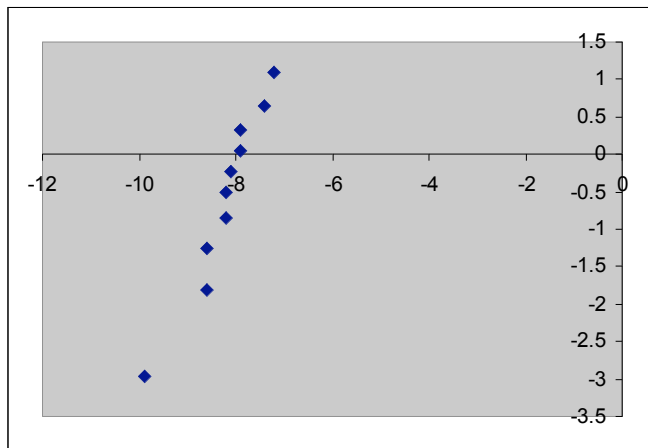## Problem Set #5

Given that most of the questions of the PSets include analytic work that cannot be properly measured by numbers, there will not be a distribution of grades per questions. Instead, each copy will be analyzed as a whole, with a maximum of comments for feedback purposes, and a global letter grade provided.

1. **Parameter estimation**
   a) *Recreate the plot*

   b) *Form a least square fit and compute estimates*

Linear approximation: $y = 1.5821x + 12.423$ ($R^2 = 0.9418$)

Estimation of Weibull parameters: given that $F(a) = 1 - S(a) = 1 - e^{-\left(\frac{a}{\eta}\right)^\alpha}$,

   $\eta = 1.58$
   $\alpha = 3.88 \times 10^{-4}$
   $\mu = 3.49 \times 10^{-4}$ m $= 0.349$ mm
   $\sigma^2 = 5.09 \times 10^{-8}$ m$^2 = 0.0509$ mm^2
   $\sigma = 2.26 \times 10^{-4}$ m $= 0.226$ m

   c) *Argue about the regression coefficient*

$R^2 = 0.94$

What does R^2 tells us? That's the question we should be asking. Its value can be interpreted as the likelihood that the sample we are looking at has been sampled from the Weibull distribution. Since R^2 is high, for practical purposes, we can use the Weibull distribution to perform statistical analysis on this data. That does not mean that the Weibull distribution *appropriately* represents the data. Other distributions might have a better fit with the data. This was not tested in the

paper. The Weibull distribution is not derived from any physical phenomenon, so it does not provide an *explanation* of the data observed.

d) Estimate the parameters with the MLE

$\eta = 1.78$
$\alpha = 3.79 \times 10^{-4}$
$\mu = 3.56 \times 10^{-4}$ m $= 0.356$ mm
$\sigma^2 = 4.25 \times 10^{-8}$ m$^2 = 0.0425$ mm^2
$\sigma = 2.06 \times 10^{-4}$ m $= 0.206$ m

$R^2 = 0.926$

e) Estimate the parameters with another method

Suggestions proposed:
- Exponential fitting
- Method of moments
- Minimizing the Mean Absolute Percentage Error (MAPE)

f) Comment

Issues to consider:
- Goodness of fit (but watch out for common traps: for instance, R^2 is typically larger for log-linear models; it does not mean that a log-linear model is always better)
- Explanatory power of the method chosen
- Unbiasedness
- Consistency
- Validity of Gauss-Markov assumptions in the experiment settings

	SSE	R^2	Adjusted R^2	RMSE
LSM	0.780	0.942	0.935	0.312
MLE	1.13	0.916	0.905	0.376

g) Suggest improvements

These are some improvement suggestions:
- Keep notation consistent with accepted standards
- Give summary of the actual data to allow re-creating the method used in the paper
- Use larger sample size
- Justify the use of the Weibull distribution
- Examine the underlying assumptions of the regression used
- Compare with other models

2. Hypothesis testing
a) Find an example, summarize it

The papers chosen are the following:
- Anderson R.D. & Jerman R.E. 'Quality management influences on logistic performance'. *Logistic and Transportation Review*. Vol.34, No.2, pp.137-148. 1998.
- Bates K.A., Amundson S.D., Schroeder R.G. & Morris W.T. 'The crucial interrelationship between manufacturing strategy and organizational culture'. *Management Science.* Vol.41, No.10, pp.1565-1580. October 1995.
- de Jong G. & Nooteboom B. 'The causality of supply relationships'. *ERIM Report Series*. http://ssrn.com/abstract=370932. March 2003.
- Gobeli D.H., Koenig H.F. & Bechinger I. 'Managing conflict in software development: A multilevel analysis'. *Journal of Product Innovation Management*. No.15, pp.423-435. 1998.
- Grant P.R., Yam B., Hosman R. & Schroeder J.A. 'Effect of simulator motion on pilot behavior and perception'. *Journal of Aircraft*. Vol.43, No.6, pp.1914-1924.
- Koh H. & Magee C.L. 'A functional approach for studying technological progress: Application to information technology'. *Technology Forecasting and Social Change*. Vol.73, pp.1061-1083. 2006.
- Moore S., Eng E. & Daniel M. 'International NGOs and the role of network centrality in humanitarian aid operations: A case study of cooperation during the 2000 Mozambique floods'. *Disasters*. Vol.27, No.4, pp.305-318. 2003.
- Muthanna K. 'Transformer insulation life assessment'. *IEEE Transactions on Power Delivery*. Vol.21, No.1, pp.150-156. January 2006.
- Novak S. 'Source by desig'. PhD thesis, *Sloan School of Management, MIT*. June 1999.
- Sadovich J.M. 'Work excitement in nursing: An examination of the relationship between work excitement and burnout'. *Nursing Economics*. Vol.23, No.2, pp.91-96. March-April 2005.
- Sagie A. 'Effects of leaders communication style and participative goal setting on performance and attitudes'. *Human Performances*. Vol.9, Issue 1, pp.51-65. 1996.
- Sosa M.E., Eppinger S.D. & Rowles C.M. 'Designing modular and integrative systems'. Proceedings of *DETC'00: ASME 2000 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*. Baltimore: September 2000.
- Valverde S., Solé R.V., Bedau M.A. & Packard N. 'Topology and evolution of technology innovation networks'. Submitted to *Physics Review Letters*. 2006.

Here is the summary of one paper (Gobeli *et al.*, 1998), by Sidharth Rupani (Courtesy of Sidharth Rupani. Used with permission.):

The paragraph below summarizing the subject and conclusions of the paper is excerpted from the abstract.

"In this paper, the authors note that conflict in a New Product Development team must be managed not only to increase the satisfaction of project team members, but also to achieve strategic project success. To provide better understanding of the important issues in conflict management, they examine the effects of three conflict factors on software

development project success: *context, conflict intensity, and conflict management style.* Using survey responses from 117 software professionals and managers, they develop a multi-level framework of success versus conflict for team-based, software development projects. Within this framework, they examine context, conflict intensity, and conflict management approaches at the team and organization levels. They conclude that for the participants in this study,

- Unresolved conflict has a strong, negative effect on overall software product success and customer satisfaction.
- Project team member satisfaction decreases substantially with higher intensity conflict at the organization level, and even more strongly at the project level.
- The combined effects of conflict intensity and conflict management style on project success are significant, but they are not as great as the combined effects of such context variables as company goals, group dynamics, and management support.
- Two conflict management styles—confronting and give and take—have beneficial effects on success at the organization level.
- Smoothing, withdrawal, and forcing all have negative effects, although only forcing has a statistically significant negative effect.

In general terms, the results suggest that management should guard against frequent use of the dysfunctional management styles—withdrawal, smoothing, and forcing. The results suggest that emphasis on confrontation—that is, true problem solving—is essential at the project level, even if a give-and-take style is better tolerated at the organization level."

The authors sent out two written surveys each (one for a project manager and one for a team member, both to be returned by mail) to 702 companies. This makes a total of 1404 surveys sent out. They received at least one response from 78 companies, and a total of 117 surveys. The actual response rate is therefore 117/1404 = 8.33%. They cite their response rate as 16%. They do this by eliminating 60 companies that responded saying that the survey did not apply to them or that they did not want to participate and other nonresponses due to changes in personnel and location etc. They thus state what they call their 'effective sample size' as 574 organizations. Then using the fact that 78 companies replied, they cite their response rate as 16%. I believe this is a misrepresentation of the situation. Since they are using an individual survey as a unit of analysis and not an organization, the117 surveys returned should be used to calculate the response rate, based on the total number of all surveys sent out (1404). Calculated in this manner, the response rate is much lower than 16%, but is not reported.

The first case in which the authors use statistical hypothesis testing is to alleviate a concern that the obtained sample is not representative of the sampling frame. This is a common concern with survey research. The authors use only one variable for such a comparison—the size of the firm.

Firm size is not the only discriminating factor among firms. Perhaps we need to be more worried about the process or project methodology used by the firm. For instance, it might be that in firms using an Agile methodology confrontation is a useful strategy, whereas in

firms using CMMI driven methodologies, compromise (and letting the process determine the product) might be useful. We do not know, but it is not clear that firm size is the only useful factor along which to obtain a distribution of firms.

Even considering firm size as the one factor - using the distribution of firm size in the sampling frame and the distribution in the obtained sample, one can see differences on visual inspection. However, the authors use a Chi-squared goodness-of-fit test to indicate that the differences between the distributions of the sampling frame and obtained sample are not significantly different from what would be expected by random variation. The calculated Chi-squared value is 10.46, as compared to the critical Chi-squared value of 15.51 (8 df, alpha of 0.05). They conclude that the null hypothesis of no difference between the distributions could not be rejected. This is a reasonable conclusion. However, in this case it would be useful to report the p-value for the chi-square value of 10.46. Presently, we do not know how close the obtained Chi-squared value of 10.46 is to the alpha of 0.05. It seems far away from the critical value of 15.51, but the p-value would help provide a much better sense for how likely or unlikely the data is.

The main conclusions of the research are drawn from Table 3 (shown below), in which correlations of the success measures with conflict intensity and conflict management styles at both the organization and project levels are shown.

Table 3 removed due to copyright restrictions.

The paper states, "Since overall success and customer satisfaction constructs were strongly correlated ($r = 0.693$), very similar correlations were observed. For this reason, we have simplified some of our discussion to include only the overall success measure." This strong correlation indicates that the two outcomes measures selected were not well

chosen in the research design. If the two outcome measures are very strongly correlated and are measuring essentially the same thing, and the authors choose to continue reporting only one variable, why select two outcomes in the first place?

The authors then state, "Conflict intensity constructs at both the organization and project levels correlate substantively (r = -0.451 and 0.403) and significantly (p < .001) with success. The patterns of the correlations also show significant relationships between success and the conflict management styles. In fact, the general patterns for both the organization level and project level range from strong and positive for confronting and give and take (suggesting success is more likely when these two conflict management styles are used), to no impact on success by smoothing or withdrawal, to a strong negative relationship between forcing and success." The authors do a good job of actually reporting in small font the real numbers for the significance probability of the correlation under the null hypothesis that the correlation is zero. However, these significance numbers don't carry much extra information in themselves. Intuitively, we understand that if a correlation coefficient is high, it is likely different from zero. therefore they do not carry much additional information.

>   b) *Suggest improvements, if possible carry out the analysis, explain*

Similarly, here are the improvement suggestions by the same student:

In general, it is good practice to report the p-values, but in this particular case, they do not carry much additional information. A situation in which I could see that the significance probabilities could possibly carry additional useful information is if the points used to calculate the correlations were spread out, or contained one outlier, or several families as in the examples shown in the ASA plots displayed in the class slides on Monday, April 9th.

Another issue is that the overall research design is almost one of fishing for correlations. By testing several different conflict resolution styles and searching for any that gave reasonable correlations with project success, we are almost assured of finding some good correlations.

There is also a big issue with how the variables were actually operationalized and the framing of the questions in the survey. If some styles were negatively framed in the questions, respondents would naturally tend to associate them negatively with project success as they realize that's what is expected of them. In effect, the survey is not really measuring the effect of conflict resolution style on project success, but what people's currently held beliefs are about how conflict resolution leads to project success. The final takeaways from this paper aren't truly surprising or valuable.

If I were to conduct this study, I would not rely on survey data for my measures of both my dependent and independent variables. I would gather actual outcome data from project management or sales. I would also establish my hypotheses about what conflict resolution factors affect the outcomes in what manner and test those individually instead

of searching for correlations in a large pool of methods. I would also choose my outcome measures more carefully, so that they do not convey essentially the same information. For any surveys that I did use, I would not report my response rate in an artificially inflated manner. I would report the p-value for the Chi-squared test to check if my obtained sample is a good representation of the sampling frame. I would choose my sample to be distributed not only along firm size, but also along project methodology used and other factors.