The Evolving Role of Statistics in Manufacturing and Business Operations

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Efficiency and the Use of and Need for Statistical Methods as a Tool for Manufacturing and Business Operations

- In a competitive, free-market economy, companies that use statistical methods **effectively** will tend to dominate those who do not.
- Globalization has and will continue to intensify this effect.
- There is, in industry, a pervasive skepticism toward statisticians.
- Nevertheless, in the U.S., the demand for statisticians, at all levels of education, has never been higher than it is today (especially for those with practical experience).

Other Factors

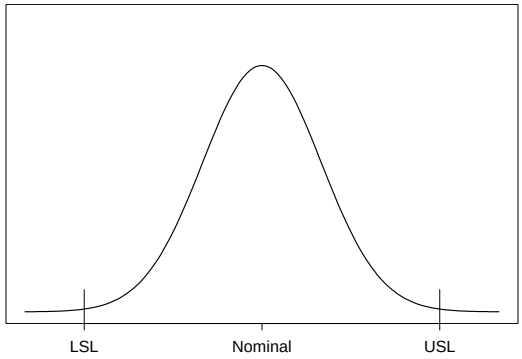
- Product demand (including service products) is driven by
  - Technology (features),
  - Quality/reliability, and
  - Price
- First-to-market often provides an important competitive advantage (implies need for "Rapid Product Development").
- **Efficiency** results from **reduction** of **Cost of Bad Quality**

Strong relationships to economics and international relations

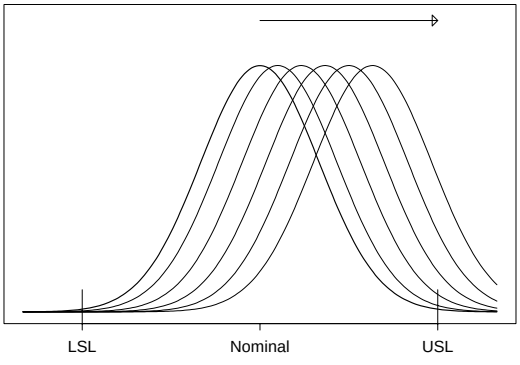
Overview

- Visualization of quality principles
- Brief history of the development and use of statistical methods in manufacturing industries (pre 1980)
- Difficulties in US manufacturing companies in the 1970's.
- The "quality revolution" of the 1980's and 1990's; the role of statistics; backlash.
- The latest quality initiative—Six Sigma. Is it different? Will it last?
- Implications for Statistics as a discipline.
- Implications for statisticians and concluding remarks

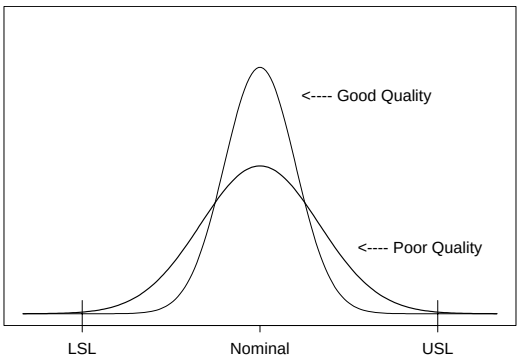
Three-Sigma Quality



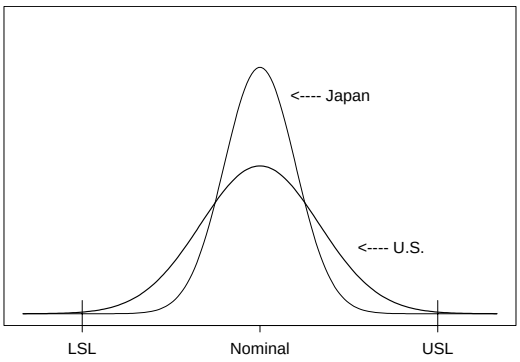
Drifting Three-Sigma Quality (Effect on Reliability)



Good and Bad Quality



Japanese and U.S. Quality



History and the Traditional Statistical Tools For Quality Control/Improvement

- Control charts (Shewhart, Bell Labs, 1924)
- Acceptance sampling (Dodge and Romig, Bell Labs, 1928)
- Designed experiments/response surface methods for process optimization (Box et al. 1950-1960)
- Robust design methods (Taguchi 1960's and 1970's in Japan, 1980's and 1990's in US)

Other Statistical Tools

- Seven simple tools (Ishikawa 1976)
  - Cause-and effect (fishbone) diagram
  - Check sheet
  - Control chart
  - Histogram
  - Pareto diagram
  - Process flow diagram
  - Scatter plot
- Statistical methods for assessing and improving reliability (Nelson 1982, Lawless 1982, Cox and Oakes 1984, Phadke 1988, Condra 1993)

Have Statistical Methods Been Useful in Industry?

- Little doubt (at least among statisticians!) about the potential
- Many success stories (selective reporting?)
- Mixed results and opinions.
- Methods were often "over sold" and applied ineffectively resulting in wasted time and efforts and little if any pay-back.

Difficulties in US Manufacturing Companies in the 1970's.

- During the 1960's and continuing through the 1970's and 1980's, Japanese products began to dominate a number of important markets:
  - Cameras/optics
  - Televisions and other consumer electronics
  - Automobiles
  - RAM chips
  - Machine tools
  - Heavy machinery
- What helped the Japanese to be so effective?
  - High quality and efficiency.
  - Wide-ranging use of statistical methods.

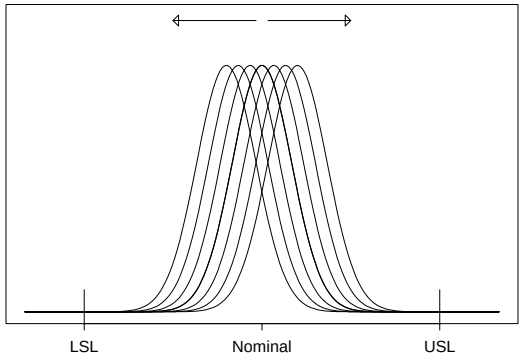
The "Quality Revolution" of the 1980's and 1990's

- **If Japan Can, Why Can't We?** NBC TV whitepaper 1980.
- Quality "Gurus" led the revolution: Feigenbaum, Juran, Deming, Taguchi, etc. advocated various flavors of "Total Quality Management" with differing amounts of focus on the use of statistical thinking and statistical methods.
- **Total Quality Management** (TQM) can be viewed as a **management framework** within which to implement tools and methods for improving quality.
- Various TQM programs were introduced, implemented (and sometimes subsequently dismantled).
- Deming spent his final years studying carefully the reasons that his approach did not help certain companies (resistance to **cultural change** is often suggested at a primary reason).

Effects of the "Quality Revolution"

- Correlation between quality program implementation and profitability?
- Mixed results.
- Where would U.S. industry be today if there had been no "Quality Revolution?"
- Some industries were probably saved and others have flourished.
- Improvements in U.S. industry, but Japan and others have not been standing still!
- Increased demand for statisticians in some high-tech industries.

Six-Sigma Quality (Target: 3.4 Defects per Million Opportunities)



Six Sigma Quality Programs

- What is different?
- What is new?
- **"Latest quality fad" or "The way of the future"?**

Six Sigma Quality Programs (also known as "Breakthrough Strategy Programs")

- Six Sigma Quality is
  - A "disciplined and highly quantitative approach to improving product or process quality."
  - "A strategic and tactical system for managing the entire business enterprise."
- **Top-down** rather than bottom-up.
- Multidisciplinary teams working on identifiably important "Six Sigma projects."
- Strong focus on documented additions to **profitability** of the company ("the bottom line"). All financial reporting has to be accurate and verifiable.
- Successful implementation at Motorola, Allied Signal, and General Electric (among others). Many other companies, around the world, are following.

Six-Sigma—The Technical Approach

- Multi-step process include variations on the following steps:
  - Recognize
  - Define
  - Measure
  - Analyze*
  - Improve
  - Control*
- Variations on the above have been proposed.
- Important dependency on the use of standard statistical methods.
- Training: Four weeks spread over three months.

Effects of Six Sigma Quality at General Electric Company 1995-2000

- **All GE employees** trained to at least the "green belt" level.
- Managers generally understand and are comfortable with concepts like sources of variability and design of experiments.
- Master Black Belts expected to mentor 20 projects per year and generating a total savings at 7 times salary in the year.
- Statistical software (MINITAB) on every engineer's desk top.
- Democratization of Statistics. Statisticians no longer have control.
- One billion dollars saved at GE in 1998.
- Nearly two billion dollars saved at GE in 1999.

The actual reasons for GE's phenomenal success are not clear, but other companies and Wall Street have taken note.

Implications of Six-Sigma Quality for Statistics

Suppose that the Six-Sigma success at General Electric can be **consistently replicated at other companies**.

- Use of **statistics** in industry will centainly increase importantly.
- Use of **statisticians** will not necessarily increase.
- Moving with the trend and applying needed corrections can provide positive synergism and new recognition for the importance of statisticians.
- If statisticians buck the trend, they are likely to be left behind as engineers do what is needed on their own.
- There are still plenty of important and interesting technical challenges for statisticians.

Challenges for Statisticians in Industry

- Help clients to be self-sufficient in their routine statistical work.
- There will still be challenging technical statistical problems that require the need of professional statisticians.
- Focus on collaborative problem solving.
- Learn the relevant language and principles of science and engineering
- Opportunities to provide leadership.
- Emphasize the need to proactive product improvement—help devise processes to avoid problems rather than correct them when they occur.

Concluding Remarks
Challenges for Statisticians in Academia

- Modern computing power and measurement/data availability are changing the way statistics is and will be use in practice.
- Educate Engineering/Business students so that they can adapt to the new industrial environment.
- Courses with focus on more on concepts and problem solving.
- Develop connections with industry.