ASQ STATISTICS DIVISION Newsletter

Volume 29, No. 3 SPRING 2011

In This Issue

Chair's Message

by Christine Anderson-Cook
candcook@lanl.gov

Christine Anderson-Cook

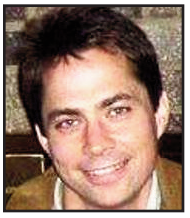
It seems like time is going faster all the time – another quarter has zoomed by and nearly 400 emails per month later, we are nearing the end of my term as Chair of Statistics Division. It has been an exciting few months for the division, and the coming months hold some good activities in store as well. I would like to thank all of the volunteers on the Statistics Division leadership who have been working hard to help provide resources, services and communication to our members. I'll elaborate more on some of these in a few moments, but first, let me announce the Executive Leadership for the 2011-2012 year.

The incoming Chair is William Brenneman, Proctor and Gamble in Cincinnati. His term will begin on July 1, 2011. The Chair-Elect will be Bill Rodebaugh, Sunoco Chemicals in Philadelphia. Our new Treasurer will be Adam Pintar,

Continued on page 3

Editor's Corner

by Paul Prew
paul.prew@ecolab.com



Paul Prew

What is it about some pieces of advice that make them stick with you? Doesn't have to be anything too profound, just something that ends up influencing you repeatedly, a little voice – someone else's – that pops up as needed. A few years back I went to see a local comedian. Don't recall whether he was funny or not, all that stuck with me was his admonition, "if you remember nothing else from tonight, remember this: never drive the Crosstown." A notorious stretch of road in Minneapolis, the Crosstown is a local highway that literally intersected Interstate 35– but not before sharing lanes for a couple miles. Cars driving north/south and those going east/west had to weave through one another, causing backups for miles in either direction on the Crosstown. Real desperation could set in among drivers. New mothers driving their first-born would tear the Baby On Board sign out of the window and begin driving on the shoulder, frantic to arrive on-time for their yoga relaxation class. Every few years, I had to find out for myself, inevitably ending up regretting it as I took my place in the Crosstown's sea of brake lights.

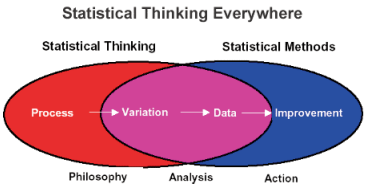
Continued on page 4

MISSION STATEMENT OF THE STATISTICS DIVISION

- Promote Statistical Thinking for quality and productivity improvement.
- Serve ASQ, business, industry, academia, and government as a resource for effective use of Statistical Thinking for quality and productivity improvement.
  - Our primary customers are Statistics Division members.
  - Other key customers are:
    - Management
    - Users and potential users of Statistical Thinking
    - Educators of the above customers
- Provide a focal point within ASQ for application-driven development and effective use of new statistical methods.
- Support the growth and development of ASQ Statistics Division members.

VISION

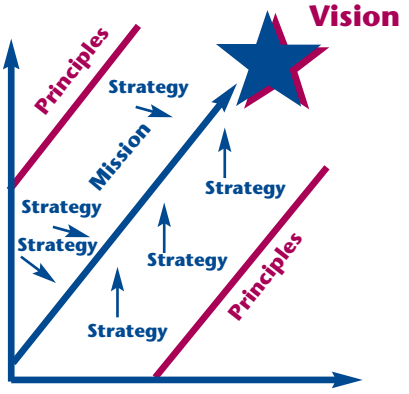
ASQ Statistics Division Vision – Statistical Thinking Everywhere



DESIRED END STATE

- Our members will be proud to be part of the Statistics Division
- Our Division's operations will be a model for other organizations.
- We will be a widely influential authority on scientific approaches to quality and productivity improvement.

ASQ Statistics Division Vision – Principles and Mission



Principles and Strategy of the ASQ Statistics Division

Principles of the Statistics

- Our customers' needs will be continuously anticipated and met (i.e., Customer focused rather than customer driven).
- Our market focus for products and services is weighted as follows:
- Greatest weight on intermediate level
- Nearly as much weight on basic level
- Much less weight on advanced level.
- Focus on a few key things.
- Balance short-term and long-term efforts.
- Value diversity (including geographical and occupational) of our membership.
- Be proactive.
- Recognize we exist for our customers.
- View statistics from the broad perspective of quality management.
- Apply Statistical Thinking ourselves; that is, practice what we preach.
- Uphold professional ethics.
- Continuously improve.

Strategy of the Statistics

- Improve our organizational effectiveness.
- Educate statistical practitioners for business.
- Expand our influence.

Disclaimer

Criteria for Basic Tools and Mini-Paper Columns

Basic Tools

Purpose: To inform/teach the "quality practitioner" about useful techniques that can be easily understood, applied and explained to others.

Criteria:
1. Application oriented/not theory
2. Non-technical in nature
3. Techniques that can be understood and applied by non-statisticians.
4. Approximately five pages or less in length (8 1/2" x 11" typewritten, single spaced.)
5. Should be presented in "how to use it" fashion.
6. Should include applicable examples.

Possible Topics:
New SPC techniques
Graphical techniques
Statistical thinking principles
"Rehash" established methods

Mini-Paper

Purpose: To provide insight into application-oriented techniques of significant value to quality professionals.

Criteria:
1. Application oriented.
2. More technical than Basic Tools, but contains no mathematical derivations.
3. Focus is on insight into why a technique is of value.
4. Approximately six to eight pages or less in length (8 1/2" x 11" typewritten, single spaced.)
   Longer articles may be submitted and published in two parts.
5. Not overly controversial.
6. Should include applicable examples.

General Information

Authors should have a conceptual understanding of the topic and should be willing to answer questions relating to the article through the newsletter. Authors do not have to be members of the Statistics Division.

Submissions may be made at any time to the Statistics Division Newsletter Editor. All articles will be reviewed. The editor reserves discretionary right in determination of which articles are published.

Acceptance of articles does not imply any agreement that a given article will be published.

Chair's Message

(continued from page 1)

National Institute of Standards and Technology, and R. N. "Herb" McGrath, Bowling Green State University will continue to serve as Secretary. Thanks to all for their commitment to the Division and their willingness to serve in such important capacities.

Some of our recent accomplishments in the division have been the launch of a new webinar series, a re-launch of the Speakers' list, further updates and enhancements to the Virtual Resource Center and the imminent start of a pilot version of a Mentoring program. We have also been active in helping to promote "Statistical Engineering" as a new focus for the Division. I'll now provide a few more details on each of these:

Our first Statistics Division webinar was held on March 16th and featured Roger Hoerl and Ron Snee giving an overview of Statistical Engineering. Over 350 participants were online to watch the presentation, and we received a lot of positive feedback about the event. We are planning on hosting one webinar per month, with the future schedule available on our website (http://www.asqstatdiv.org/webinars.php).

The new version of the Speakers' list is also available online at http://www.asqstatdiv.org/speakerlist.php. If you are hosting an event and are looking for a qualified speaker to talk on a quality or statistical theme, we have compiled a list of potential candidates for you to consider. Their areas of expertise are also listed if you have a particular topic in mind.

The Virtual Resource Center continues to develop nicely with new content and search capabilities. Go to the Statistics Division online library at http://asq.org/statistics/quality-information/library/ and search for a topic from among the keywords listed or enter your own topic. With over 100 items listed, we hope that we can connect you with the content you are interested in.

We are also starting a pilot Mentoring Program to connect some of the expertise of our established members with the quest for knowledge and professional growth for our more junior members. If you are interested in participating (either as a mentor or mentee), please contact Herb McGrath at rnmcgra@bgsu.edu. More details will also be available on our websites.

Finally, a topic close to my heart is the new "Statistical Engineering" initiative that we have started to promote. The Statistical Engineering initiative seeks to increase awareness and appreciation for how those tools are used to solve important problems. To be most effective might involve using several statistical tools in progression. Having an awareness of how to best construct this process seems beneficial. We could learn from others who have experience in this area. A symposium on the topic is being held in Williamsburg (May 3-5), and short courses on the topic are being offered as part of the Quality and Productivity Research Conference (June 7-10, http://www.cpe.vt.edu/qprc/shortcourse.html) and the Fall Technical Conference (October 12-15, http://www.asqstatdiv.org/ftc.htm). We hope that we can start a grass-roots movement to help develop interest, awareness and information about this topic that reflects what so many of us do in our daily working lives.

In closing, I am happy to announce that the Statistics Division has achieved the J.S. McDermond total Quality Award - the highest level of achievement attainable by a Division from ASQ's Quality Management Program (QMP) for the year 2008-2009 under the leadership of Vijay Nair. This award recognizes Divisions for their dedication and commitment to their members. To help us maintain this level of success, please let me know what we are doing well, how we can further improve, and what products or services you would like us to provide. I welcome input from all members! I can be reached at candcook@lanl.gov.

Editor's Corner

Continued from page 1

Some advice sticks with you because it changes your worldview. I started my career as an industrial engineer, interning at a small electronic component manufacturer. There really wasn't anyone to mentor me, so I relied on what I'd learned in my classes. "Line balancing" seemed opportune, as I could see that there was an unequal distribution of work on some assembly lines. One person would have inventory piled up in front of them, as they could not keep up with the pace of the previous operation. Like me on the Crosstown, those electronic components were barreling along, thinking they were making good time, oblivious to the inevitable traffic jam. So we took some duties from over-capacity people downstream, gave them to the under-utilized people upstream so the line was balanced, and productivity numbers improved.

Still, the company maintained several weeks worth of backlogged orders. Then the company hired a manufacturing manager, and he advised me, "Look for the bottleneck. Not any bottleneck, The Bottleneck." The Bottleneck is the operation that constrains the *company*, not just one line, from meeting demand. I knew then that I should have been concentrating on the Varnish Room, where the components got encapsulated in varnish to prevent corrosion. *This* was the Crosstown. Everything the company made went through that process, performed using one oven by one young guy with a reputation for being temperamental. He was a full-blooded Scotsman who enjoyed wearing kilts on the weekend. It's probably for the best that the internship ended before I had to tackle the Varnish Room. I've seen Braveheart. The damage done by those in kilts and blue face paint. What happens when the guy's face is blue from breathing solvents all day? Regardless, in future assignments I concentrated my industrial engineering efforts on finding and streamlining The Bottleneck.

In my work as a statistician, I got a couple of pieces of advice from my first boss – "always plot the data," and "when someone comes to you with data, ask if they'll take you to their lab and show you how they got it". These are now instinctual to me, but certainly weren't when I was fresh out of school and accustomed to "plug-and-chug" with pristine data from tables in textbooks. Last month I came across more advice for statisticians, on presenting your findings – "Write it so that your little sister would understand it." (found in the magazine Significance). The same article is full of advice for statistical presentations; see the In Case You Missed It column of this newsletter. In the same magazine, there's an article "Making Information Beautiful – and Clear" with guidance on good graphics.

More advice? Sam Gardner ends his Mini-Paper series on Model Selection with a warning about the perils of over-fitting when allowing computers to algorithmically choose your models. And the recurring Stat Resources on the Web column uncovers a website devoted to Innovation, with "detailed guidance for implementation" as author Mindy Hotchkiss puts it. So read these articles. And never drive the Crosstown.

Stat Division Webinar Series Kicks Off

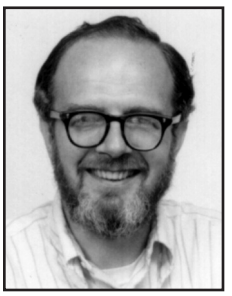
In March the Stat Division started a series of free monthly webinars with Ron Snee and Roger Hoerl presenting on their popular topic "Statistical Engineering." The webinar drew a large attendance and prompted numerous discussions...this was followed up in April by Gordon Clark's talk on "Simulation and Six Sigma" which gave a very engaged audience great ideas and insights on the use of simulation for process improvement!

We plan on continuing these offerings each month and feedback from members is that this is a great offering from the division that adds value to membership. Our next webinar is scheduled for
3:00 pm on May 9th, when Pat Whitcomb will present "Algorithmic Design of Physical Experiments." To register, please visit
https://www1.gotomeeting.com/register/612312936.

NOMINATIONS SOUGHT FOR WILLIAM G. HUNTER AWARD

by Daksha Chokshi

The ASQ Statistics Division is pleased to announce that nominations are now open for its William G. Hunter Award for 2011.



William G. Hunter was the first chairman of the Statistics Division of the American Society for Quality Control (now American Society for Quality). His leadership as a communicator, consultant, educator, and innovator, and his ability to integrate statistical thinking into many disciplines serve as exemplary models for the Division's members and beyond.

Objective

The Statistics Division established the William G. Hunter Award in 1987 to encourage and promote outstanding accomplishments during a career in the broad field of applied statistics, and to recognize an implementer who achieves results.

Qualifications

Any outstanding leader in the field of applied statistics, regardless of ASQ Statistics Division membership status, is qualified. Candidates must have demonstrated a high level of professionalism, significant contributions to the field, and a history of inspirational leadership and application. A person may be nominated may times but may win the award only once.

Procedure

The nominator must have the permission of the person being nominated and letters from at least two other people supporting the nomination. Claims of accomplishments must be supported with objective evidence. Examples include publication lists and letters from peers. Nominators are encouraged to read the accompanying article "William G. Hunter: An Innovator and Catalyst for Quality Improvement" written by George Box in 1993 (http://www.asqstatdiv.org/documents/William%20Hunter%20-%20Innovator%20-%20by%20George%20Box_1993.pdf) to get a better idea of the characteristics this award seeks to recognize.

Nominations for the current year will be accepted until July 15. Those received following July 15 may be considered for the current year — if not, they will be held until the following year. A committee of past leaders of the Statistics Division and awardees selects the winner. The award is presented at the Fall Technical Conference in October.

The award criteria and nomination form can be downloaded from the "Awards" page of the ASQ Statistics Division website (http://www.asqstatdiv.org/awards.htm) or may be obtained by contacting Daksha Chokshi via phone 561-796-8373 and/or e-mail daksha.chokshi@pwr.utc.com.

MODEL SELECTION
Part 2 – Model Selection Procedures

Sam Gardner, MP Technical Specialist
The SAS Institute
Lafayette, IN

SamGardner@JMP.com

Abstract

This article is the second of a two part series on model selection criteria and model selection procedures. These tools have been employed by statisticians for many years, but more frequently these tools are being used by quality professionals from diverse backgrounds. The purpose of the first article was to introduce and describe common model selection criteria. This second article will describe some model selection procedures and how they are used for automatic model building and feature selection.

Introduction

Model selection is the process of choosing a statistical model that adequately describes or accurately predicts the system under observation. In the not so distant past, model selection was a more advanced statistical tool relegated to those with access to statistical computing power and the training and education on how to implement these methods. Today, statistical computing tools and resources are available and accessible to a broad range of modelers and the model selection process has become less tedious. This article will discuss model selection in the context of linear statistical models, where the response variable is a continuous variable. Model selection procedures discussed include stepwise regression, ranking all possible models, and model averaging.

Model Selection Procedures

Stepwise Regression:

Stepwise regression starts with a baseline model and then subsequently adds or removes terms to the model in iterative steps[1]. At each step a decision is made on which is the most important change to make (addition or removal of model terms). This continues until some stopping criterion is met. How many model terms to add or remove at each step can be varied, but the most common approach is to add or remove just one model term. Another modification preserves the "hierarchy of effects", in that if a higher order interaction term is to be included in the model, then all of the lower order terms must also be included. It is a common practice in fitting linear models to require hierarchy of effects, even if the main effects have p-values that are not statistically significant on their own.

Part 2 – Model Selection Procedures

Continued from page 6

To frame the discussion, let Y be the response variable being modeled, and let $X_1, X_2, \ldots, X_K$ be the candidate set of variables. Consider the model with main effects and second order interactions, so the general form of the linear model is (μ is the intercept, β's are slopes):

$$Y = \mu + \sum_{i=1}^{K} \beta_i X_i + \sum_{i=2}^{K} \sum_{j=1}^{i} \beta_{ij} X_i X_j$$

Performing model selection on this model entails determining which of the $(K + K(K–1)/2)$ model factors (main effects and interactions) are to be included in the model. In this case, that means there are $(2^{(K+K(K–1)/2} –1)$ models to choose from. Model selection using stepwise regression is equivalent to deciding the values of the coefficients in the model, with excluded terms having coefficient values set to zero.

Forward Selection: Forward selection begins with the simplest model, that of $Y=\mu$, and proceeds to add model terms (note this simplest model has no X terms – it assumes that none of the proposed factors has a relationship with the response Y. In that case, the best model is the average μ.) The most common way forward selection is performed is to use the F-ratio/p-value approach. Here, the p-value for adding each single term is calculated, and the term with the smallest p-value is considered the most important term, and is added to the model. Inclusion is subject to a threshold, often a 0.10 or 0.25 significance level. The process is repeated stepwise to search for additional terms to add until no terms have a p-value beneath the threshold.

Some stepwise procedures allow for the preservation of the effects hierarchy, so that when we specify that the X_jX_k interaction term is included, then X_j and X_k must also be included. In this case the F-ratio/p-value calculated is for that comparison between the full model (model with more terms) and reduced model (model with fewer terms). Alternative criteria such as minimizing Akaike's Information Criteria (*AICc*) or cross-validation can also be used for determining which terms to include at each step. AICc was defined in Part 1 of this series, cross-validation will be defined shortly.

Backward Selection: This method is similar to forward selection, but this approach begins with the full model (all terms included) and then proceeds to remove model terms. Again, the most common way this is performed is to use the F-ratio/p-value approach, but alternatives such as minimizing *AICc* or cross-validation can also be used.

Mixed Selection: One can combine a forward and backward selection process by alternating between the forward selection algorithm and the backward selection algorithm. So, suppose one starts with a forward selection step and adds one term, then another term. From that point forward, as long as there are at least two candidate model terms in the model, perform a backward selection step to see if the addition of a model term has made another model term insignificant. Subsequently, one would alternate back and forth between a forward selection step and backward selection step until no more subsets of model terms are found to be entered or removed.

Part 2 – Model Selection Procedures

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More on Cross-Validation: Cross-validation involves holding back part of the available data from the model fitting process and using that "hold-out" portion of the data to assess the predictive ability of the fitted model.

K-fold cross-validation divides the data in to K portions. The model under consideration is fit K separate times, each time holding out one of the portions. For each of the K model fits, a measure of model quality (often R^2) is calculated, and the K different R^2's are averaged. This approach can be useful when there is limited data available for model fitting and you need all of the data to perform the model selection process.

Another hold-out strategy is to use a dedicated portion of the data to test the quality of a fitted model (usually based on the R^2). The data set used to fit the model is call the "training" set, and the hold-out portion is called the "test" set. This approach can be useful when you have a larger amount of data available for model fitting, and can be especially valuable when you want to compare several different types of models, giving each model a fair assessment based on measure of fit on the test set. Of course, one must take care to ensure that both the training and test data sets are representative of the process being modeled.

Based on cross-validated R^2, selection decisions are made on which terms and how many terms to add or remove from a model.

Boston Housing[2] Example:
This example is an econometric modeling problem, where the response (Y) is the median home price in 1970 for each of the census tracts in the Boston, Massachusetts region (*note: this data set is available by request from the author*). The fourteen model factors (X_1, X_2, …, X_{14}) under consideration are environmental, geographic, economic, and demographic measures for each census tract. Suppose the goal in analyzing the data is to uncover the factors that relate to home value. Then a stepwise regression approach may be useful. Both forward selection and backward selection will be performed, and we will not require hierarchy of effects. The F-ratio/p-value approach is used, and the probability to enter or leave is set at 0.25. In the original paper that describes this data, the authors felt that X_1 and $X_1 * X_1$ should be included as candidate model terms, and we will do the same. The remaining terms will only be considered as linear terms in the model.

In comparing the results of the two approaches, we get slightly different models (see Figures 1 and 2 for JMP® software's stepwise regression output). In particular, for forward selection the $X_1 * X_1$ term is not included, while it is retained for the model found by backward selection. This highlights another important consideration when performing model selection: the model you get from the selection algorithm may be dependent on the structure of the data, the candidate model terms you include, and the selection algorithm itself. This would suggest that we should take more than one model selection approach and then evaluate all the models that appear to be reasonable. At this point, subject knowledge and scientific judgment should be used to select the most appropriate model.

Part 2 – Model Selection Procedures

Continued from page 8

Current Estimates

Lock	Entered	Parameter	Estimate	nDF	SS	"F Ratio"	"Prob>F"
☑	☑	Intercept	36.341145	1	0	0.000	1
☐	☑	X1	-17.376023	1	541.9117	24.158	1.21e-6
☐	☐	X1*X1	0	1	19.61339	0.874	0.35027
☐	☑	X2	-0.1084133	1	245.374	10.939	0.00101
☐	☑	X3	0.04584493	1	257.8244	11.494	0.00075
☐	☐	X4	0	1	2.51754	0.112	0.73799
☐	☑	X5	2.7187163	1	227.2137	10.129	0.00155
☐	☑	X6	3.80157884	1	1963.662	87.539	2.9e-19
☐	☐	X7	0	1	0.062707	0.003	0.9579
☐	☑	X8	-1.4927115	1	1448.939	64.593	6.8e-15
☐	☑	X9	0.29960845	1	500.9185	22.331	3e-6
☐	☑	X10	-0.011778	1	273.6193	12.198	0.00052
☐	☑	X11	-0.9465246	1	1206.449	53.783	9.2e-13
☐	☑	X12	0.00929084	1	270.8225	12.073	0.00056
☐	☑	X13	-0.5225535	1	2723.484	121.411	2.1e-25

Step History

Step	Parameter	Action	"Sig Prob"	Seq SS	RSquare	Cp	p	AICc	BIC
1	X13	Entered	0.0000	23243.91	0.5441	362.6	2	3289.02	3301.65
2	X6	Entered	0.0000	4033.072	0.6386	185.53	3	3173.62	3190.45
3	X11	Entered	0.0000	1711.324	0.6786	111.54	4	3116.22	3137.23
4	X8	Entered	0.0000	499.0776	0.6903	91.382	5	3099.53	3124.72
5	X1	Entered	0.0000	759.5636	0.7081	59.656	6	3071.66	3101.02
6	X5	Entered	0.0003	328.2714	0.7158	47.08	7	3060.23	3093.75
7	X12	Entered	0.0008	272.8371	0.7222	36.966	8	3050.8	3088.48
8	X3	Entered	0.0047	189.9361	0.7266	30.533	9	3044.72	3086.54
9	X2	Entered	0.0446	94.71193	0.7288	28.327	10	3042.69	3088.65
10	X9	Entered	0.0017	228.6043	0.7342	20.177	11	3034.7	3084.79
11	X10	Entered	0.0005	273.6193	0.7406	10.028	12	3024.47	3078.67

Figure 1: Forward Regression Results

Current Estimates

Lock	Entered	Parameter	Estimate	nDF	SS	"F Ratio"	"Prob>F"
☑	☑	Intercept	31.4773323	1	0	0.000	1
☐	☐	X1	0	1	1.392682	0.062	0.80336
☐	☑	X1*X1	-13.374611	1	560.1324	25.011	7.93e-7
☐	☑	X2	-0.1082137	1	244.5578	10.920	0.00102
☐	☑	X3	0.0485337	1	290.984	12.993	0.00034
☐	☐	X4	0	1	2.267489	0.101	0.75069
☐	☑	X5	2.78209823	1	237.3703	10.599	0.00121
☐	☑	X6	3.76406286	1	1919.885	85.728	6.3e-19
☐	☐	X7	0	1	0.56066	0.025	0.87447
☐	☑	X8	-1.4286367	1	1423.862	63.579	1.1e-14
☐	☑	X9	0.29605429	1	489.6803	21.866	3.78e-6
☐	☑	X10	-0.011871	1	279.1876	12.467	0.00045
☐	☑	X11	-0.96752	1	1239.1	55.329	4.5e-13
☐	☑	X12	0.00917443	1	263.7769	11.778	0.00065
☐	☑	X13	-0.5243141	1	2753.85	122.967	1.1e-25

Step History

Step	Parameter	Action	"Sig Prob"	Seq SS	RSquare	Cp	p	AICc	BIC
1	All	Entered	.	.	0.7411	15	15	3029.78	3096.29
2	X7	Removed	0.7951	1.521217	0.7411	13.068	14	3027.72	3090.14
3	X1	Removed	0.8219	1.140119	0.7411	11.118	13	3025.65	3083.96
4	X4	Removed	0.7507	2.267489	0.7410	9.2188	12	3023.63	3077.84

Figure 2: Backward Regression Results

Part 2 – Model Selection Procedures

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All Possible Models:

A way to answer the question "which models are the best models" is to fit *all possible* models, and then rank those models according one of the model assessment criteria. One then chooses the model(s) that rank the best among all possible models. In the Boston Housing example, there are 14 possible model terms that could be included in the model, and the set of all possible models has $2^{14} - 1 = 16383$ separate models to consider. Ranking these models according to *AICc* and choosing the model with the lowest *AICc* gives the model shown in the JMP® output below.

SSE	DFE	RMSE	RSquare	RSquare Adj	Cp	p	AICc	BIC
11063.143	494	4.7323384	0.7410	0.7352	9.2188467	12	3023.634	3077.839

Current Estimates

Lock	Entered	Parameter	Estimate	nDF	SS	"F Ratio"	"Prob>F"
☑	☑	Intercept	31.4773323	1	0	0.000	1
☐	☐	X1	0	1	1.392682	0.062	0.80336
☐	☑	X1*X1	-13.374611	1	560.1324	25.011	7.93e-7
☐	☑	X2	-0.1082137	1	244.5578	10.920	0.00102
☐	☑	X3	0.0485337	1	290.984	12.993	0.00034
☐	☐	X4	0	1	2.267489	0.101	0.75069
☐	☑	X5	2.78209823	1	237.3703	10.599	0.00121
☐	☑	X6	3.76406286	1	1919.885	85.728	6.3e-19
☐	☐	X7	0	1	0.56066	0.025	0.87447
☐	☑	X8	-1.4286367	1	1423.862	63.579	1.1e-14
☐	☑	X9	0.29605429	1	489.6803	21.866	3.78e-6
☐	☑	X10	-0.011871	1	279.1876	12.467	0.00045
☐	☑	X11	-0.96752	1	1239.1	55.329	4.5e-13
☐	☑	X12	0.00917443	1	263.7769	11.778	0.00065
☐	☑	X13	-0.5243141	1	2753.85	122.967	1.1e-25

Step History

Step	Parameter	Action	"Sig Prob"	Seq SS	RSquare	Cp	p	AICc	BIC

All Possible Models

Ordered up to best 56 models up to 14 terms per model.

Model	Number	RSquare	RMSE	AICc	BIC
X1*X1,X2,X3,X5,X6,X8,X9,X10,X11,X12,X13	11	0.7410	4.7323	3023.63	3077.84
X1,X2,X3,X5,X6,X8,X9,X10,X11,X12,X13	11	0.7406	4.7362	3024.47	3078.67
X1*X1,X2,X3,X4,X5,X6,X8,X9,X10,X11,X12,X13	12	0.7411	4.7367	3025.65	3083.96

Figure 3: All Possible Models

One limitation of this approach is when the number of model terms is large and it is computationally unfeasible to compute all models. For example, if we had 30 possible model terms, the total number of models to estimate would be over 1 billion ($2^{30} - 1 = 1{,}073{,}741{,}823$). One way to deal with this limitation is to only consider models that have up to a certain number of terms. For instance, with 30 possible model terms, if we consider all possible models with up to 6 model terms included, then the total number of models is

$$\binom{30}{1} + \binom{30}{2} + \ldots + \binom{30}{6} = 768211$$

which may be more computationally feasible.

Part 2 – Model Selection Procedures

Continued from page 10

Model Averaging:

As we just saw, term-by-term selection algorithms can give different answers, depending on the algorithm, the candidate model terms, and the data. Another approach is to consider multiple reasonable models and average them together to come up with a good final model. This approach is called model averaging. The general approach in model averaging is to calculate many models (perhaps all possible models or all possible models with restrictions on the total number of terms in the model), calculate a model fit measure, and then weight each model according to this measure. The average model that is generated is the weighted average

$$M = \sum_i w_i M_i$$

where M_i is the i^{th} model under consideration and w_i is the weight assigned to that model. A common weighting scheme uses each model's AICc to weight the importance of the model.

Consider the Boston Housing example again, using the same candidate model terms as before. We fit all possible models and determine their *AICc* and smooth *AICc* weights and calculate the weighted model average. JMP® can compute the averaged model in its stepwise regression platform, and the coefficients of the terms in the averaged model are shown output below.

Model Averaging

Averaging models with 1 to 14 terms, using a cutoff AICc weight quantile of 1, which resulted in using 16383 out of 16383 models fit

Parameter	Estimate	Std Error
Intercept	32.7472	.
X1	-4.5517	11.22473
X1*X1	-9.8977	8.53538
X2	-0.1070	0.03257
X3	0.0475	0.01360
X4	0.0051	0.03179
X5	2.7232	0.85031
X6	3.7824	0.40967
X7	-0.000378	0.00676
X8	-1.4401	0.19059
X9	0.2964	0.06397
X10	-0.0119	0.00346
X11	-0.9645	0.13044
X12	0.0092	0.00267
X13	-0.5243	0.04823

Figure 4: Model Averaging Results

Part 2 – Model Selection Procedures

Continued from page 11

Note that this final model includes all of the candidate terms; however, each candidate term has a different amount of importance in the prediction. One way to see this importance is to use a marginal effects plot for each variable (available in JMP®'s Prediction Profiler). From this view, we can see that X6, X8, and X13 have the strongest effect size over their range when compared to the other factors.

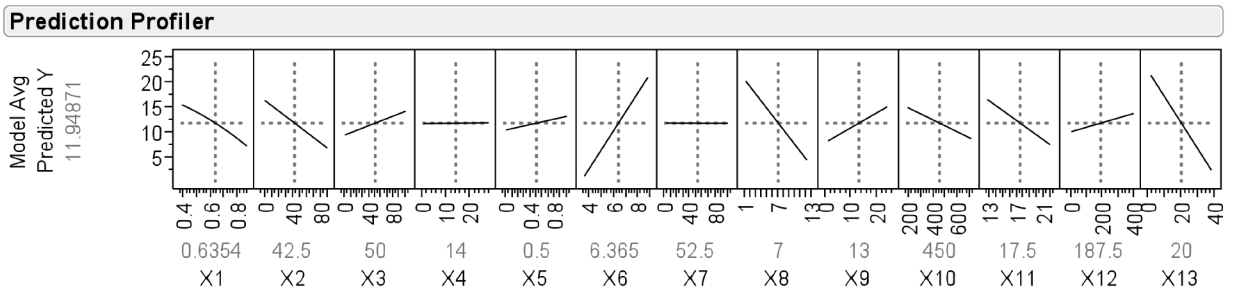

Figure 5: Averaged Model Profile

Cautions

Consider this quote from Claeskens and Hjort[3] (Section 7.4)

"The applied statistics community has picked up on model selection methods partly via the convenience of modern software packages. There are certain negative implications of this, however. 'Standard practice' has apparently become to use a model selection technique to find a model, after which this part of the analysis is conveniently forgotten, and inference is carried out as if the selected model had been given a priori."

The main caution and concern that these authors share is that, too often, statistical practitioners are overly optimistic about the results of model selection methods and the quality of the models that they produce. While these methods can be very useful, you should always describe the process of model selection in your final work. Additionally, you should carefully evaluate the quality of the model that is chosen from a model selection procedure. Using cross-validation approach or an independent test data set to evaluate the final model can provide a fair assessment of the model quality.

Part 2 – Model Selection Procedures

Continued from page 12

Conclusion

A key to proper use of model selection procedures is an understanding of the underlying methods and algorithms. This two part series has given an overview of model selection methods and criteria that are commonly used and available to most statistical practitioners. In situations where many possible models need to be considered and where the underlying relationship between model factors and model outputs need to uncovered, these methods can be of great value.

References

[1]Neter, J., Kutner, M., Nachtscheim, C., Wasserman, W., Applied Linear Statistical Models, (4^{th} ed), Irwin/McGraw-Hill, Chicago, IL, USA, (1996).

[2]Harrison, D. and Rubinfeld, D., "Hedonic housing prices and the demand for clean air," Journal of Environmental Economics and Management, Elsevier, vol. 5(1), pages 81-102, March (1978).

[3]Claeskens, G. and Hjort, N.L., Model Selection and Model Averaging, Cambridge University Press, Cambridge, UK (2008)

Institute for Continual Quality Improvement
May 16-18, 2011
Pittsburg, PA

by Gordon Clark, Activity Chair for the Institute for Quality Improvement

You are invited to attend the second Institute for Continual Quallity Improvement (ICQI) held jointly with this year's World Conference on Quality Improvement (WCQI). The Statistics and Quality Management Divisions have organized the ICQI and are offering networking and educational opportunities using their extensive resources. The ICQI will have 16 concurrent sessions and 12 workshops. Visit the ICQI web site at http://asq.org/conferences/institute-for-continual-quality-improvement/index.html for session and workshop descriptions and to register. Your registration allows you to attend ICQI and WCQI sessions.

The theme for the conference is "The New Role of Quality: Tomorrow's Applications of Proven Quality Tools". The ICQI focus areas include:

- ❏ Quality basics
- ❏ Management principles
- ❏ Strategies and processes for improving quality
- ❏ Data-driven decision making
- ❏ Statistical thinking and methods
- ❏ Statistical engineering
- ❏ Risk management
- ❏ Organizational excellence

Ron Snee

Ron Snee is the keynote speaker on May 16. Ron is the president of Snee Associates. The title of his address is "Continual Improvement - Creating Competitive Advantage." Dr. Nicole Lurie is the keynote speaker on May 17. She is the Assistant Secretary for Preparedness and Response at the US Department of Health and Human Services.

Dr. Nicole Lurie

Virtual Resource Center Update

by Gordon Clark

This article describes progress in developing the Virtual Resource Center since the report in the Fall 2010 newsletter, Vol. 29, No. 1. The mission of the Virtual Resource Center (VRC) is to provide comprehensive resources supporting the mission of the division that are easily accessible and searchable online by division members. Formulating the Content Area List was a key step in developing the VRC. This list permits us to assess the comprehensiveness of our resources. Currently, the list has eleven major topics and each major topic has subtopics. By mapping each item (article) in our set of resources to the Content Area List we can facilitate searches for articles in specific areas and identify gaps in our set of resources.

Starting last fall, we have mapped 95 articles, dating back to 1988, appearing in newsletters to the content area list. These articles included 55 mini-papers, 22 Youden addresses, and 18 Basic Tools articles. At the Fall Technical Conference, we had a mapping activity with ten individuals participating. The following persons have mapped articles: Christine Anderson-Cook, William Brenneman, Daksha Chokshi, Gordon Clark, Sam Gardner, Mindy Hotchkiss, Michael Joner, Harry Koval, Busaba Laungrungrong, Herb McGrath, Amit Mitra, Harsha Perera, Bill Rodebaugh, and Carlie Shannon. Given an article, we assigned a value of 2 to the subtopic(s) in the Content Area List having a primary relation or main focus for the article. Each subtopic having some relation, but not the main focus, was given a value of 1.

The following table gives the total mapping scores for the eleven major topics. Based on the 95 articles we have mapped, the major topic Survey Sampling and Market Feedback Analysis is a gap. However, we have more articles and publications to map. That major topic has the following subtopics: A. Objectives, Basic Concepts, and Terminology; B. Survey Design Principles (Questionnaire Design and Statistical Design); C. Survey Implementation; and D. Analysis of Survey Data.

Major Topics	**Total Score**
The Role of Statistics in Industry	81
Statistical Thinking and Data-Driven Decision-Making	109
Data Management and Knowledge Management	13
Fundamental Statistical Concepts	71
Measurement Characterization	28
Process Monitoring and Quality Control	83
Experimental Design	89
Data Analysis and Predictive Modeling	49
Reliability	21
Survey Sampling and Market Feedback Analysis	0
Other Advanced Topics	5

The major topic in the 95 articles that has the greatest emphasis is Statistical Thinking and Data-Driven Decision-Making. The total mapping scores for its subtopics are listed in the following table. Articles feature each subtopic of this major topic.

Statistical Thinking and Data-Driven Decision Making Subtopics	**Total Score**
Definition and Philosophy	24
Applications in System Definition and Improvement	13
Process Improvement Strategies	34
System Definition Tools	2
Data Analysis Tools	21
Knowledge-Based Tools	4
Quality Management	11

We are in the process of posting the complete set of 95 articles to our division web site Library. You can view these articles and download them by visiting http://asq.org/statistics/quality-information/library/.

Statistics Division Awards Showcase (April 2011)

Christine Anderson-Cook, currently Chair of the Statistics Division, was named a 2011 recipient of the 26th Annual Governor's Awards for outstanding New Mexico women. Started in 1986, this prestigious award recognizes women for their community leadership, effectiveness of advocacy for positive change for women and families and leadership in their careers.

G. Geoffrey Vining, professor of statistics in the College of Science at Virginia Tech, has been awarded the Shewhart Medal from the American Society for Quality. The medal is the highest award for technical leadership in the field of quality control. It is presented annually to an individual who has made the most outstanding contributions to the science and techniques of quality control or who has demonstrated leadership in the field of modern quality control. Dr. Vining is a member of the Statistics Division and a past Chair of the Division.

New ASQ Fellows

ASQ recently granted Fellow status to fifteen members. These individuals were elected Fellows by ASQ's board of directors in November 2010. Fellows are recognized as having achieved professional distinction and pre-eminence in the technology, theory, education, application or management of quality control. Statistics Division members and their citations are listed below.

Gordon Clark, Clark Solutions Inc., Worthington, Ohio — For outstanding leadership in promoting statistical thinking and contributions to his ASQ division's statistical thinking blog; for his improvement to ASQ's Statistics Division website and other division websites through the Division Affairs Council; and for his initiation of a forum for continual quality improvement.

Lou Ann Lathrop, Computer Engineering Services at Chrysler Group LLC, Auburn Hills, Mich. — For significant and tireless contributions to the advancement and promotion of the quality profession; for support, leadership, and encouragement of divisional and ASQ activities and initiatives; and for dedication, visioning, and expansion of traditional quality principles to improve the healthcare industry.

Johannes Ledolter, University of Iowa, Iowa City, Iowa — For developing new, important statistical methods for quality and process improvement; for innovative applications of statistical methods to solve important quality problems; for effective training of students at universities and in the industry; and for dedicated leadership to the quality profession.

Jeanenne "Jd" Marhevko, SPX Test & Measurement, Canton, Mich. — For significant contributions to the quality assurance profession spanning 25 years through quality management, consulting, and developing and teaching quality methods, leading to significant financial reductions to industry, and for extensive publications and presentations on the principles of effective strategic planning.

IN CASE YOU MISSED IT

☞ Advice on Presenting Statistical Information

The American Statistical Association and the Royal Statistical Society are sending out a quarterly magazine Significance to their members. The last issue had a helpful and amusing article about how to make presentations on statistically-oriented topics. Follow the directions below to see the article, "Dr Fisher's casebook: Why do young people mumble?"

http://www.wiley.com/bw/journal.asp?ref=1740-9705&site=1 > view sample issue > current issue

While you're there, look for some more advice in the recurring Toolkit section, "Making Information Beautiful – and Clear" by Julian Champkin. This article illustrates some ideas on graphical displays advanced by David McCandles, who is becoming rather well-known in this area.

☞ Inaugural Statistical Practice Conference

A new conference with an intriguing premise is being launched next year by the American Statistical Association. The program is a long ways from being announced, but appears to have a Statistical Engineering bent that is largely missing from the Spring Research Conference and the Joint Statistical Meetings, the two big ASA confabs that (until now, maybe) would be targeted to Statistics Division members.

ASA Announces Inaugural Statistical Practice Conference

The ASA will host the inaugural 2012 American Statistical Association Conference on Statistical Practice in Orlando, Florida, February 16-18, 2012. Statistical Practice 2012 aims to bring together hundreds of statistical practitioners, including data analysts, researchers and scientists, who engage in the application of statistics to solve real-world problems on a daily basis. The conference will provide an opportunity to learn about the latest statistical methodologies and best practices in statistical design, analysis, programming and consulting.
https://www.amstat.org/meetings/csp/2012/index.cfm

☞ ASQ Statistics Division Speakers are Available for Your Next Meeting

If you are interested in having a speaker from the ASQ Statistics Division attend your meeting, we are at your service.

Topics include: Statistical Thinking, Reliability, Lean Six Sigma, Voice of Customer, Design of Experiments, Graphic Data Analysis, Statistical Process Control & Change Management. For more information and a printable PDF list of speakers, please visit http://www.asqstatdiv.org/speakerlist.php

SPEAKERS

James Alloway, EMSQ Associates (New York)
Mark Anderson, Stat Ease, Inc. (Minnesota)
Christine Anderson✍Cook, Los Alamos Laboratory (New Mexico)
William Brenneman, Procter & Gamble (Ohio)
Daksha Chokshi, United Technologies Corporation (Florida)
Gordon Clark, Clark Solutions, Inc. (Ohio)
Wayne Fischer, MD Anderson Cancer Center (Texas)
Robert Gerst, Converge Consulting Group (Calgary)
Robert Klein, Applied Marketing Science, Inc. (Massachusetts)
William Latzko, Latzko Associates (New Jersey)
Dennis Lin, Penn State University (Pennsylvania)
Robert Mitchell, 3M Corporation (Minnesota)
Wayne Nelson, Member (New York)
Greg Piepel, Battelle Northwest (Washington)
Jack ReVelle, Member (California)
Dean Stamatis, Contemporary Consultants (Michigan)
Rip Stauffer, Woodside Quality Solutions (Minnesota)
Wayne Taylor, Taylor Enterprises (Illinois)
William Trappin, California State University (California)
Donald Wheeler, SDC Press, Inc. (Tennessee)
Pat Whitcomb, Stat Ease, Inc. (Minnesota)

TREASURER'S REPORT

2010-2011 Budget

Statistics Division

July 2010 - March 2011

Revenue	Approved 2009-2010 Budget	Actual YTD	Approved 2010-2011 Budget
Dues	$ 50,000	$ 26,703	$ 46,000
Retail Sales		$ 400	$ 500
Workshops/Courses	$ 500	$ -	$ 500
Interest	$ 1,100	$ 86	$ 500
Royalties	$ -	$ 237	$ 500
Miscellaneous	$ -	$ -	$ -
Total	**$ 51,600**	**$ 27,427**	**$ 48,000**

Assets - 2009/2010/2011				
Chase Checking Acct				
	Balance Date	**July '09**	**May '10**	**Mar '11**
		$ 66,783	$ 17,123	$ 11,045

Money Market Acct				**0.25%**
	Balance Date	**July '09**	**May '10**	**Mar '11**
		$ 121,217	$ 51,616	$ 51,702

ASQ Reserve Fund Investment				
	Balance Date	**July '09**	**May '10**	**Mar '11**
		$ 66,064	$ 179,934	$ 204,414

ASQ Statistics Division - Total Assets				
	Balance Date	**July '09**	**May '10**	**Mar '11**
		$ 254,064	$ 248,673	$ 267,161

Ott Scholarship				
	Assets	**July '09**	**May '10**	**Mar '11**
	Scholarship Fund	$ 208,859	$ 230,796	$ 251,326

Ott Scholarship				
	Expenses	**Approved 2009-2010 Budget**	**Actual YTD**	**Approved 2010-2011 Budget**
	Scholarship (2)	$ 10,000	$ -	$ 10,000

Expenses		Approved 2009-2010 Budget	Actual YTD	Approved 2010-2011 Budget
WCQI Events & Meetings		*$ 12,500*	*$ 2,516*	*$12,000*
	Meetings/Hospitality	*$ 3,500*	*$ 221*	*$3,000*
	Travel	*$ 7,000*	*$ 610*	*$7,000*
	Exhibitor Fees	*$ 2,000*	*$ 1,686*	*$1,000*
	Promotional Items (C-in-C)	*$ -*	*$ -*	*$1,000*
	Miscellaneous	*$ -*	*$ -*	*$0*
FTC Events & Meetings		*$ 17,100*	*$ 8,796*	*$11,500*
	Meetings/Hospitality	*$ 5,000*	*$ 344*	*$2,500*
	Travel	*$ 7,000*	*$ 3,762*	*$3,500*
	Student Grants	*$ 2,000*	*$ 2,195*	*$2,000*
	Early Career Grants	*$ -*	*$ 285*	*$1,000*
	Hunter, Nelson, and Youdon Awards	*$ 500*	*$ 596*	*$500*
	Hunter & Nelson Recipient Travel	*$ 1,000*	*$ 810*	*$500*
	Youden Speaker Travel	*$ 500*	*$ 805*	*$1,500*
	Promotional Items	*$ 1,100*	*$ -*	*$0*
Planning & Events		*$ -*	*$ 7,934*	*$12,000*
	OPS Planning Meeting	*$ -*	*$ 1,087*	*$3,000*
	OPS Planning Travel	*$ -*	*$ 6,847*	*$9,000*
Other Conferences		*$ 5,700*	*$ 4,704*	*$5,700*
	Outreach (Sponsorships)	*$ 2,200*	*$ 600*	*$2,200*
	Standards	*$ 3,500*	*$ 2,777*	*$3,500*
	Travel (including DAC mtng)	*$ -*	*$ 1,327*	*$0*
Publications (Body of Knowledge)		*$ 12,300*	*$ 3,192*	*$5,000*
	Newsletter Printing	*$ 2,000*	*$ 760*	*$2,000*
	Newsletter Postage	*$ 500*	*$ -*	*$500*
	Special Publication Printing	*$ 6,000*	*$ -*	*$0*
	Special Publication Postage	*$ 2,000*	*$ -*	*$0*
	Special Publication Reprints	*$ 1,000*	*$ -*	*$0*
	Special Publication Honorarium	*$ 500*	*$ -*	*$0*
	Narrated Slideshows	*$ 300*	*$ 152*	*$300*
	Body of Knowledge Activity	*$ -*	*$ 2,280*	*$2,200*
Administration		*$ 7,500*	*$ 2,571*	*$5,000*
	New Member Mailings	*$ 500*	*$ -*	*$0*
	Technology Related (Web, Apps)	*$ 4,500*	*$ 1,402*	*$1,500*
	Teleconferences	*$ 500*	*$ 145*	*$800*
	ASQ Testimonials ($60 each)	*$ 300*	*$ -*	*$300*
	Service Awards (WCQI, FTC Reps)	*$ 700*	*$ 58*	*$700*
	Outgoing Chair's Gift	*$ 500*	*$ 965*	*$500*
	Miscellaneous	*$ 500*	*$ -*	*$1,200*
Total		**$ 55,100**	**$ 29,712**	**$51,200**

STATISTICS DIVISION COMMITTEE ROSTER

Members of STAT Council

2010-2011

Committee	Name	Division Position	E-mail address	Telephone
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Chair	Christine Anderson-Cook	Division Chair	c-and-cook@lanl.gov	505-606-0347
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Non-Voting Member	Vijay Nair	Testimonial Awards	vnn@umich.edu	734-763-8018
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Non-Voting Member	Shari Kraber	FTC Short Course Chair 2010	shari@statease.com	612-746-2035
Non-Voting Member	Gordon Clark	Institute for Quality Improvement	gclark007@columbus.rr.com	614-888-1746

The *ASQ Statistics Division Newsletter* is published three times a year by the Statistics Division of the American Society for Quality.

All communications regarding this publication, **EXCLUDING CHANGE OF ADDRESS,** should be addressed to:

Paul Prew
Ecolab Research Center
Mail Stop ESC-F4412-A
655 Lone Oak Drive
Eagan, MN 55121-1560
email: paul.prew@ecolab.com

Other communications relating to the Statistics Division of ASQ should be addressed to:

Christine Anderson-Cook,
Division Chair
Statistical Science Group
Los Alamos National Laboratory
PO Box 1663, MS F600
Los Alamos, NM 87545
Email: c-and-cook@lanl.gov

Communications regarding **change of address** should be sent to ASQ at:

American Society for Quality
P.O. Box 3005
Milwaukee, WI 53201-3005

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UPCOMING NEWSLETTER DEADLINES FOR SUBMISSIONS

Issue	Vol.	No.	Due Date
Fall	30	1	August 31, 2011

VISIT THE STATISTICS DIVISION WEBSITE:
www.asqstatdiv.org

ASQ Periodicals with Applied Statistics content

Journal of Quality Technology
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Quality Engineering
http://asq.org/pub/qe/index.html

Six Sigma Forum
http://asq.org/pub/sixsigma/

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Statistical Thinking Blog
http://community.asq.org/statistics

External Website
http://www.asqstatdiv.org/

Internal Website
http://asq.org/statistics/index.html