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PART I

Fundamental Quality Improvement and Statistical Concepts

CHAPTER 1

Introduction

This is a book about using statistical methods to improve quality. It is not a book about Total Quality Management (TQM), Total Quality Assurance (TQA), just-in-time (JIT) manufacturing, benchmarking, QS-9000, or the ISO 9000 series. In other words, the scope of the book is essentially restricted to statistical techniques. Although standards such as QS-9000 and ISO 9000 are *potentially* useful, they are oriented toward the *documentation* of quality problems, not the identification or eradication of problems. Furthermore, many people feel that companies tend to believe that all they need to do is acquire ISO 9000 certification, thus satisfying only a minimum requirement.

Statistical techniques, on the other hand, are useful for identifying trouble spots and their causes, as well as predicting major problems before they occur. Then it is up to the appropriate personnel to take the proper corrective action.

The emphasis is on quality *improvement*, not quality control. On July 1, 1997 the American Society for Quality Control (ASQC) became simply the American Society for Quality (ASQ). The best choice for a new name is arguable, as some would undoubtedly prefer American Society for Quality Improvement (the choice of the late Bill Hunter, former professor of statistics at the University of Wisconsin). Nevertheless, the name change reflects an appropriate movement away from quality *control*. George Box has emphasized that systems are not stationary and that improvements should constantly be sought. In defending his statement in Box (1997a) that there are "not truths, only major steps in a never-ending (and diverging) process that helped predict natural phenomena," Box (1997b) pointed out that "Orville and Wilber Wright undoubtedly had profound knowledge about the design of flying machines" in 1903, but their plane looks primitive now.

What is quality? How do we know when we have it? Can we have too much quality? The "fitness for use" criterion is usually given in defining quality.

Statistical Methods for Quality Improvement, Third Edition. Thomas P. Ryan.

Specifically, a quality product is defined as a product that meets the needs of the marketplace. Those needs are not likely to be static, however, and will certainly be a function of product quality. For example, if automakers build cars that are free from major repairs for 5 years, the marketplace is likely to accept this as a quality standard. However, if another automaker builds its cars in such a way that they will probably be trouble free for 7 years, the quality standard is likely to shift upward. This is what happened in the Western world some years ago as the marketplace discovered that Japanese products, in particular, are of high quality.

A company will know that it is producing high-quality products if those products satisfy the demands of the marketplace.

We could possibly have too much quality. What if we could build a car that would last for 50 years. Would anyone want to drive the same car for 50 years even if he or she lived long enough to do so? Obviously, styles and tastes change. This is particularly true for high technology products that might be obsolete after a year or two. How long should a personal computer be built to last?

In statistical terms, quality is largely determined by the amount of variability in what is being measured. Assume that the target for producing certain invoices is 15 days, with anything less than, say, 10 days being almost physically impossible. If records for a 6-month period showed that all invoices of this type were processed within 17 days, this invoice-processing operation would seem to be of high quality.

In general, the objective should be to reduce variability and to "hit the target" if target values exist for process characteristics. The latter objective has been influenced by Genichi Taguchi (see Chapter 14) who has defined quality as the "cost to society."

1.1 QUALITY AND PRODUCTIVITY

One impediment to achieving high quality has been the misconception of some managers that there is an inverse relationship between productivity and quality. Specifically, it has been believed (by some) that steps taken to improve quality will simultaneously cause a reduction in productivity.

This issue has been addressed by a number of authors including Fuller (1986) who related that managers at Hewlett–Packard began to realize many years ago that productivity rose measurably when nonconformities (i.e., product defects) were reduced. This increase was partly attributable to a reduction in rework that resulted from the reduction of nonconformities. Other significant gains resulted from the elimination of problems such as the late delivery of materials. These various problems contribute to what the author terms "complexity" in the workplace, and he discusses ways to eliminate complexity so as to free the worker for productive tasks. Other examples of increased productivity resulting from improved quality can be found in Chapter 1 of Deming (1982).

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1.2 QUALITY COSTS (OR DOES IT?)

It is often stated that "quality doesn't cost, it pays." Although Crosby (1979) said that quality is free (the title of his book) and reiterated this in Crosby (1996), companies such as Motorola and General Electric, which launched massive training programs a few decades ago, would undoubtedly disagree. The large amount of money that GE committed to a particular training program, Six Sigma, was discussed in, for example, the January 13, 1997 issue of the *Wall Street Journal*. Wall Street has recognized Six Sigma companies as companies that operate efficiently, have greater customer satisfaction, and so on. Six Sigma is discussed in detail in Chapter 17.

What is the real cost of a quality improvement program? That cost is impossible to determine precisely, since it would depend in part on the quality costs for a given time period without such a program as well as the costs of the program for the same time period. Obviously, we cannot both have a program and not have a program at the same point in time, so the quality costs that would be present if the program were not in effect would have to be estimated from past data.

Such a comparison would not give the complete picture, however. Any view of quality costs that does not include the effect that a quality improvement program will have on sales and customers' perceptions is a myopic view of the subject. Should a supplier consider the cost of a statistical quality control program before deciding whether or not to institute such a program? The supplier may not have much choice if it is to remain a supplier. As a less extreme example, consider an industry that consists of 10 companies. If two of these companies implement a statistical quality improvement program and, as a result, the public soon perceives their products to be of higher quality than their competitors' products, should their competitors consider the cost of such a program before following suit? Definitely not, unless they can adequately predict the amount of lost sales and weigh that against the cost of the program.

1.3 THE NEED FOR STATISTICAL METHODS

Generally, statistical techniques are needed to determine if abnormal variation has occurred in whatever is being monitored, to determine changes in the values of process parameters, and to identify factors that are influencing process characteristics. Methods for achieving each of these objectives are discussed in subsequent chapters. Statistics is generally comparable to medicine in the sense that there are many subareas in statistics, just as there are many medical specialties. Quality "illnesses" generally can be cured and quality optimized only through the sagacious use of combinations of statistical techniques, as discussed in Chapter 17.

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1.4 EARLY USE OF STATISTICAL METHODS FOR IMPROVING QUALITY

Although statistical methods have been underutilized and underappreciated in quality control/improvement programs for decades, such methods are extremely important. Occasionally their importance may even be overstated. In discussing the potential impact of statistical methods, Hoerl (1994) pointed out that Ishikawa (1985, pp. 14–15) stated the following: "One might even speculate that the second world war was won by quality control and by the utilization of modern statistics. Certain statistical methods researched and utilized by the Allied powers were so effective that they were classified as military secrets until the surrender of Nazi Germany." Although such a conclusion is clearly arguable, statistical methods did clearly play a role in World War II. See Grant and Lang (1991) for a detailed account of the use of statistical quality control methods in World War II in the United States and shortly thereafter.

Shortly after the war, The American Society for Quality Control was formed in 1946; it published the journal *Industrial Quality Control*, the first issue of which had appeared in July 1944. In 1969 the journal was essentially split into two publications—the *Journal of Quality Technology* and *Quality Progress*. The former contains technical articles whereas the latter contains less technical articles and also has news items. The early issues of *Industrial Quality Control* contained many interesting articles on how statistical procedures were being used in firms in various industries, whereas articles in the *Journal of Quality Technology* are oriented more toward the proper use of existing procedures as well as the introduction of new procedures. Publication of *Quality Engineering* began in 1988, with case studies featured in addition to statistical methodology. The Annual Quality Congress has been held every year since the inception of ASQC, and the proceedings of the meeting are published as the *ASQ Annual Quality Transactions*.

Other excellent sources of information include the Fall Technical Conference, which is jointly sponsored by ASQ and the American Statistical Association (ASA), the annual Quality and Productivity Research Conference, and the Annual Meetings of ASA, which are referred to as the Joint Statistical Meetings (JSM).

There are also various "applied" statistics journals, which contain important articles relevant to industry, including *Technometrics*, published jointly by ASQ and ASA, *Quality and Reliability Engineering International, IIE Transactions, Applied Statistics* (*Journal of The Royal Statistical Society, Series C*), *and The Statistician* (*Journal of The Royal Statistical Society, Series D*). The latter two are British publications.

Readers interested in the historical development of statistical quality control in Great Britain are referred to Pearson (1935, 1973). An enlightening look at the early days of quality control practices in the United States, as seen through the eyes of Joseph M. Juran, can be found in Juran (1997). See also Juran (1991).

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1.5 INFLUENTIAL QUALITY EXPERTS

Walter A. Shewhart (1891–1967) came first. As discussed more fully in Chapter 2, he invented the idea of a control chart, with certain standard charts now commonly referred to as "Shewhart charts." Shewhart (1931) is still cited by many writers as an authoritative source on process control. The book was reprinted in 1980 by ASQC. Shewhart (1939) was Shewhart's other well-known book.

W. Edwards Deming (1900–1993) was such a prominent statistician and quality and productivity consultant that his passing was noted on the front page of leading newspapers. Ironically, he was about 80 years old before he started receiving much attention in the United States, and this was essentially a very slow reaction to his accomplishments in helping the Japanese progress from having poor quality products prior to 1950 to later being able to manufacture products of superior quality.

His "14 points for management" for achieving quality have frequently been cited, and also changed somewhat over the years. It has been claimed that there are as many as eight versions. One version is as follows.

1. Create a constancy of purpose.
2. Adopt a new philosophy.
3. Cease dependence on inspection.
4. Work constantly to improve the system.
5. Break down barriers between departments.
6. Do not award business to suppliers solely on the basis of price.
7. Drive out fear.
8. Eliminate numerical goals, targets, and slogans.
9. Eliminate work standards and substitute leadership.
10. Institute a program of training and education for all employees.
11. Institute modern training methods.
12. Remove the barriers that make it difficult for employees to do their jobs.
13. Institute and practice modern methods of supervision.
14. Create a management climate that will facilitate the attainment of these objectives.

Although these 14 points are typically applied in industrial settings, they can be modified slightly and applied in other settings. For an application that is certainly far removed from manufacturing, Guenther (1997) gave a closely related list of 14 points for parenting.

There is one point of clarification that should be made. When Deming argued against target values, he was arguing against targets for production quotas, not target values for process characteristics. The use of target values for process characteristics is advocated and illustrated in Chapter 14, although target values for process characteristics should generally not be used with control charts, as discussed in Section 4.7.10.

Deming was constantly berating American management, believing that about 90% of quality problems were caused by management. Deming's views on the shortcomings of American management can be found in many places, including Chapter 2 of Deming (1986). In general, Deming claimed that management (1) emphasizes short-term thinking and quarterly profits rather than long-term strategies, (2) is inadequately trained and does not possess an in-depth knowledge of the company, and (3) is looking for quick results.

Deming has also been given credit for the PDCA (Plan–Do–Check–Act) cycle, although in his later years his preference was that it be called the PDSA cycle, with "Study" replacing "Check." This has been termed "Deming's Wheel," but Deming referred to it as Shewhart's cycle. The cycle consists of planning a study, performing the study, checking or studying the results, and acting in accordance with what was learned from the study. See, for example, Cryer and Miller (1994) and Johnson (2002) for additional information on the PDCA cycle.

Several books have been written about Deming; one of the best-known books was written by Mary Walton, a journalist (Walton, 1986). See also Walton (1990), which is a book of case studies, and Voehl (1995). The latter is an edited volume that contains chapters written by some prominent people in the field of quality improvement

Joseph M. Juran (1904–2008) is another prominent quality figure, one who, like Deming, had an extremely long life. He is mentioned only briefly here, however, because his contributions have been to quality management rather than to the use of statistical methods for achieving quality improvement. His quality control handbook, which appropriately enough was renamed *Juran's Quality Control Handbook* when the fourth edition came out in 1988, does contain a few chapters on statistical techniques, however. The name was changed to *Juran's Quality Handbook* for the fifth edition (which has 1872 pages), with A. Blanton Godfrey as co-editor. The first edition was published in 1951 and has been used as a reference book by countless quality practitioners.

Eugene L. Grant (1897–1996) has not been accorded the status of other quality pioneers, but nevertheless deserves to be mentioned with the others in this section. In Struebing (1996), Juran is quoted as saying "His contribution to statistical methodology was much greater than (W. Edwards) Deming's. Even though his impact on quality was profound and he was much more instrumental in advancing quality than Deming, the media—which overstated Deming's contribution—didn't publicize Grant's contributions." Grant has been described as a quiet worker who did not seek to extol his accomplishments. He was a career academic who was on the faculty of Stanford University from 1930 until he retired in 1962. In the field of quality improvement, he was best known for his classic book *Statistical Quality Control*, first published in 1946. Recent editions of the book have been co-authored by Richard S. Leavenworth. The seventh edition was published in 1996. A very large number of copies of the book were sold through the various editions, but some observers felt that his teaching of statistical quality control during World War II contributed at least as much to the increase in the use of quality techniques as has his well-known book. The Eugene L. Grant Award was named in his honor and is given annually by the American Society for Quality to an individual who has "demonstrated outstanding leadership in the development and presentation of a meritorious educational program in quality control."

Harold F. Dodge (1893–1976) is known for his contributions to acceptance sampling, especially the Dodge–Romig Sampling Inspection Tables. Although acceptance sampling is covered only briefly in this book (in Section 4.10), Dodge's contributions were noteworthy as he originated several types of acceptance sampling plans and served as a consultant to the Secretary of War during World War II. He was employed in the Quality Assurance Department at Bell Laboratories from 1917 to 1958 and finished his career as a professor of applied mathematical statistics at the Statistics Center at Rutgers University from 1958 until 1970.

George E. P. Box (1919–) is not generally listed as a quality leader or "guru," but his contributions to statistical methods for improving quality are well known. His quality-related book, Box, Luceño, and del Carmen Paniagua-Quinones (2009), extols the authors' ideas and suggested approaches for improving quality. The primary message of that book is that control charts and engineering process control should be used in tandem. This idea is discussed in Chapter 17 of this book. He is the author of several other books, the best known of which is Box, Hunter, and Hunter (2005). Box also had a column entitled *George's Corner* during the early years of the journal *Quality Engineering*. He was named an Honorary Member of ASQ by the ASQ Board of Directors in 1997 in recognition of his contributions to quality improvement.

There are, of course, many other quality leaders, but they won't be listed here for fear of leaving someone out. Some indication of the influence of researchers on the state of the art of statistical quality control is given by the references that are listed in the following chapters, and also by the number of pages on which such researchers are mentioned, as shown in the book's Subject Index.

The quality leaders who were profiled in this chapter, while having differing areas of expertise, do have one obvious thing in common, as, except for Shewhart, they've had an extremely long life.

1.6 SUMMARY

Statistical methods should be used to identify unusual variation and to aid in pinpointing the causes of such variation, whether it be for a manufacturing process or for general business purposes. The use of statistical methods has produced improvements in quality for many organizations during the past few decades in particular. These improvements, in turn, should result in increased productivity. The tools for accomplishing this are presented primarily in Parts II and III, with some basic methods presented briefly in Chapter 2.

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