STATeaser

ABOUT STAT-EASE® SOFTWARE, TRAINING, & CONSULTING FOR DOE

Workshop Schedule

Experiment Design Made Easy (EDME)

October 22-23: Minneapolis, MN
December 10-11: Minneapolis, MN*
February 4-5, 2014: Minneapolis, MN
March 3-4, 2014: San Diego, CA*
$1295 ($1095 each, 3 or more)

Response Surface Methods for Process Optimization (RSM)

December 12-13: Minneapolis, MN*
March 5-6, 2014: San Diego, CA*
$1295 ($1095 each, 3 or more)

Mixture Design for Optimal Formulations (MIX)

November 5-6: Minneapolis, MN*
March 10-11, 2014: San Diego, CA
$1295 ($1095 each, 3 or more)

Advanced Formulations: Combining Mixture & Process Variables (MIX2)

November 7-8: Minneapolis, MN*
$1495 ($1195 each, 3 or more)

PreDOE: Basic Statistics for Experimenters Online Course

Free (a $95 value). Learn more at: http://www.statease.com/clas_pre.html.

5th European DOE User Meeting

July 9-11, 2014: Cambridge, UK
Save the date!

*Attend the EDME/RSM, EDME/MIX, or MIX/MIX2 workshops in the same week and save $395 on tuition!

Workshops limited to 16. Multiclass discounts are available. Contact Shari Kraber at 612.746.2035 or workshops@statease.com.

Stat-Ease statistics made easy®

Statistics Point the Way to Save Time Commuting

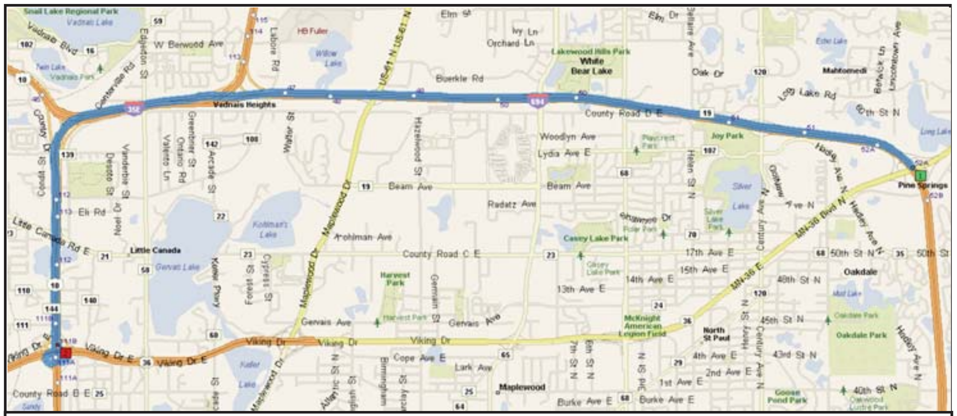

Figure 1: Bypass on I694 around stop-lighted stretch of Hwy 36

Every workday I join scores of suburbanites on a commute into Minneapolis from our lovely town of Stillwater nestled in the scenic Saint Croix Valley on the eastern border of Minnesota. However, a big decision looms ahead for all of us at a juncture a dozen miles down the road west—whether to go:

- ❖Directly into downtown on Minnesota Highway 36 (7.6 miles with 3 stoplights), or
- ❖Via a bypass on Interstate 694 (8.5 miles of freeway).

For no particular reason other than the inertia of staying on 36, I'd been passing on the 694 bypass. But I began to wonder what I might be missing for savings on commuting time. Therefore I set up a simple comparative experiment to generate conclusive statistical evidence on which route to take in to work.

From the Factorial tab of Design-Expert® software, I set up a simple comparison using the General Factorial design. I sized it on the basis of a 1.5 signal-to-noise ratio, which led to me choosing an experiment with 16 runs—8 each for the two categorical levels (the alternative routes).

In early spring (weeks 13-16 of 2013) I proceeded each workday to the point at the east where the routes split and triggered my smartphone stopwatch app while following the direction specified on the randomized run sheet. At the point of the bypass convergence on the west side I concluded my timing. The results are seen in Table 1 on page 2, along with the routes I took and the time for driving them.

Let's go over the results using Design-Expert. At first it appeared from the half-normal plot of effects that it made no significant difference which route I took—the square effect "A" fell

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Run	Comments	Route	Time (sec)
1	Traffic less due to it being Easter week	MN 36	409
2	Ditto.	MN 36	396
3	Ditto (Good Friday)	US 694	450
4	Start time estimated. Forgot to note at actual point.	US 694	449
5		US 694	468
6	Still have not hit any red lights on Hwy 36--keep on 'til I do.	MN 36	424
7		MN 36	406
8		US 694	455
9	Hit 1 red light that forced me to a stop! Rain.	MN 36	561
10		US 694	460
11	Wet roads from snow (!) overnight.	MN 36	457
12		US 694	467
13	Slowed by 3rd (last) light	MN 36	428
14		MN 36	425
15		US 694	467

Table 1: Results of route experiment

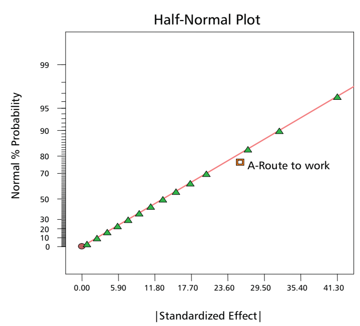

Figure 2: Half-Normal Plot of Effects (All Data)

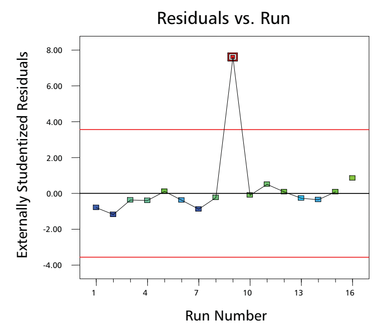

Figure 3: Outlier on Diagnostics Plot

in line with the green triangles of pure error generated by the replicated runs (see Fig. 2).

However, one outlier stood way out in the diagnostic plots—Run 9 (see Fig. 3).

The special cause was clear: My luck on highway 36 finally ran out and I got held up by a red light. Ironically, soon after this experiment, the Minnesota Department of Transportation (MnDOT) began reconstruction of this stretch of road to remove this stoplight. With this run ignored, the effect of route becomes significant (see Figs. 4 & 5).

Now it seems that Hwy 36 is the way to

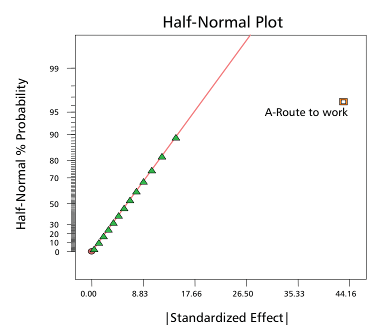

Figure 4: Half-Normal Plot of Effects (Outlier Ignored)

go. But hold on, the MnDOT project will not remove all the lights on Hwy 36, only the one, with the others to follow in future years until this becomes a freeway.

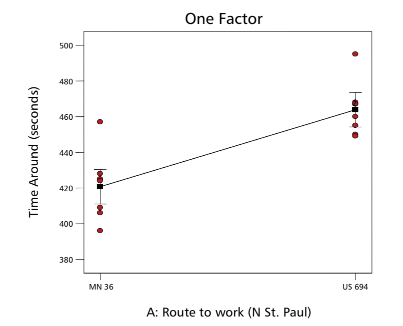

Figure 5: Effect Plot (Outlier Ignored)

For now the way is clear—I must take the I694 bypass because the other route is closed due to construction. After that, lacking energy early in the morning to veer off, I will probably revert to just staying on Highway 36 and chancing the remaining lights. If I build up ambition, I will embark on a much longer study to work out the probability of hitting all greens. I think I was just lucky during this experiment, but the sample size is too small to tell. I really should track this for the considerable number of runs that would be needed to estimate the proportion of times a traffic light stops me. To be continued…

—Mark Anderson, mark@statease.com

P.S. Also see the blog I wrote on this.

P.P.S. For the record, during my experiment I diligently noted the week of the year, the workday (1=Mon…5=Fri), the start time (at the split point), the weather conditions and the number of red lights encountered. Then I ran a more complex regression analysis with these variables treated as covariates. However, other than providing me some added fun working with statistics, nothing that was not already obvious came out of it.

Regressing the Rupee's Plunge (The Dangers of Happenstance Regression)

Over the past couple of years, Design-Expert software (DX) has really taken hold in India and I've been there a few times to attend conferences and teach classes. Before my last trip there in August, a headline caught my attention, "Rupee at all-time low vs. USD". That was good news for my wife Kristen and I, because our U.S. dollars (USD) bought more goods, services, and food…not to mention better lodging. I am glad she could finally join me on this life-changing journey to India.

Back to the headline... Being a part of the renowned BRIC countries (Brazil, Russia, India, and China) that were growing wildly over the last couple of decades, one might assume the rupee would be relatively strong. However, that is certainly not the case.

Why is the rupee weakening to historic levels (see Fig. 1)? There are a lot of variables that could be involved. That's the thing; economic indicators, like job growth, GNP growth, and the value of a currency, are usually tied together. That is, they are highly correlated. There are so many possible factors that are moving in unison, it is hard to tell what the true cause of the decline in the rupee is. That surely doesn't stop the financial reporters from assigning a cause to every up and down of a financial market, but there is little chance they are right. This type of data, when it is just gathered or monitored from a steady state process, is known as happenstance data. There is no planning prior to data collection or purposeful changes to the input factors. You just get what you get.

This is often the case for an industrial experimenter when he/she collects data from a process on the factory floor. In a production process, the goal is to keep producing parts that meet specifications. In order to do this, statistical process control charts may be used to see if the process is in control (and producing good parts). Process control mechanisms can compensate for the control of one input by changing another. Just as with the economic data, this collinearity between factors prohibits discovering which factor is the true cause of changes.

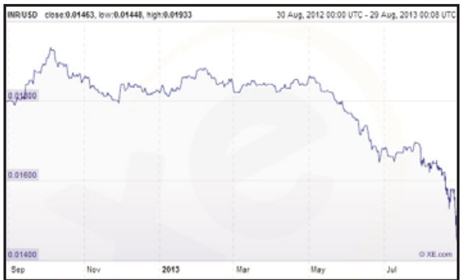

Figure 1: The Indian rupee's plunge (graph provided by www.XE.com)

Figure 2: Brooks, Kristen & the Taj Mahal

Let's contrast this with our specialty, design of experiments (DOE). With DOE, we carefully collect data in a prescribed manner, making sure that all of the right combinations of factors are tested and that effects can be estimated independently of other factor effects. That is what an "orthogonal" design means. Every factor effect can be calculated independently. That's easy when you have control of the factors, but what about economic data and policies? Can we control every factor that influences the rupee vs. USD exchange rate? Just as importantly, are these factors independent of one another (i.e. low collinearity)? The answer is a resounding NO!* You will likely find that there are any number of possible models that will fit a data set with highly correlated factors equally well. The problem is that we don't know which one is right.

To illustrate this, let's go back to the data on the Indian rupee. Looking at some economic indicators, we can try to determine what important indicator can predict the value of the rupee. Overall, I looked at 18 economic indicators, 9 each from the U.S. and Indian economies. I gathered data from over 19 years, 1994-2012.

I was able to fit a wide variety of models with all of the factors, while getting close to the same statistical fit as measured by the R^2adj, R^2pred and F values for the models. This could be achieved by just swapping some factors in and others out. This makes sense because many of the factors were correlated with greater than 0.7 correlation coefficients (you can evaluate this via the graph columns node in DX). This illustrates the first downfall in happenstance regression…high collinearity among factors.

So, I took another approach to simplify the analysis. I decided to focus on just a subset of the factors that I expected to be the most important and easy to understand. I narrowed it down to four factors: (1) India gross national income (GNI) per capita, purchasing power parity (PPP), (2) India year over year

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(yoy) GDP growth, (3) India yoy inflation %, and (4) India lending interest rate %. I first fit the full data set to a model, but then was reminded of an important check that should be done when fitting historic data: data splitting. This means to hold back some of the data when fitting a model. Then, check how well you can predict the remaining data. This validates the model's predictive capability. So, I first fit the model with only 50% of the data.

The first sign of trouble was that I got a different model from when I used the full data set. Then, I used the prediction node in DX to compare the verification runs with the 95% prediction interval (95% PI). This interval should contain future single observations with 95% confidence. All of the verification runs I held back fell outside of the interval, i.e. failed validation. I went back and fit the model with 80% of the data, but half of my verification runs still missed the mark. If you have enough data, this data splitting technique should be used as a sanity check to see whether the model can predict future data, or is only good at predicting what happened last time (when the data was collected).

Of course, I could go back and look at more historical data to improve the model, but I know that this is a fool's game. The following quote sums up trying to predict the future of the economy with historical data:

"Trying to predict the future is like trying to drive down a country road at night with no lights while looking out the back window."

—Peter Drucker, Austrian-born management consultant and educator.

To prevent accidents, I say turn on the lights and go for a statistically-designed experiment (DOE).

My wife and I enjoyed our trip to India. No matter what the cause of the rupee's fall, we appreciated the extra buying power as we finally trekked to one of the New Seven Wonders of the World…the Taj Mahal (see Fig. 2 on page 3).

—Brooks Henderson, brooks@statease.com

*In fact, this is precisely the reason J.W. Longley (1967) chose his set of economic data to test computer regression algorithms and show what misleading things can happen with such ill-conditioned data. For a more detailed discussion of this data set and its pitfalls, see *RSM Simplified* by Mark Anderson and Pat Whitcomb (chapter 2). You can also follow along and analyze (or at least try to analyze) this highly correlated data set in a tutorial we've set up in Design-Expert. That tutorial can be found at: http://statease.com/dex8files/manual/dx/DX8-04H-HistRSM-P1.pdf.

In the Spotlight: Stat-Ease IT Team

09/13

Stat-Ease is proud to introduce you to our IT team (listed in the order shown in Figure 1): Ben Nugent, Neal Vaughn, Joe Carriere, Tryg Helseth, and Hank Anderson. They are responsible for programming Design-Expert and Design-Ease® software, providing technical support to our customers, and handling IT issues at Stat-Ease.

We have an experienced staff. Tryg started working on Design-Ease software with founder Pat Whitcomb in the fall of 1984. Neal and Hank (Principal Mark Anderson's son) joined the Stat-Ease team in the late 1990's, while Joe and Ben are valued new additions within the last few years.

Besides being fun with a wonderful sense of humor, this group is also very capable. Expect great new things in future releases of the software!

Figure 1: Stat-Ease IT staff. Pictured from left to right are:
Ben Nugent, Neal Vaughn, Joe Carriere, Tryg Helseth, Hank Anderson