Accelerate Your Innovation with Smarter Experiments

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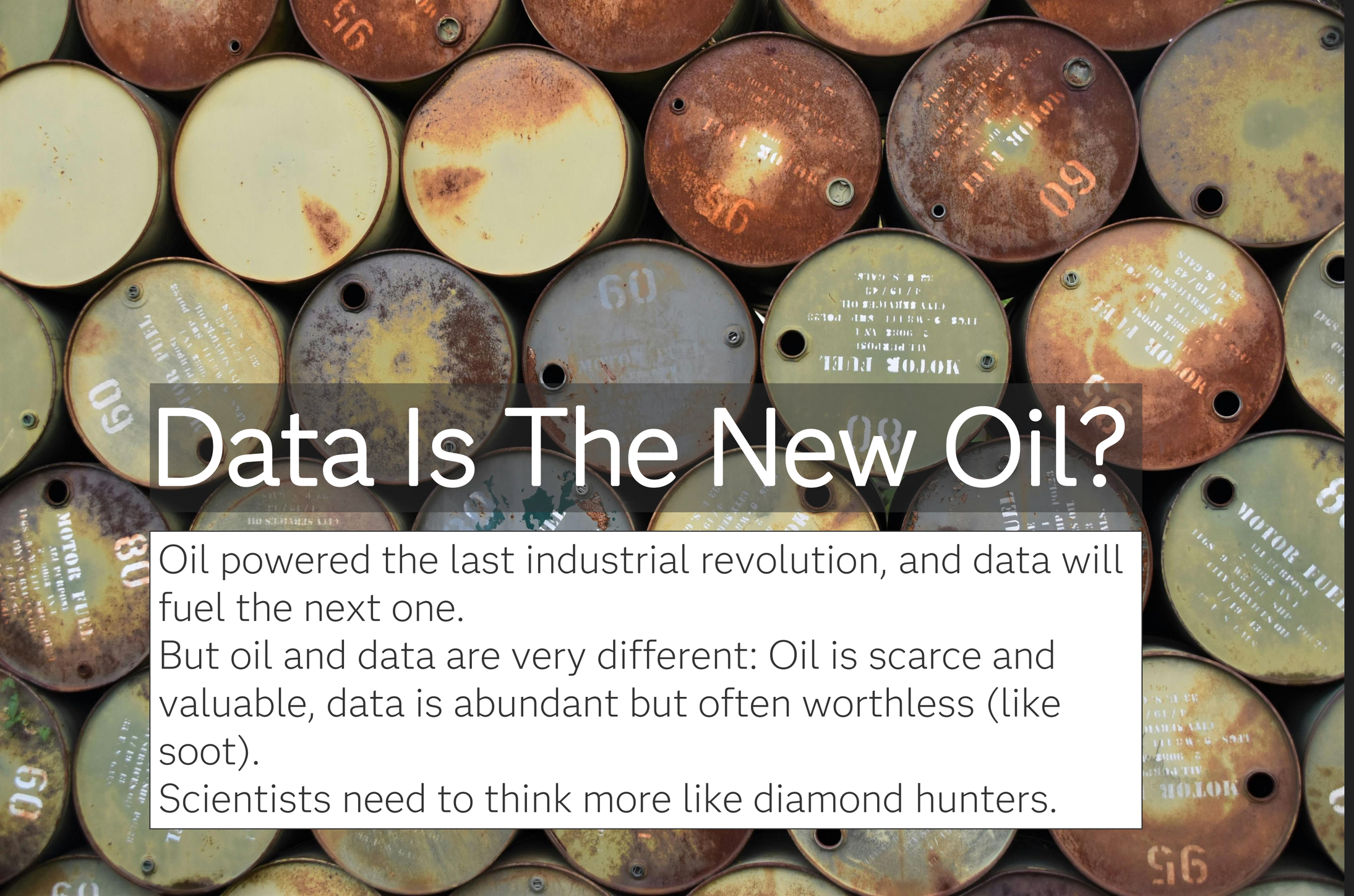
The Digital Future of Science and Engineering

Myth or Reality?



Data Is The New Oil?

Oil powered the last industrial revolution, and data will fuel the next one.
But oil and data are very different: Oil is scarce and valuable, data is abundant but often worthless (like soot).
Scientists need to think more like diamond hunters.

Photo by Waldemar: https://www.pexels.com/photo/rusty-oil-barrels-stacked-3151717/

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In the lab of the future, practical tasks will be automated and researchers will instead spend their time coding those machines and their data workflows. Really?
We don’t say that if you want to use laboratory glassware you need to be a glassblower.
So why should you need to code to use the digital tools of science and engineering?

Scientists And Engineers All Need To Learn Python?

Photo by Markus Spiske: https://www.pexels.com/photo/green-and-yellow-printed-textile-330771/

Closed-Loop, Self-Driving Labs Are The Future?

In the lab of the future experiments are run and analysed by automated hardware, and algorithms use the data to decide the next recipe to try, with no human intervention. Would that be good? This will be biased towards experiments that are easily automated. You need humans' less codifiable knowledge, theory, experience, intuition. And their intervention to safely explore new ranges of factors likes higher temperatures, concentrations or pressures.

Photo by Tara Winstead: https://www.pexels.com/photo/robot-pointing-on-a-wall-8386440/

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Big Data And AI Is The Answer To Everything?

COVID was the biggest challenge of our lifetimes.
And AI and Big Data had no impact.
The big wins were all from small data statistics: REACT surveillance, Recovery trial, Vaccine Development.

Photo by Markus Spiske: https://www.pexels.com/photo/green-and-yellow-printed-textile-330771/

Why Statistical Design and Analysis of Experiments?

Companies: get better products to market, faster

Managers: ensure best use of science and engineering time and resource

Individuals: advance your career

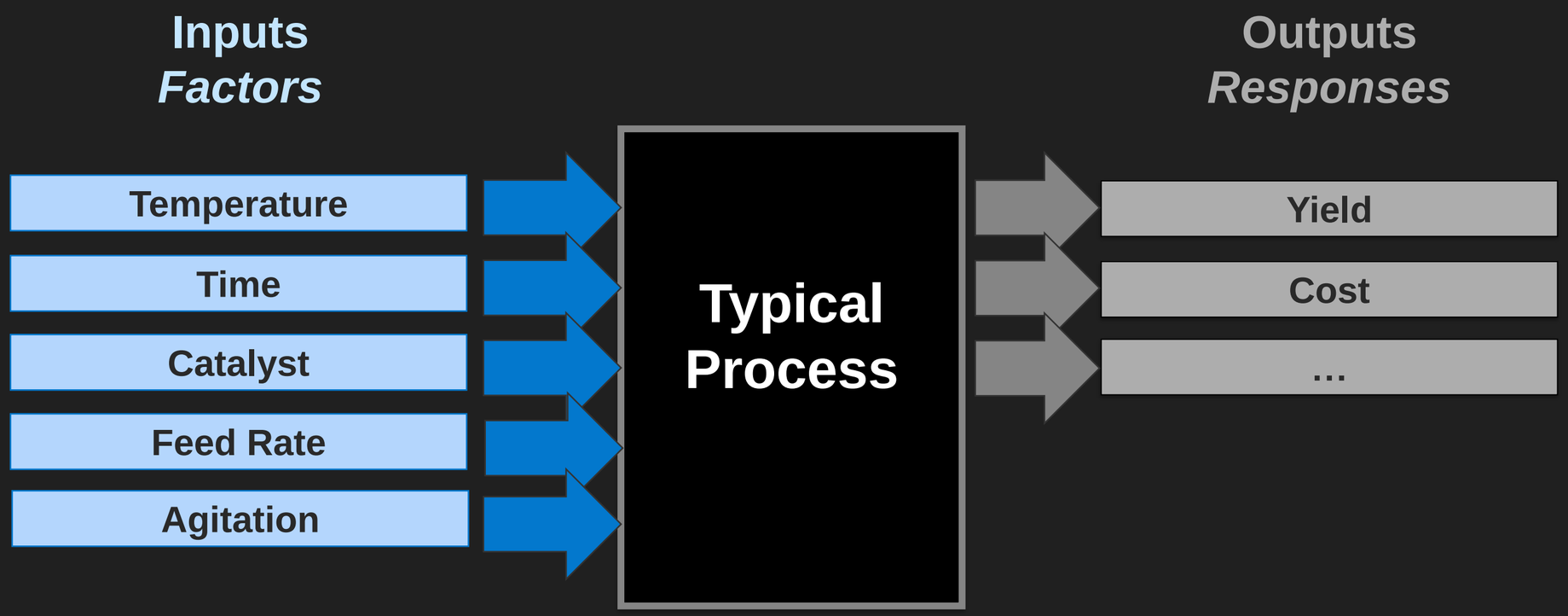
Why Statistical Design and Analysis of Experiments?

Predictability

Productivity

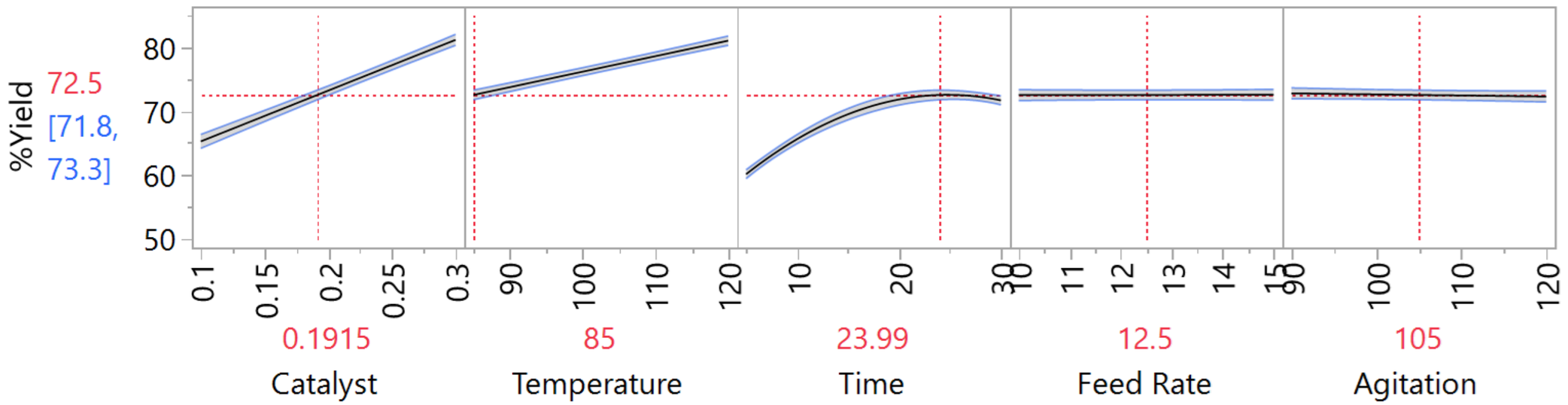
Promotion

Why Do We Experiment?



Process Understanding

Why Do We Experiment?



Process Understanding

What’s wrong with traditional “trial-and-error”, “the fair test”, and “one-factor-at-a-time”?

The Tale of Two Scientists

Once upon a time…

Dr Stevie
Principal Scientist

Dr Charlie
Associate Scientist

VP R&D

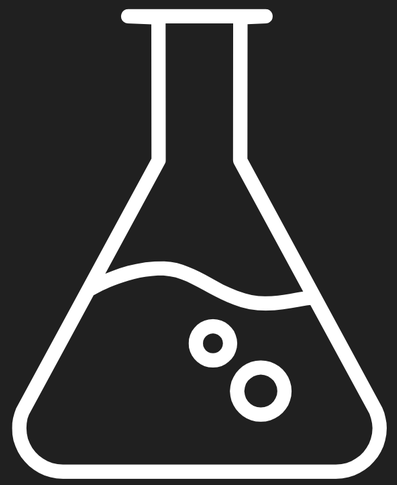
One day the VP of R&D came to them and said…

“You both have 9 attempts to maximise the yield of this process by changing only temperature and pH.”

Inputs
Factors

Temperature (30-70)

pH (6.0-8.0)



Output
Response

%Yield

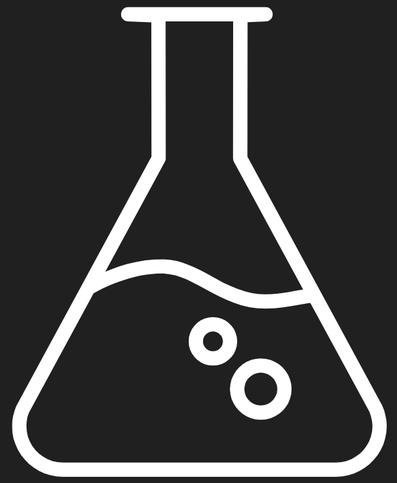
Dr Stevie: “I know exactly what I will do to win.”

Dr Charlie: “Oh dear! What should I do?”

Inputs
Factors

Temperature (30-70)

pH (6.0-8.0)



Output
Response

%Yield

Just then, a strange old man appeared on Dr Charlie's LinkedIn feed…

“Vary all your factors at the same time to efficiently explore the full possibility space.”

Two weeks went by…

VP R&D

	A	B	C	D	E	F
1						
2		Run	pH	Temperature	%Yield	
3		1	6.5	30	33	
4		2	6.5	40	44	
5		3	6.5	50	52	
6		4	6.5	60	55	
7		5	6.5	70	37	
8		6	6	60	38	
9		7	7	60	57	
10		8	7.5	60	51	
11		9	8	60	37	
12						

Dr Stevie

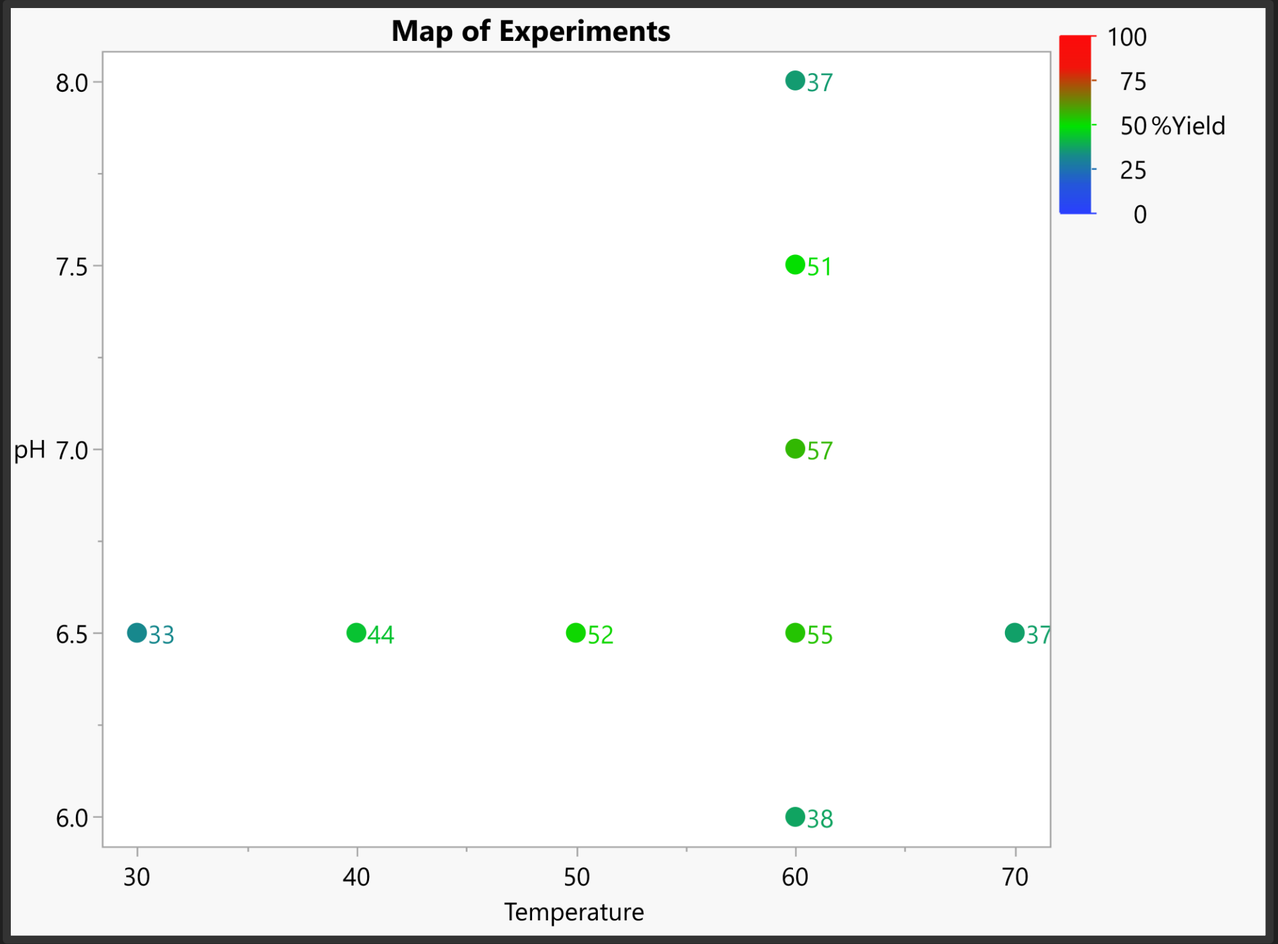
VP R&D

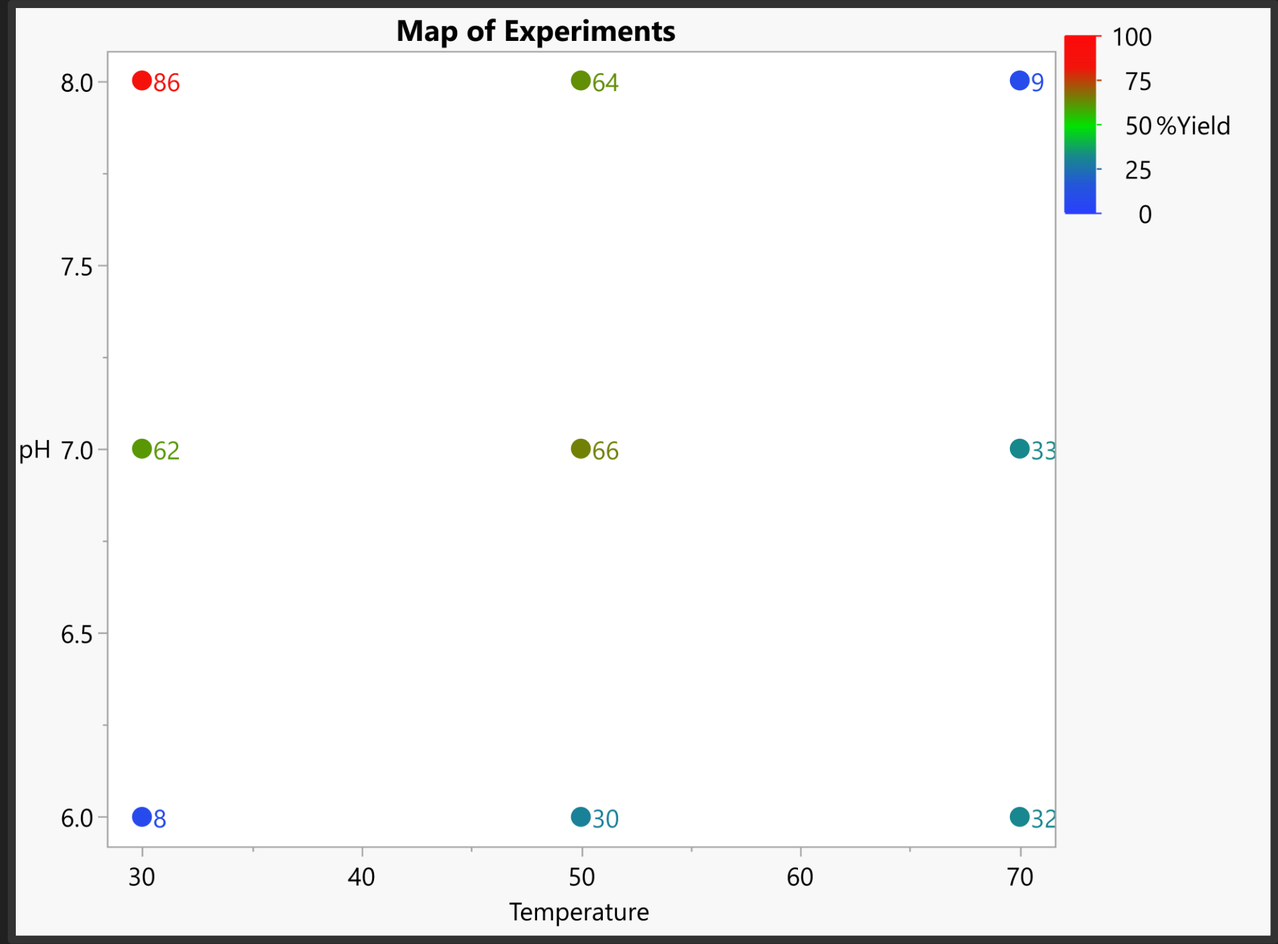
	Run	pH	Temperature	%Yield
1	1	6	30	8
2	2	8	50	64
3	3	6	70	32
4	4	6	50	30
5	5	7	50	66
6	6	8	30	86
7	7	8	70	9
8	8	7	30	62
9	9	7	70	33

Dr Charlie

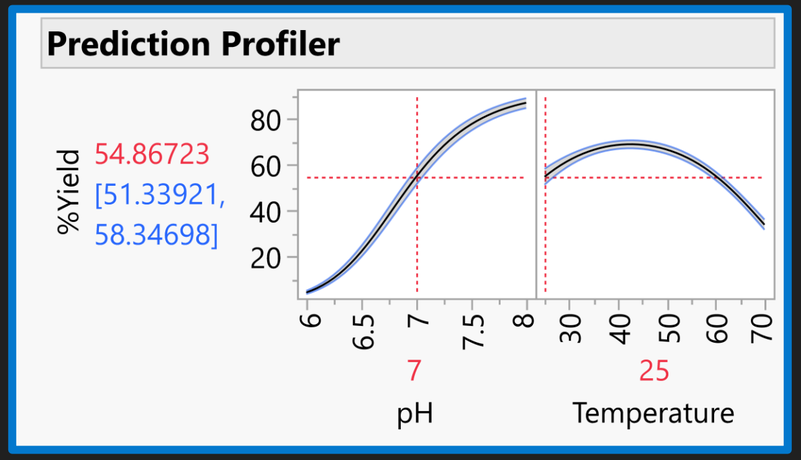
Dr Stevie

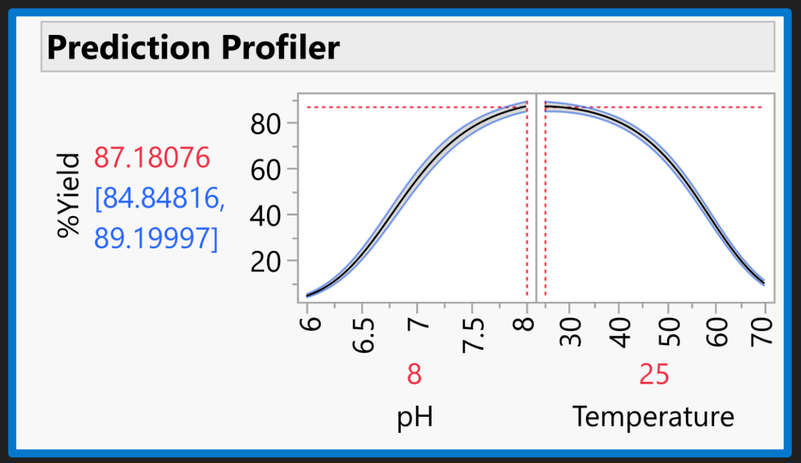
Dr Charlie

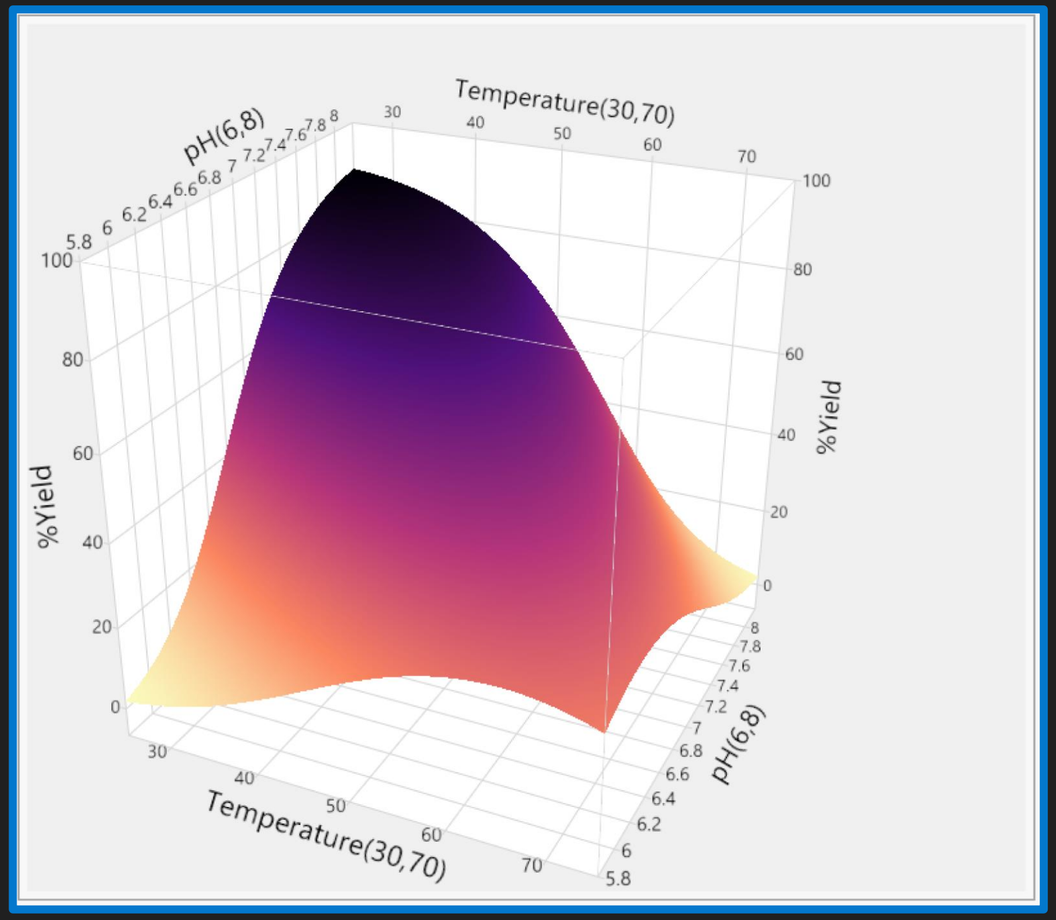




Dr Charlie



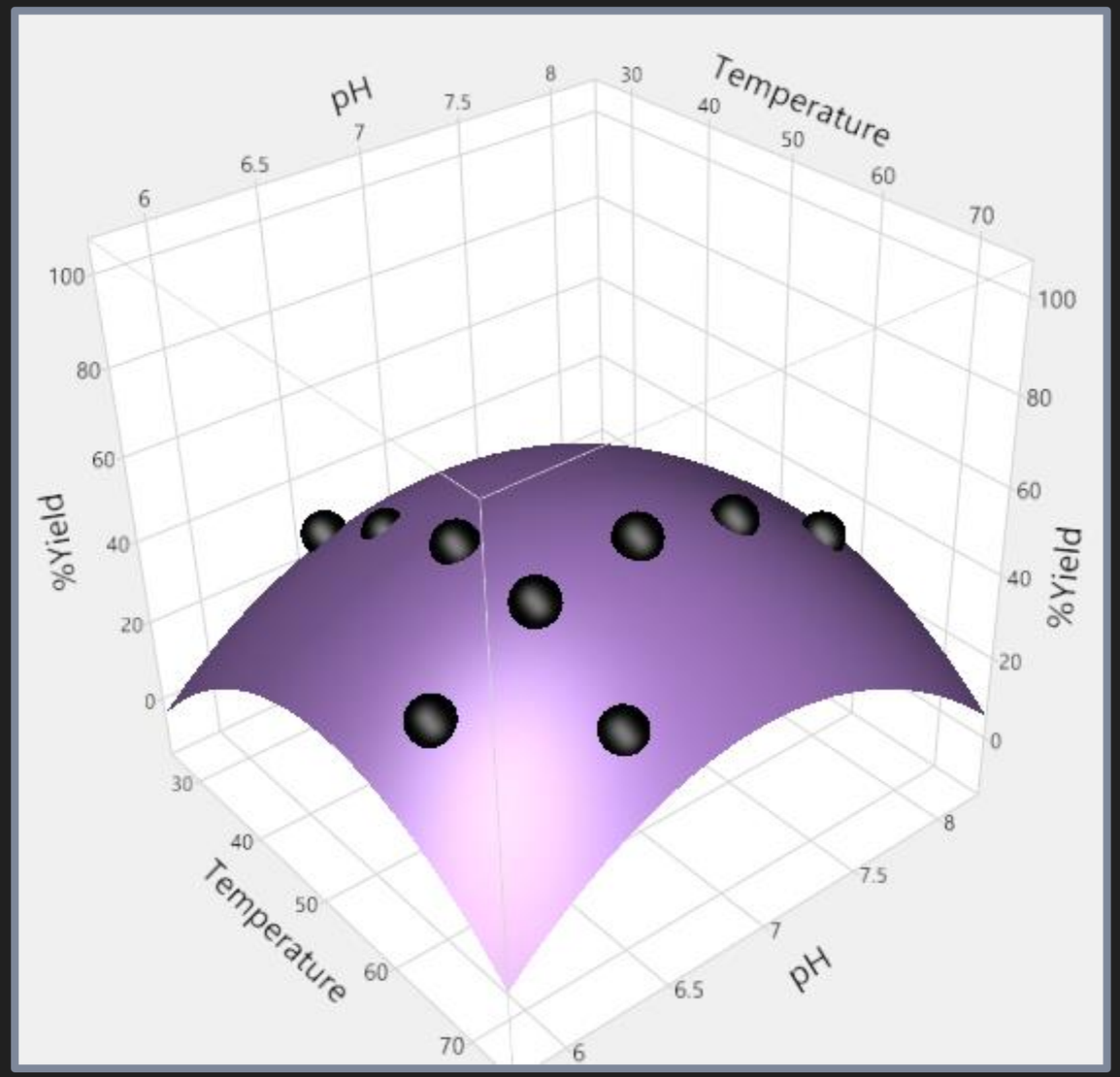


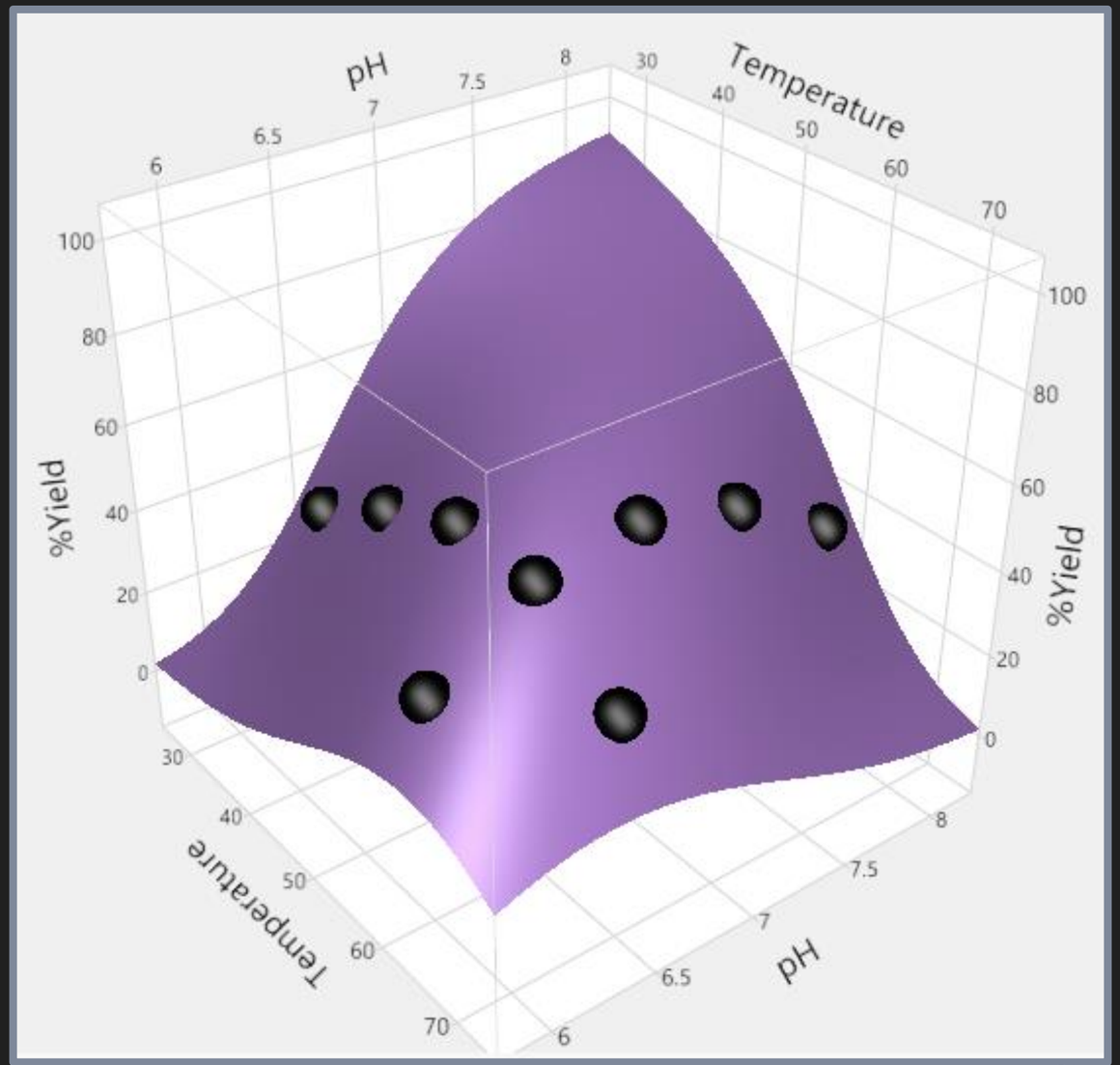


Dr Stevie
IT

Dr Charlie
Director of Innovation

One-Factor-At-a-Time Does Not Work





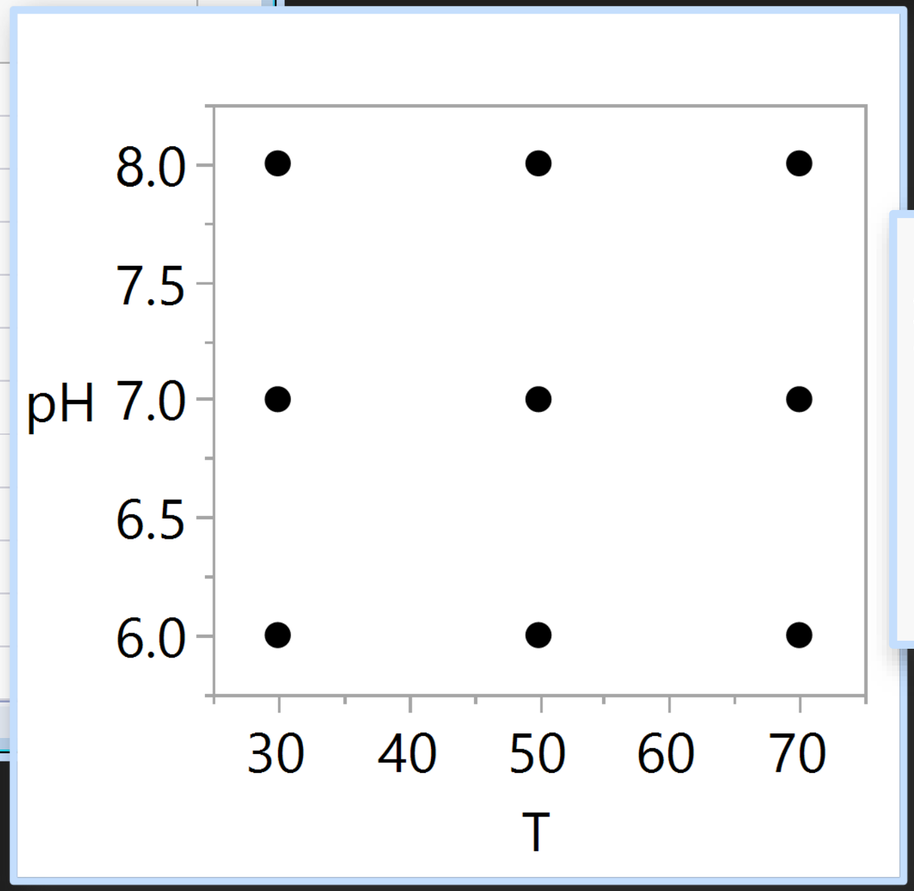
Design of Experiments

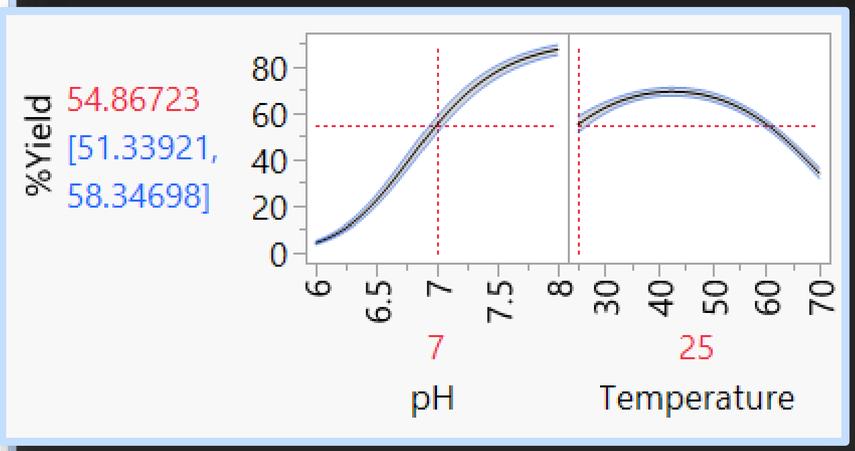
Maximise information by efficiently exploring all possibility space

3x3 Factorial - JMP Pro

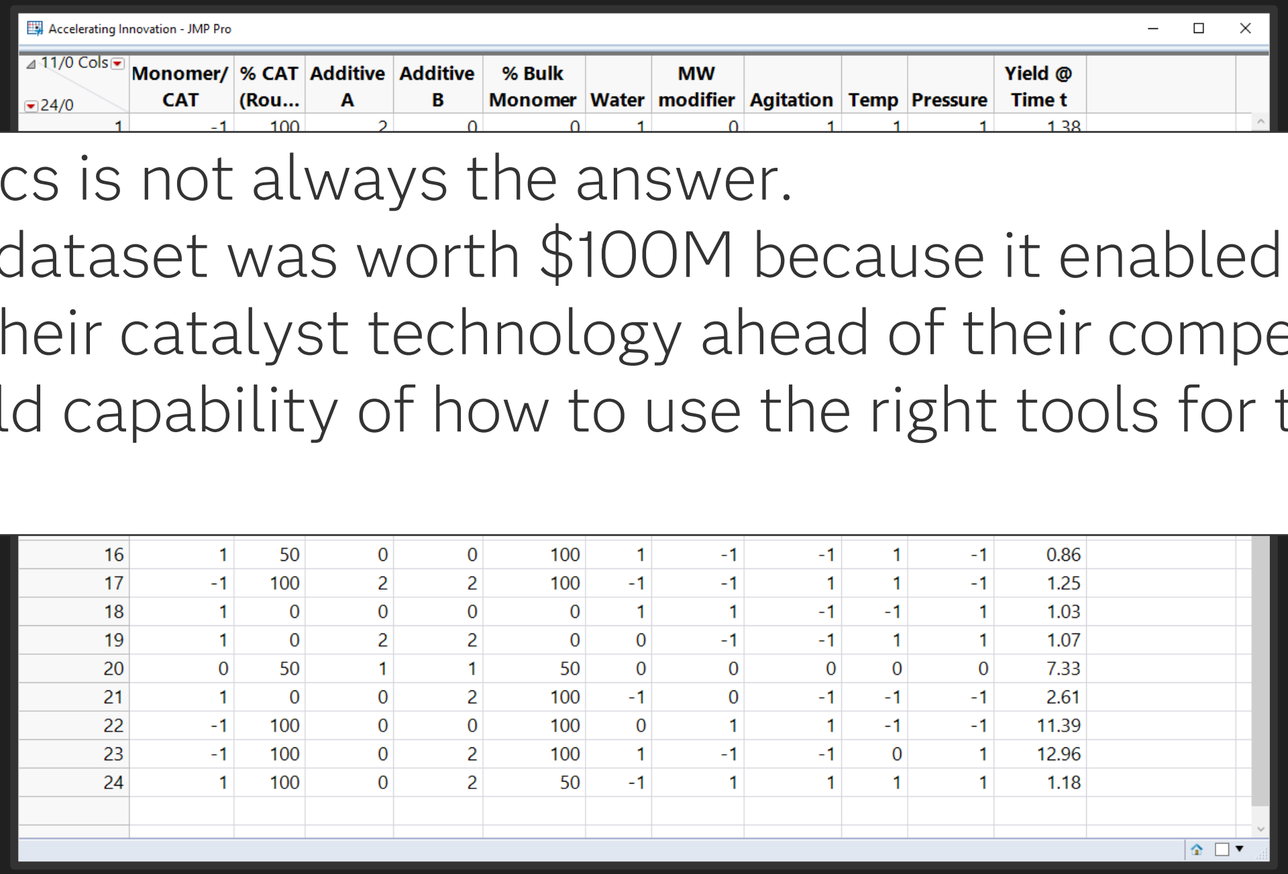
	Run	T	pH	Yield
1	1	50	6	•
2	2	70	6	•
3	3	50	7	•
4	4	70	7	•
5	5	50	8	•
6	6	70	8	•
7	7	30	7	•
8	8	30	8	•
9	9	30	6	•

evaluations done





The $100,000,000 data table



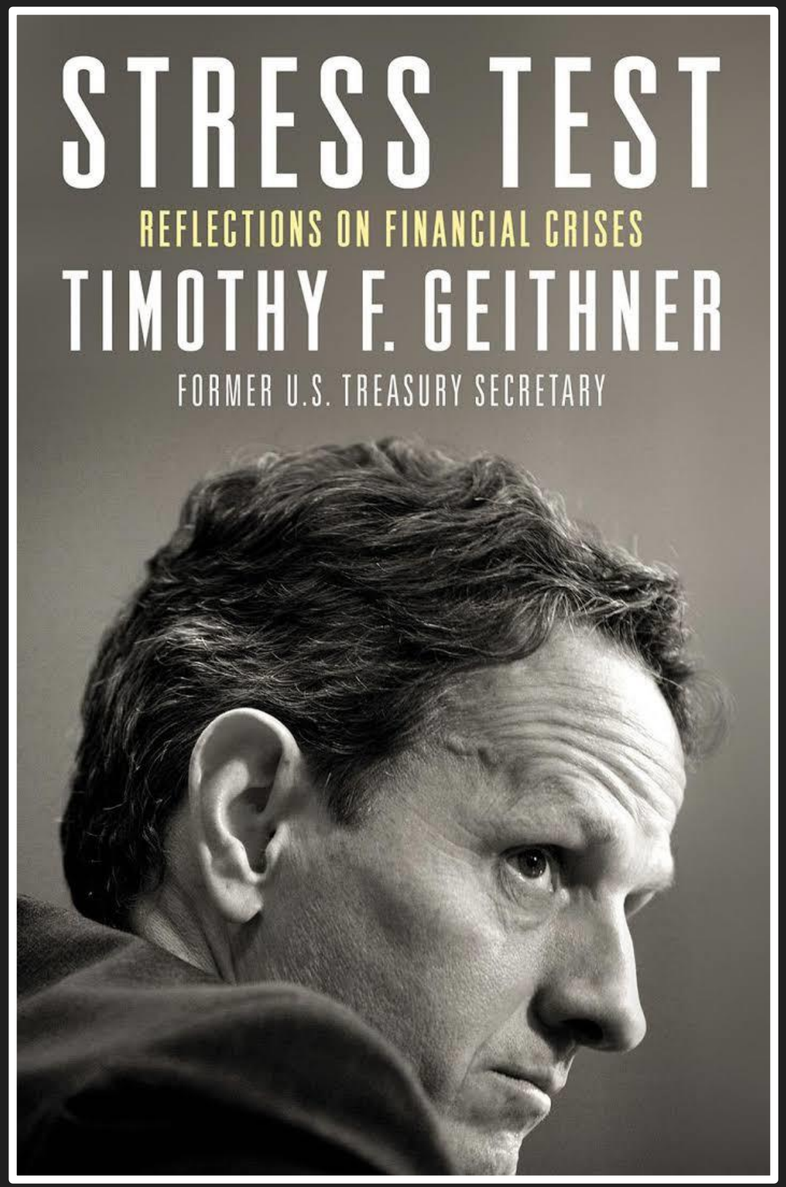
	Monomer/ CAT	% CAT (Rou...	Additive A	Additive B	% Bulk Monomer	Water	MW modifier	Agitation	Temp	Pressure	Yield @ Time t
1	-1	100	2	0	0	1	0	1	1	1	1.38
16	1	50	0	0	100	1	-1	-1	1	-1	0.86
17	-1	100	2	2	100	-1	-1	1	1	-1	1.25
18	1	0	0	0	0	1	1	-1	-1	1	1.03
19	1	0	2	2	0	0	-1	-1	1	1	1.07
20	0	50	1	1	50	0	0	0	0	0	7.33
21	1	0	0	2	100	-1	0	-1	-1	-1	2.61
22	-1	100	0	0	100	0	1	1	-1	-1	11.39
23	-1	100	0	2	100	1	-1	-1	0	1	12.96
24	1	100	0	2	50	-1	1	1	1	1	1.18

Big Data analytics is not always the answer.
This very small dataset was worth $100M because it enabled a spin-out to commercialise their catalyst technology ahead of their competitors.
You need to build capability of how to use the right tools for the right objective.

858 bytes

“Plan beats no plan”

“Hope is not a strategy”



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Organisations: better products and services to market, faster

Managers: ensure your scientists and engineers are most productive

Individuals: advance your career

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