

Point 8. Drive out fear. Companies who have struggled with implementing Deming's 14 points know that fear is a powerful force that maintains the status quo and impedes many changes that accompany the transformation to a quality- and customer-driven organization.

Theodore Lowe and Gerald McBean identify six "monsters of fear" and discuss their consequences. [13] Fear of reprisal and fear of failure are closely related monsters that result in a please-the-boss mentality and an aversion to accepting risk or generating new ideas. Fear of providing information, which derives from fear of reprisal and fear of failure, leads to concealing information that could help identify and solve problems. This monster also encourages the fabrication of figures to please management and the accompanying increase in process variation due to tampering. Another of Lowe and McBean's monsters is fear of not knowing. This monster emerges in organizations where managers are expected to control everything in their fiefdoms. The waste to the organization is incalculable. A manager in this environment gets involved in even the most obscure details of work and ends up losing track of the role his department plays in the organization--"he has his hands in all the ashtrays but doesn't know what the floor plan is."

Fear of giving up control lurks in organizations where management's job is viewed as controlling people rather than processes. This fear results in suboptimization, attaining one department's or group's goals at the expense of others, and squelches the work force's intrinsic motivation. The final monster, fear of change, is an obvious impediment to process improvement.

Such fears create an environment where accurate data are nonexistent and where people are too protective of their jobs to accurately report on problems, failures, or defects. Without accurate data, it is impossible to describe or measure variation and thus impossible to reduce or eliminate it. Fear paralyzes a work force that could otherwise be actively engaged in reducing variation.

Point 9. Break down barriers between departments. Separate goals and objectives for different departments result in variation and obstruction rather than cooperation. Reducing variation for the organization as a whole requires cooperation across departmental boundaries. An understanding of variation and cross-functional cooperation is required to optimize the organization as a system.

Point 10. Eliminate slogans, exhortations, and targets for the work force. Someone once said, "Insanity is hoping for different results while continuing to do the same thing." Improvement comes only from changed processes and methods. Since most of the complexities and problems in work are due to common causes, only management can make the required changes. As shown in the cases discussed earlier, the results of slogans and exhortations aimed at the work force only lead to demoralization, tampering, and increased variability rather than to effective change.

Point 11(a). Eliminate work standards (production quotas). Work standards are an assertion that there is little or no variation in a task. They presume, for instance, that the time to complete a job or the amount of work that can be done in an hour is the same for all people under all circumstances. This presumption obviously ignores variation in working conditions, materials, and methods. Another flagrant lack of understanding of variation is portrayed in the statement: "You've done it once, that proves you can do it every time." There will always be variation. Some days will be better than others. Work standards lead to a failure to measure and plan for variation, which in turn leads to missed deadlines, short shipments, sandbagging, and poor morale.

Production schedules are, of course, necessary and desirable. Knowledge of the variation in a common cause system enables managers to forecast what can be realistically produced. This can then be translated into workable production schedules. Knowledge of process variation helps managers plan for variation, thus minimizing missed deadlines, short shipments, sandbagging, and poor morale.

Point 11(b) Eliminate management by objectives. Management by objectives rewards people and departments for reaching short-term measurable goals. Management by objectives leads to suboptimization--one department's goals being reached at the expense of the company as a whole. For instance, it is common in many companies that sales sells products that production cannot produce. The sales department therefore reaches its monthly or quarterly goal, but the rest of the company (production, customer service, etc.) pays the price in stressed systems, employees who rush to produce the products, and backlash from unsatisfied customers.

Some managers fake conformance to goals. For example, they might store products that exceed this month's quota to meet next month's quota or fill the production quota at the expense of product quality. The system also breeds fear and hostility, encourages finger pointing, and limits the amount of possible improvement. [14]

All of these consequences support mechanisms that increase real variability while often giving the illusion of reducing variability. In effect, they destroy mechanisms that might reduce real variability. [15] Management-by-objective systems reward results without

paying sufficient attention to the methods by which they are received. A system that rewards people's efforts toward improvement would have greater value. [16]

Instead of pleasing the manager by providing the right figures, the focus needs to be on pleasing the customer each and every day. It should not be acceptable to have end-of-the-month rushes to meet quotas or goals.

Point 12(a). Remove barriers to pride of workmanship for hourly workers. Examples of barriers to pride of workmanship for the hourly worker include pressure to use defective materials in production to meet daily quotas, inspection procedures that lack operational definitions, instruments and machines that do not function properly or are not in control, and poor supervision. Workers often have no way of knowing whether the job is performed correctly. In addition to contributing to the demoralization of the work force, these barriers contribute to variability in output.

Point 12(b). Remove barriers to pride of workmanship for management and engineering. In this point, Deming calls for the abolishment of annual or merit ratings and management by objectives. A merit rating system "nourishes short-term performance, annihilates long-term planning, builds fear, demolishes teamwork, nourishes rivalry and politics." [17] People working in the same common cause system can be rated quite differently when, in fact, their apparent performance is beyond their control. Managers should not act as judges, inspecting results at the end of the process; instead, they should be leaders, working upstream with employees to reduce variability at the early stages of the process. In short, merit rating systems support behaviors that increase variation and destroy behaviors that reduce variation. [18, 19, 20]

Point 13. Institute a vigorous program of education and self-improvement. Knowledge is needed for the advancement of an organization as well as society. Providing information on variation and other elements of what Deming calls "profound knowledge" (systems theory, theory of knowledge, and psychology) is an obvious place to start. [21] But, to have benefits, education and self-improvement need not be directly related to an employee's job. Any education or self-improvement increases an employee's self-esteem and potential to contribute to improvements in existing processes and advances in technology.

Point 14. Put everybody to work to accomplish the transformation. Coordinating the activities of everyone connected with the organization contributes significantly to the reduction of variation and the optimization of the entire system.

The unknown and unknowable

Deming writes, "It was Dr. Lloyd Nelson who years ago remarked that the most important figures for management are unknown and unknowable. We could add that the most important losses and gains are not even under suspicion."[22] The effects of the reward system, the efficacy of the training program, losses that result from tampering, losses that ensue from suboptimization, and loss of market share due to unsatisfied customers all seem to defy quantification. Yet these are prominently among the most important figures for management.

The best weapons against these losses are embodied in Deming's 14 points: providing constancy of purpose, understanding variation and removing it from our processes and systems, and reducing fear. Only by internalizing the 14 points and understanding the

role of variation will management be able to deal effectively with challenges in coming years.

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References

1. Lynda Finn, Tim Kramer, and Sue Reynard, Design of Experiments: Shifting Quality Improvement into High Gear. Madison, WI: Joiner Associates Inc., 1987. [This article is available for download from the TQM BBS. Filename: DOX.ZIP.]

2. George Box, William Hunter, and J. Stuart Hunter, Statistics for Experimenters. New York, NY: John Wiley and Sons, 1978.

3. Hitoshi Kume, Statistical Methods of Quality Improvement. Tokyo: The Association for Overseas Technical Scholarship, 1985.

4. Donald Wheeler and David S. Chambers, Understanding Statistical Process Control. Knoxville, TN: Statistical Process Controls, Inc., 1986.

5. Continuing Process Control and Process Capability Improvement. Dearborn, MI: Ford Motor Company, Statistical Methods Office, 1983.

6. Thomas W. Nolan and Lloyd P. Provost, "Understanding Variation," Quality Progress, May 1990, pp. 75-77.

7. W. Edwards Deming, Out of the Crisis. Cambridge, MA: MIT Press, 1986. pp. 346-353.

8. Ibid, p. 248.

9. Nolan and Provost, "Understanding Variation," pp. 75-77.

10. Daniel Kahneman and Amos Tversky, "On the Psychology of Prediction," Psychological Review, Vol. 80, 1973, pp. 237-251.

11. Thomas J. Boardman and Eileen C. Boardman, "Don't Touch That Funnel!" Quality Progress, December 1990.

12. Deming, Out of the Crisis, Chapter 8.

13. Theodore A. Lowe and Gerald M. McBean, "Honesty Without Fear," Quality Progress, November 1989.

14. Brian L. Joiner and Peter R. Scholtes, Total Quality Leadership vs. Management by Results. Madison, WI: Joiner Associates Inc., 1985. [This article is in preparation for posting on the TQM BBS. Filename: TQMVSMR.ZIP.]

15. Lowe and McBean. "Honesty Without Fear."

16. Stanley M. Moss, "Appraise Your Performance Appraisal Process," Quality Progress, November 1989.

17. Deming, Out of the Crisis, p. 102.

18. Ronald D. Moen, "The Performance Appraisal System: Deming's Deadly Disease," Quality Progress, November 1989.

19. Peter R. Scholtes, An Elaboration on Deming's Teachings on Performance Appraisal. Madison, WI: Joiner Associates Inc.. 1987.

20. Moss, "Appraise Your Performance Appraisal Process."

21. W. Edwards Deming, "Foundation for Management of Quality in the Western World," unpublished manuscript, 1990

22. Ibid.

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