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"THE VIEW FROM AN IVORY TOWER"

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Introduction

It is quite an honor to deliver the 2004 Youden Address.

I will touch on the following four topics: economic trends affecting U.S. industry and the future of our professions, the changing academic environment, the use of journal article citation rates, and the relatively new development of quality profile monitoring.

U. S. Economic Trends

In preparing my presentation I found it very helpful to read the addresses of the last twenty Youden speakers, available at the ASQ Statistics Division website (http://www.asqstatdiv.org/newsletterarch.php).

Brian Joiner's 1984 Address was entitled "The Key Role of Statisticians in the Transformation of North American Industry". His focus was on the survival of U.S. industry. In 1985, Ron Snee began his Address stating, "Some feel that, if the U.S. is not careful, it will become a colony once again – exporting raw materials and importing finished goods."

What has happened in the past twenty years?

Well, the Six-Sigma initiative incorporates many of the aspects of the managerial climate recommended by Joiner. These include a scientific approach with a focus on processes, the use of teams, and the elimination of barriers between departments. Snee reported, "W. E. Deming tells us that statistics is too important to be left to statisticians. The goal is to get many statistically-minded workers, scientists, engineers, and managers in industry; it is not to employ a lot of statisticians." Indeed, this has happened through Six-Sigma. The success of Six-Sigma is due, in large part, to the contributions of statistics and statisticians.

But what is happening now with respect to the U.S. economy and manufacturing? I make no claim to being an economist, but the trends that were of primary concern twenty years ago appear to be of even greater concern now. Figure 1 shows the number of manufacturing jobs in the U.S. over the last fifty-five years. The recent drop in manufacturing jobs is at least as dramatic as that so troubling twenty years ago. Manufacturing jobs as a percentage of the total non-farm payroll jobs have continued to decrease, from 19% in the 1980s to 11% in 2003.

Last February you may have heard that the Bush administration's economic team was floating the idea that fast food employment be reclassified as a manufacturing job. The Economic Report of the President prominently featured, "Sometimes seemingly subtle differences can determine whether an industry is classified as manufacturing. For example, mixing water and concentrate to produce soft drinks is classified as manufacturing. However, if that activity is performed at a snack bar, it is considered a service." From my reading of the more complete passage, however, I don't think the idea of reclassification was seriously being proposed.

Figure 1: Total U. S. Manufacturing Jobs (in millions).

Sources: Congressional Budget Office; Department of Labor, Bureau of Labor Statistics.

Note: The vertical bars indicate periods of recession as defined by the National Bureau of Economic Research.

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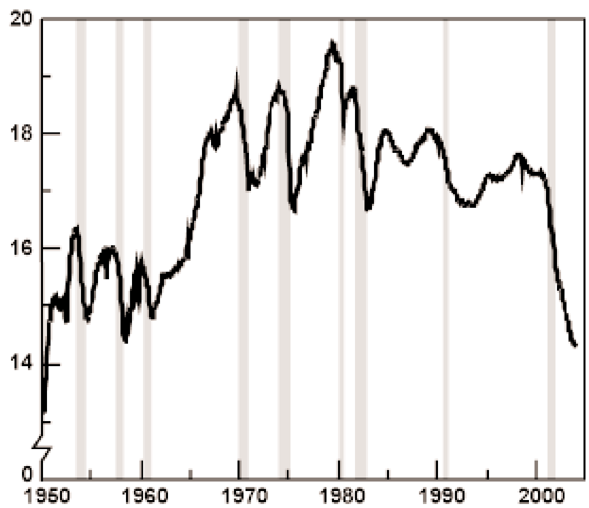
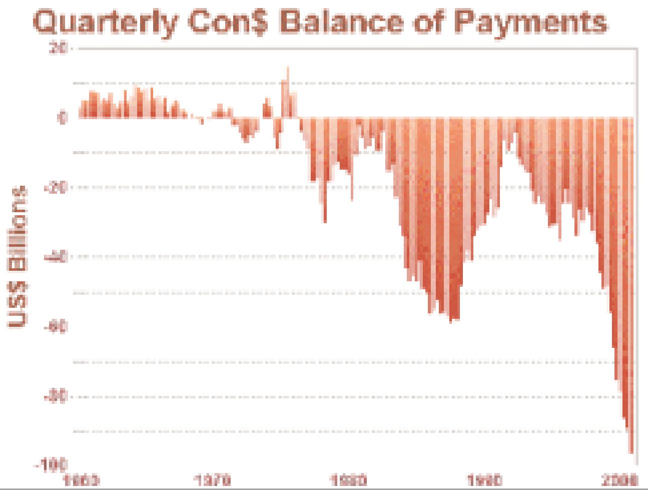


From Figure 2, one can see the U. S. trade deficit situation is more unfavorable now than it was twenty years ago. The trade deficit as a percentage of the GDP is roughly twice what it was in the mid 1980s and setting record highs. Although many argue otherwise in our new information economy, I cannot imagine us maintaining a prosperous economy without a reasonable trade balance or maintaining a thriving middle class without relatively high-paying manufacturing jobs.

Figure 2: U. S. Trade Balance, Source: U.S. Department of Commerce.

In the large healthcare portion of our economy there are many opportunities for the effective use of statistics and for quality improvement. Health care is not in danger of being outsourced. The tremendous quality, waste, and inefficiency problems in this industry have been well-documented. See, for example, Institute of Medicine (2001). It has been estimated that as many as 90,000 people die each year due to medical errors of some sort.



As evidence of the distance to go in health care improvement, a June 6, 2004 Associated Press article, “New Rules Fight Surgery Mix-Ups”, reported on new methods to identify that the patient and body part due to be operated on were indeed the correct ones. There have been 275 known cases of errors in this regard since 1999, although such errors are reported voluntarily and thus undercounted. Researchers found that the marking of operation locations had been inconsistent, for example, with some hospitals using an “X” on the body to indicate “operate here” and others using “X” to indicate “don’t operate here”. Another problem was the posting of X-rays backwards. The final word of advice by Dr. Dennis O’Leary, who heads the Joint Commission on Accreditation of Healthcare Organizations, was for the patient to speak up before being anesthetized if it is not clear that proper identification has been made. It is not reassuring that the patient must be the final quality control inspector in this situation.

It seems that basic industrial problem solving could go a long way toward health care quality improvement. There seems to be a lot of low-hanging fruit. Medical applications often require modifications of industrial methods. For example, in health care the monitoring of mortality rates is not as straightforward as monitoring defect rates in industry since it often requires risk adjustment in which a model is used to account for the level of severity of illness for each patient. For more information on process monitoring in healthcare and public health, the reader is referred to Steiner, Cook, Farewell, and Treasure (2000), Benneyan and Borgman (2003), Sonesson and Bock (2003), and Grigg and Farewell (2004).

The University Environment

Webster’s New World Dictionary defines “ivory tower” as *a place, such as a university, thought of as being more peaceful than the real world and set apart from its problems*. The ivory tower is, however, much less set apart from the real world than it used to be.
Many universities, especially large state universities, have moved toward the “corporate” management model. The key elements of this model are the following: requiring more and more faculty members to generate revenue to

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support themselves and their graduate students, viewing students as customers to be satisfied, increasing class sizes, devaluing faculty input in university decisions, hiring part-time and adjunct faculty for cost savings, and directly or indirectly attacking tenure. Many of the changes imposed by administrators are designed to improve the metrics by which universities, colleges, and departments are ranked. Virginia Tech administrators, for example, want us to be in the top thirty research universities, for example, as measured solely by research expenditures.

State funding for U. S. public universities has declined. For example, since 2001, Virginia funding for in-state college and university students fell 22%, from $6,352 per student to $4,949. State legislatures often impose restrictions on tuition increases. This combination has resulted in increasing pressure for universities to seek federal and corporate grants and contracts. When I spoke on academic life at the 2002 FTC in Valley Forge, PA, I discussed “Publish or Perish” and “Publish or Languish” imperatives for faculty. Now these increasingly out-of-date slogans are being replaced by “Show Me the Money.”

The emphasis on grantsmanship, in particular, places many academic statisticians at a serious disadvantage since we do not have the large equipment requirements that account for much of the funding in many of the other sciences and engineering disciplines. Funding expectations vary widely by university and by college within university, with, for example, engineering faculty with the greatest expectations and business faculty with the least. It is becoming more and more tempting for many administrators, however, to hire professors who can attract large amounts of federal and corporate funding. This can hurt many of the important disciplines, such as statistics and industrial engineering, with professors that don’t generally fall into this category.

Since there is increased competition for limited federal funding, it will become increasingly necessary for corporations to provide financial and political support to the academic departments that they value. Corporate financial support for research, particularly from pharmaceutical companies, often comes with strings attached. Stein (2004, p. 13) reported that corporate sponsors of university research reserved the right to withhold or block publication to protect industry secrets about half of the time. Some question whether university professors should be doing this type of research.

I might add that professors are generally allowed to do corporate and other consulting averaging up to one day a week. The funding of many professors who do corporate training and consulting does not flow through the university since, for one reason, the overhead charged by the university can represent up to a third of the budget. From the university point of view, this type of funding obviously does not count.

In my view the corporate model leads to a lowering of the quality of education and, in the extreme, to a loss of academic freedom. For a more complete discussion of these issues, see Scott (2001). Overall, academic life is becoming more difficult and demanding for those of us interested in industrial statistics.

Journal Article Citation Counts

I find the study of citation counts of journal articles to be quite interesting, although many question its value. Citation counts are limited in assessing the impact of papers, but I believe that they shed some light on which papers have been found to be most useful by researchers in statistics and other fields. Citation counts are playing an increasing role in the rankings of journals and researchers. Citation analyses are also required in many academic tenure and promotion decisions, especially at the full professor level.

The two journals most closely associated with the FTC are *Technometrics* and the *Journal of Quality Technology* (*JQT*). The Appendix contains lists of some of the current most-cited papers in these journals based on Web of Science data. The overall most-cited *Technometrics* papers in List 1 tend to be on widely applicable statistical methods; in particular, regression, ridge regression, multivariate analysis, and outlier detection. It is interesting that the paper on multiple comparison methods by Dunn (1964) is so highly cited. Ryan and Woodall (2004) found that the most-cited papers in statistics included several on multiple comparison methods.

List 2, with the most-cited *Technometrics* paper by volume, contains quite a few SPC and DOE-related papers. In contrast List 1 contained only one paper in these categories, Box and Behnken (1960). List 3 shows the most-cited *JQT* papers by volume. Authors Bill Hunter, Jim Lucas, John MacGregor, Geoff Vining, Derek Bingham, and Randy Sitter appear on both lists.

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Surprisingly, the most-cited paper in *JQT* was cited more than the most cited paper in *Technometrics* for several years of publication.

Although there has been no study to identify the most-cited *JQT* and *Technometrics* authors, the clear leader in this category for *Technometrics* is George Box with 2,634 citations (as of 7/6/04). The Web of Science lists separate entries for the spelling and various misspellings of an author's name. Professor Box, for example, is listed as EPG Box, G Box, GE Box, GEP Box, GET Box, GPE Box and P Box! This type of database issue complicates the determination of accurate citation counts.

Technometrics is more highly cited than *JQT*. In 2003, *Technometrics* papers received 2,511 citations while *JQT* papers received 846. All citation counts are undercounts since the Web of Science does not cover citations in all journals, e.g., those in *Quality Engineering*. Journals are usually ranked on the basis of the citation impact factor. This metric is the ratio of the total number of citations received in a given year to papers published in the journal in the previous two years to the number of articles published in these previous two years. The two-year time frame seems much too short to meaningfully compare statistical journals due to the length of the review and publication process.

Figure 3 shows the number of citations to *Technometrics* papers in 2003 by year of their publication in *Technometrics*. The citation counts for 2002 and 2001 were used to calculate the 2003 citation impact factor of 0.775.

Figure 3: Number of Citations to *Technometrics* Papers in 2003 by Year of Publication. (From *Journal Citation Reports*.)

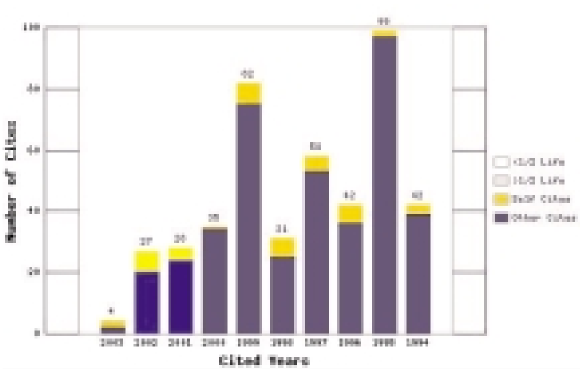
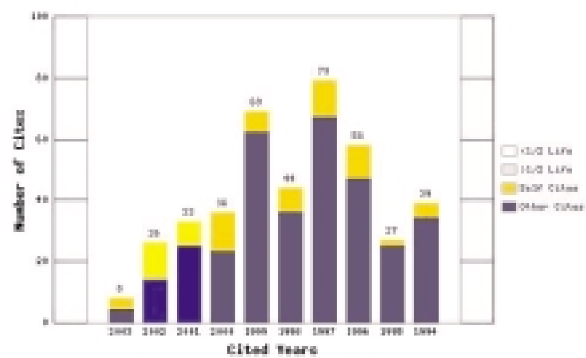


Figure 4 contains citation results for *JQT*, which had a 2003 citation impact factor of 0.766. The total numbers of citations in 2003 for articles published since 1994 are very similar for the two journals with *Technometrics* at 448 and *JQT* at 419. *JQT* has a higher rate of journal self-citations, but this is not surprising given its more narrow focus.

Figure 4: Number of Citations to *JQT* Papers in 2003 by Year of Publication. (From *Journal Citation Reports*.)



Ryan and Woodall (2004) reported that the most-cited statistical paper is Kaplan and Meier (1958) with roughly 28,000 citations. For some perspective, the citation impact of this single paper is greater than that of all of the contributions of George Box published in *Technometrics* combined together and then multiplied by a factor of ten. To make the list of the top twenty-five most-cited statistical papers required over 2,000 citations.

We need to support our key technical journals. Full electronic access to all past issues of *Technometrics* and *JQT* is inexpensive. Although citation rates are relatively strong, both journals are declining in circulation to a disturbing degree. I encourage you to subscribe to these journals if you don't already have access. If you are not finding the types of articles you need, I urge you to contact the editors with your input and suggestions, perhaps with ideas for a review or tutorial paper that would be of interest.

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Quality Profile Monitoring

In his Address in 1994 Roger Hoerl pointed to the limitations of research in statistical process control (SPC). He stated, "Those of us who work on two (or three) dimensional products, such as rolls of steel or paper, where well-known patterns exist in the two dimensions, are not particularly interested in SPC papers which assume 'random sampling'." In his 1995 Address John MacGregor reported a tremendous resistance by statisticians to using more complex and alternative approaches to SPC. He advised moving beyond the overly simple univariate and typical multivariate assumptions.

Most of my research over the past twenty years has been on control charting. I found it difficult to move as far as John MacGregor has recommended, however, because I am not a chemical engineer and no chemical plant manager in his or her right mind is going to give me control of one of their reactors.

In most statistical process control (SPC) applications it is assumed that the quality of a process or product can be adequately represented by the distribution of a univariate quality characteristic or by the general multivariate distribution of a vector consisting of several correlated quality characteristics. In many practical situations, however, the quality of a process or product is better characterized and summarized by a relationship between a response variable and one or more explanatory variables. Thus, at each sampling stage one observes a collection of data points that can be represented by a curve (or profile). It is the relationship between the variables that is to be modeled and monitored. Woodall et al. (2004) gave a review of profile monitoring. The model-fitting approaches have involved linear regression, non-linear regression, nonparametric regression, and the use of wavelets. There are many calibration and manufacturing applications. The monitoring of quality profiles clearly moves SPC in the directions indicated as needed by Roger Hoerl and John MacGregor.

Conclusions

We have limited influence on the U.S. economy, but I think we should support initiatives and political leaders that show promise for supporting a stronger manufacturing base in the U.S. An obvious major adverse factor is the globalization of the economy. If our manufacturing base continues to weaken, many quality professionals may consider moving from manufacturing to health care.

The corporate management model is generally inappropriate for universities. The most important step for maintaining the excellence of higher education would be for states to adequately fund universities, even if this requires raising taxes. If all tax cuts were good and all tax increases bad, then the optimal level of taxes would be zero. This is clearly absurd. I agree with Mote (2004), the president of the University of Maryland, that if the federal and state governments continue to shift financing responsibilities to the universities, then access and/or quality will decrease. Those in academia should consider joining the American Association for University Professors (AAUP), which fights against the excesses resulting from the use of the corporate model.

If you are an author of journal papers, consider the effect of your reference lists. It would be helpful for authors to review the literature not just before a paper is written, but also after it has been accepted for publication. Relevant papers most likely will have appeared in the literature during this time. Citing these new articles can strengthen a paper and increase the citation impact factors of our journals.

Finally, I encourage you to investigate the subject of profile monitoring. I see this as the most exciting and promising area of research in SPC. It opens the SPC up to many areas of applied statistics involving model-fitting and allows us to address a much wider variety of engineering applications.

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APPENDIX: Most-Cited *Technometrics* and *JQT* Papers

List 1: Overall Most-Cited Papers in *Technometrics* (as of 7/6/04 Web of Science)

1077 Wold, Svante (1978), "Cross-validatory estimation of the number of components in factor and principal components models", *Technometrics*, 20, 397-405.

1003 Hoerl, Arthur E., and Kennard, Robert W. (1970), "Ridge regression: Biased estimation for nonorthogonal problems", *Technometrics*, 12, 55-67.

837 Mallows, C. L. (1973), "Some comments on C_p", *Technometrics*, 15, 661-675.

829 Dunn, Olive Jean (1964), "Multiple comparisons using rank sums", *Technometrics*, 6, 241-252.

698 Spendley, W., Hext, G. R., and Himsworth, F. R. (1962), "Sequential application of simplex designs in optimisation and evolutionary operation", *Technometrics*, 4, 441-461.

664 Lachenbruch, Peter A., and Mickey, M. Ray (1968), "Estimation of error rates in discriminant analysis (Com: V10 p204-205; Add: V10 p431)", *Technometrics*, 10, 1-11. Lachenbruch, Peter A. (1968), "Addendum to ``Estimation of error rates in discriminant analysis'' (V10 p1-11)", *Technometrics*, 10, 431-432.

597 Hartley, H. O. (1961), "The modified Gauss-Newton method for the fitting of non-linear regression functions by least squares", *Technometrics*, 3, 269-280.

490 McKay, M. D., Beckman, R. J., and Conover, W. J. (1979), "A comparison of three methods for selecting values of input variables in the analysis of output from a computer code", *Technometrics*, 21, 239-245.

479 Box, G. E. P., and Behnken, D. W. (1960), "Some new three level designs for the study of quantitative variables (Corr: V3 p131; V3 p576)", *Technometrics*, 2, 455-475.

472 Cook, R. Dennis (1977), "Detection of influential observation in linear regression", *Technometrics*, 19, 15-18.

469 Hoerl, Arthur E., and Kennard, Robert W. (1970), "Ridge regression: Applications to nonorthogonal problems (Corr: V12 p723)", *Technometrics*, 12, 69-82.

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450 Golub, Gene H., Heath, Michael, and Wahba, Grace (1979), "Generalized cross-validation as a method for choosing a good ridge parameter", *Technometrics*, 21, 215-223.

432 Marquardt, Donald W. (1970), "Generalized inverses, ridge regression, biased linear estimation, and nonlinear estimation", *Technometrics*, 12, 591-612.

423 Grubbs, Frank E. (1969), "Procedures for detecting outlying observations in samples", *Technometrics*, 11, 1-21.

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164 Conover, W. J., Johnson, Mark E., and Johnson, Myrle M. (1981), "A comparative study of tests for homogeneity of variances, with applications to the outer continental shelf bidding data (Corr: V26 p302)", *Technometrics*, 23, 351-361.

114 Lucas, James M., and Crosier, Ronald B. (1982), "Fast initial response for CUSUM quality-control schemes: Give your CUSUM a head start", *Technometrics*, 24, 199-205.

142 Beckman, R. J., and Cook, R. D. (1983), "Outlier…………..s (C/R: p150-163)", *Technometrics*, 25, 119-149.

119 Steinberg, David M., and Hunter, William G. (1984), "Experimental design: Review and comment (C/R: p98-130)", *Technometrics*, 26, 71-97.

185 Hosking, J. R. M., Wallis, J. R., and Wood, E. F. (1985), "Estimation of the generalized extreme-value distribution by the method of probability-weighted moments", *Technometrics*, 27, 251-261.

202 Bohachevsky, Ihor O., Johnson, Mark E., and Stein, Myron L. (1986), "Generalized simulated annealing for function optimization", *Technometrics*, 28, 209-217.

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32 HAHN, G.J. (1970), "Statistical Intervals for a Normal Population: Part 1. Tables, Examples and Applications", 2, 115-125.

44 SNEE, R.D. (1971), "Design and Analysis of Mixture Experiments", 3, 159-169.

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