

Quasi-Experiments

CLASS 7

Joel Shapiro
Clinical Associate Professor, MEDS

Northwestern | Kellogg

TEST AND LEARN

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The process of trying an initiative for the purpose of rigorous measurement. Informs whether initiative was successful, whether it was worthwhile, how to improve it, how to move forward.

Not looking backwards and asking “what was effective,” but deliberately and strategically planning opportunities for precise measurement of effectiveness.

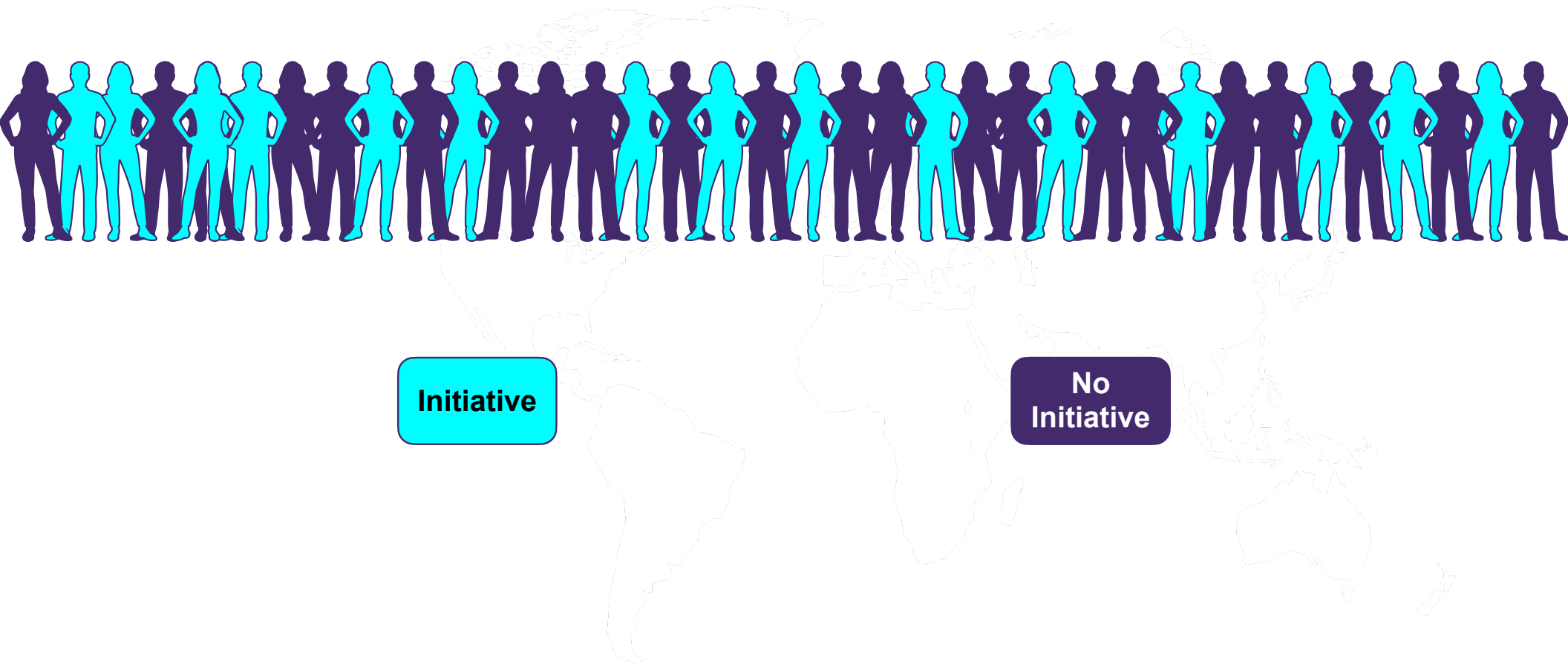
Gold standard = **business experimentation**

A business experiment creates equivalent groups and deploys the initiative to one group only. This ensures that the only difference between the groups is the initiative itself, allowing us to infer that any differences in measured group outcomes are due to the initiative.

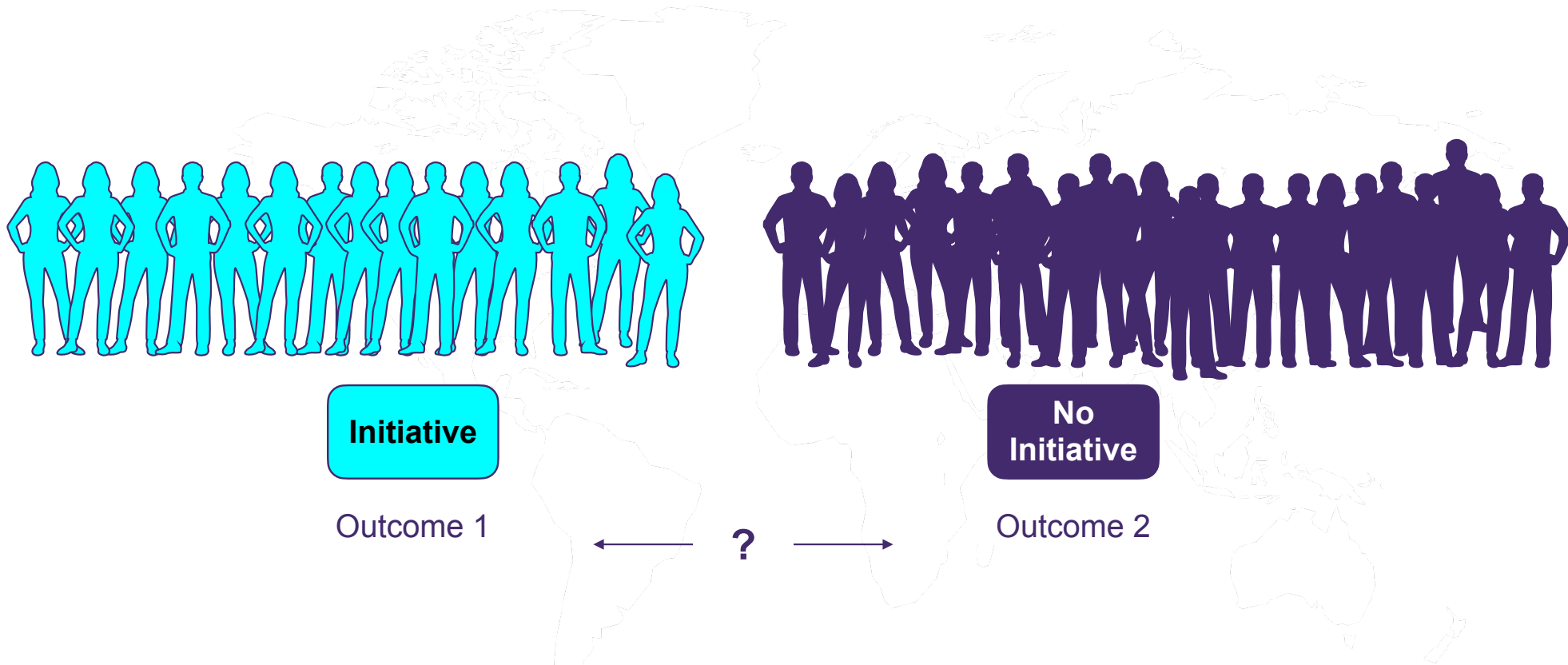
TEST AND LEARN



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If Outcome 1 > Outcome 2 by 10%,
= Initiative is responsible for a **10% lift in outcome!**

TEST AND LEARN



An “initiative” can be anything you want to assess:

- Price promo
- Sales training program
- Vaccine
- Harrah’s free steak dinner



Outcome 1



Outcome 2

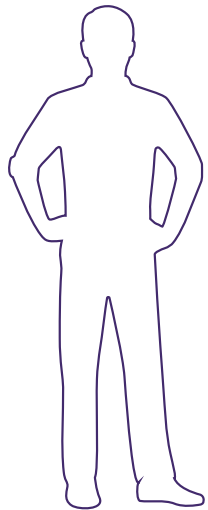
No
Initiative



If Outcome 1 > Outcome 2 by 10%,
= Initiative is responsible for a **10% lift in outcome!**

BUT SOMETIMES YOU CAN'T EXPERIMENT

“We have a great new technology that I think is going to help you perform better. I’m going to give it to some of you, and withhold it from others!”



?!?!?!?

BUT SOMETIMES YOU CAN'T EXPERIMENT

Why not? Common barriers include:

- **Cost outweighs the likely benefit**
You don't want to spend \$50k to solve a \$30k problem.
- When it could be **unethical** to randomly give something to one person and not another
 - A productivity tool at work
 - A curriculum support tool for kids in a school
 - A new work at home policy
 - A potentially valuable pill to a sick person?
- When **logistically it would be difficult** to divide a group and keep them separate
 - A pricing discount (by coupon or email)
 - Assets from a digital marketing campaign

SECOND BEST METHODS: FOR WHEN YOU CAN'T EXPERIMENT

True experiments enable a true “apples to apples” comparison. Second-best methods enable a comparison of things that are *mostly / hopefully* alike.

Examples include:

- Look-alike / matching
- Regression
- Regression discontinuity
- Difference-in-differences
- Many more

These are often called **Quasi-Experiments**. They are NOT experiments, but they try to isolate the causal relationship between an initiative and an outcome to mimic an experiment.

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True experiments enable a true “apples to apples” comparison. Second-best methods enable a comparison of things that are *mostly / hopefully* alike.

Examples include:

- Look-alike / matching
- ✓ • **Regression**
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- ✓ • **Difference-in-differences**
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DIFFERENCE IN DIFFERENCES

EXAMPLE: A NEW SALES INCENTIVE STRUCTURE

Imagine you want to know whether a new incentive compensation structure will be effective

Current Structure
Fixed 3% commission

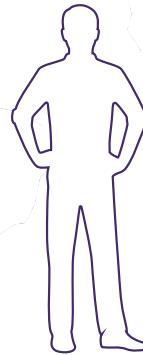
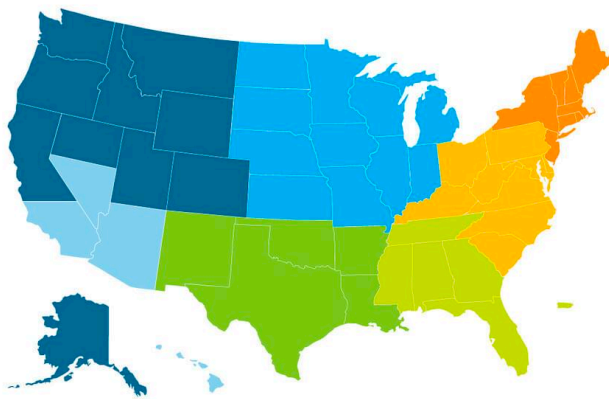
VS

New Structure
Variable per-deal commission
Sliding scale from 2% to 5%

An experiment would be ideal, but maybe challenging...

SOLUTION: PHASED ROLL-OUT WITH DIFFERENCE-IN-DIFFERENCES

Phased roll-out = iteratively choose groups / territories / areas to try new initiative
Difference-in-differences = measurement technique

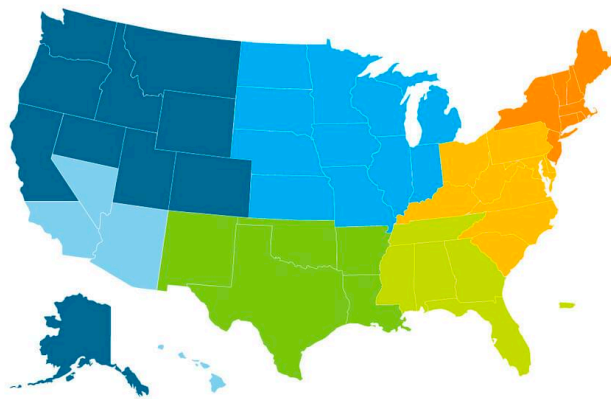


“Let’s try it in one area first
and see how it goes...”

How about the Northwest
region?”

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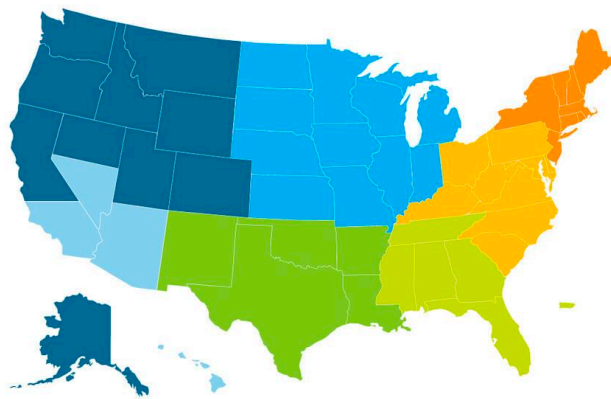
Weekly sales pre roll-out

Northwest

\$10,000

SOLUTION: PHASED ROLL-OUT WITH DIFFERENCE-IN-DIFFERENCES

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Northwest

Weekly sales pre roll-out

\$10,000

-New Structure-

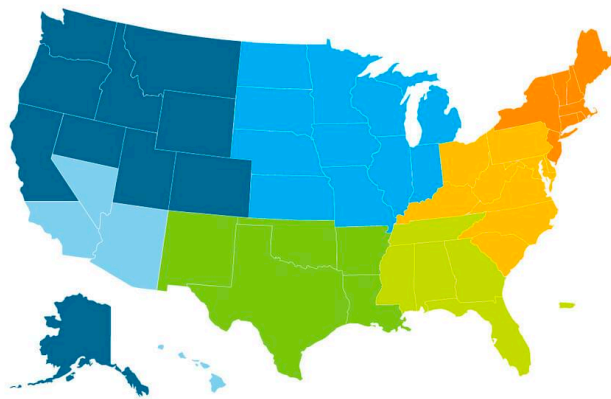
Weekly sales post roll-out

\$12,000

+20%

SOLUTION: PHASED ROLL-OUT WITH DIFFERENCE-IN-DIFFERENCES

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Weekly sales pre roll-out

Northwest

\$10,000

All others

\$9,000

-New Structure-

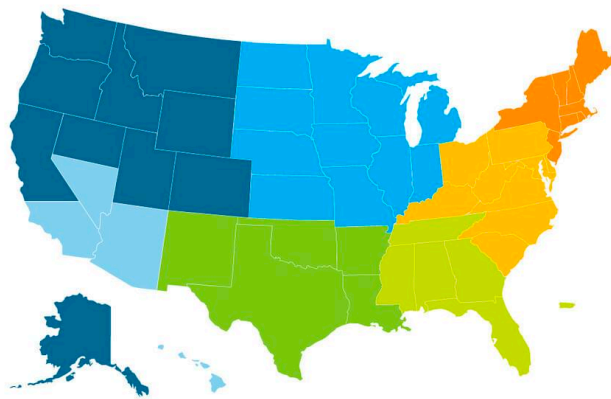
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Weekly sales pre roll-out

Northwest

\$10,000

All others

\$9,000

-New Structure-

-No New Structure-

Weekly sales post roll-out

\$12,000

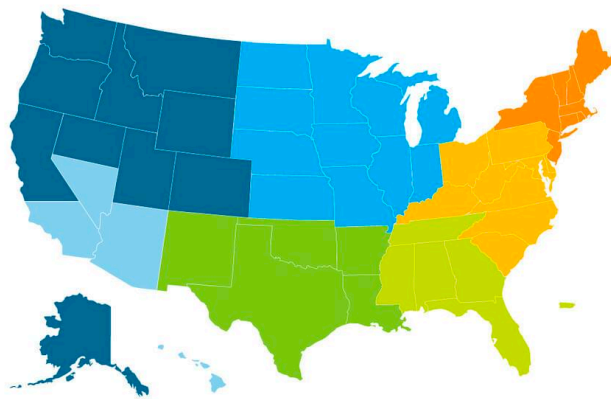
\$10,000

+20%

+11%

SOLUTION: PHASED ROLL-OUT WITH DIFFERENCE-IN-DIFFERENCES

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Weekly sales pre roll-out

Northwest

\$10,000

All others

\$9,000

-New Structure-

-No New Structure-

Weekly sales post roll-out

\$12,000

\$10,000

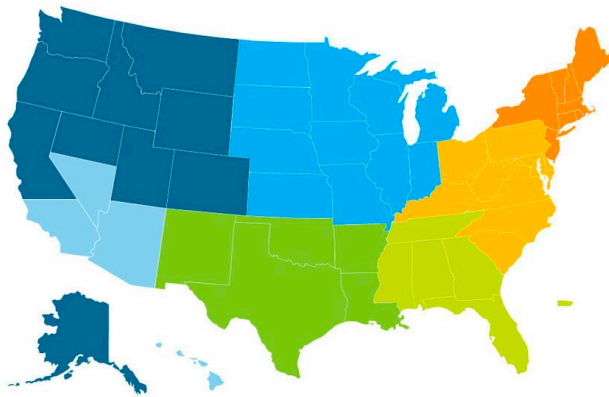
+20%

+11%

"Difference of differences" = 20%-11% = 9%

SOLUTION: PHASED ROLL-OUT WITH DIFFERENCE-IN-DIFFERENCES

Phased roll-out = iteratively choose groups / territories / areas to try new initiative
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	Northwest	All others
Weekly sales pre roll-out	\$10,000	\$9,000
-New Structure-		-No New Structure-
Weekly sales post roll-out	\$12,000	\$10,000
	+20%	+11%

New structure increases sales by 9%

SOLUTION: PHASED ROLL-OUT WITH DIFFERENCE-IN-DIFFERENCES

Phased roll-out = iteratively choose groups / territories / areas to try new initiative
Difference-in-differences = measurement technique



What assumptions need to be true for this statement to be true?

	Northwest	All others
Weekly sales pre roll-out	\$10,000	\$9,000
-New Structure-		-No New Structure-
Weekly sales post roll-out	\$12,000	\$10,000
	+20%	+11%

New structure increases sales by 9%



REGRESSION

The goal with regression for causal inference is to include independent variables (features) that “soak up” all variation in the outcome that is not caused by the variable of interest.

REGRESSION FOR CAUSAL INFERENCE

Example: what is the relationship between education and income in today's workforce?

$$\textit{income} = \alpha + \beta * \textit{education}$$

This is woefully poor at estimating the causal effect of education on income. Why?

REGRESSION FOR CAUSAL INFERENCE

Example: what is the relationship between education and income in today's workforce?

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This is woefully poor at estimating the causal effect of education on income. Why?

There are other factors..., such as “motivation”

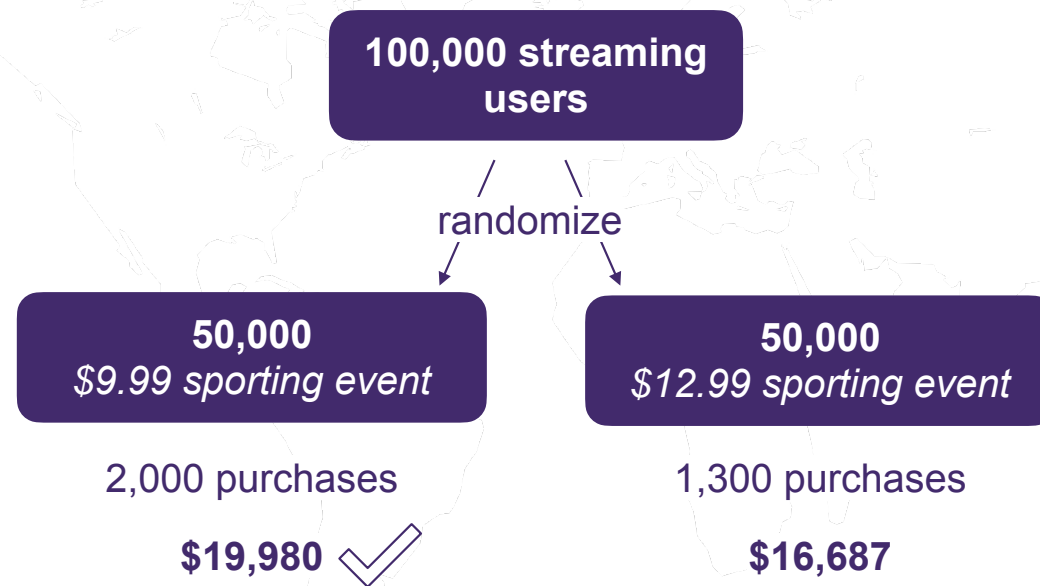
$$\text{income} = \alpha + \beta * \text{education} + \gamma * \text{motivation} + \delta * \text{otherstuff}$$

↑
Leaving this as the variation
caused by education

↑
Ideally “controls” for confounding variation

PRICING WITH REGRESSION

We often see pricing decisions made with regression analyses. Ideally, we would know the causal effect of price on demand...



A 30% increase in price causes a 35% decrease in demand.

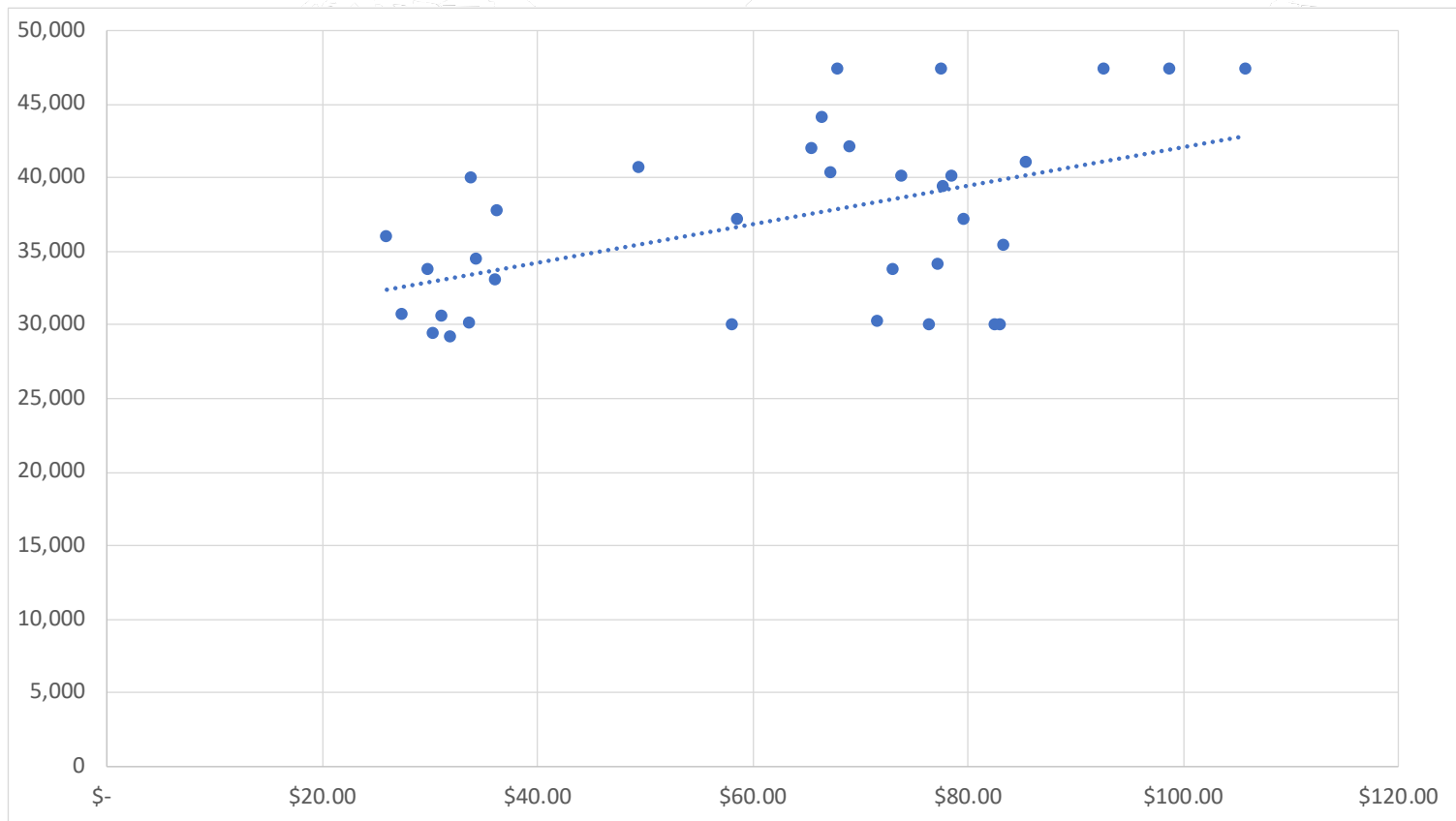
PRICING: WHY NOT JUST LOOK AT HISTORICAL DATA?

What price should we charge for
NU Football tickets?

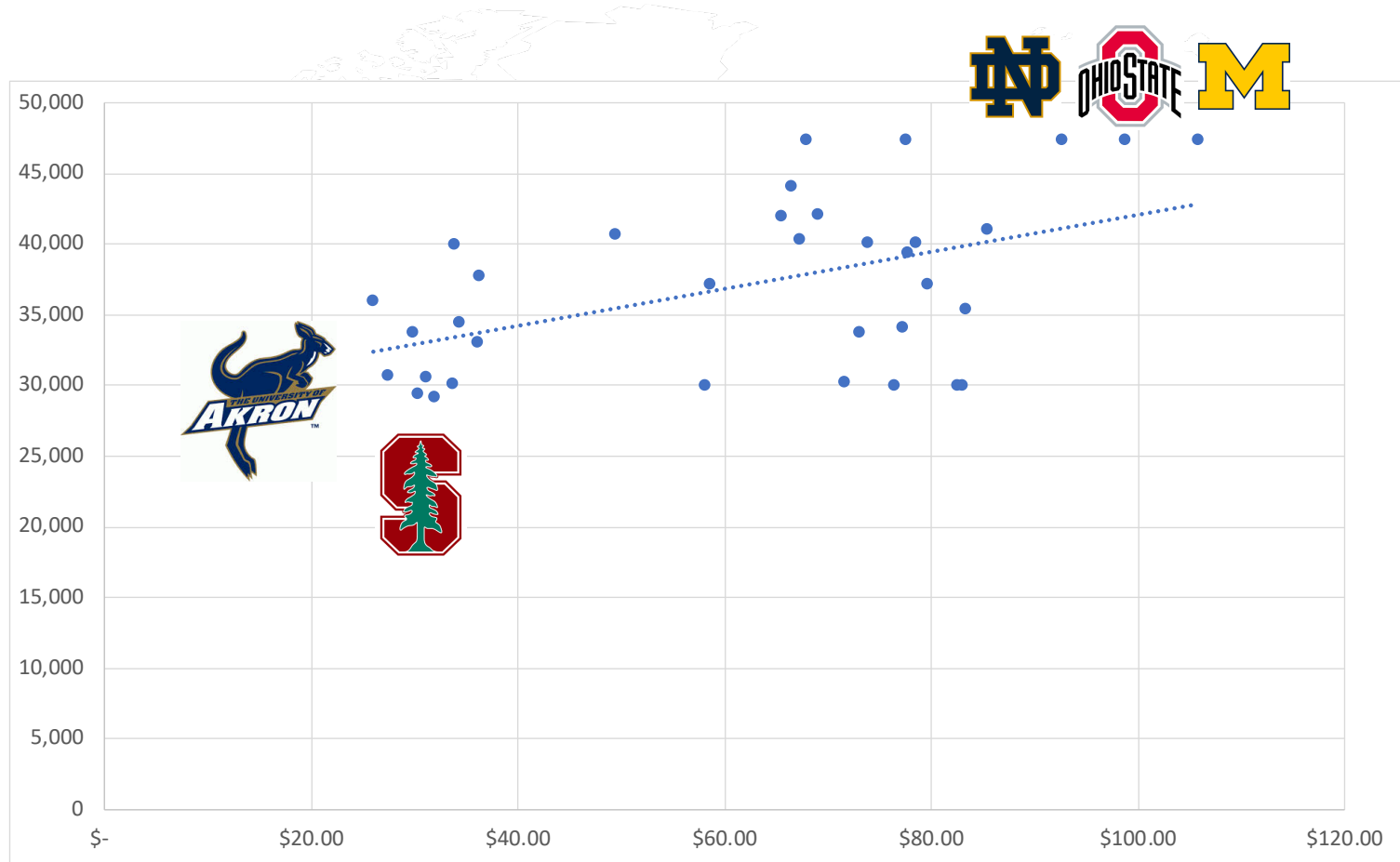
5 YEARS OF DATA

seaso	item	date	day_g	cover	game	kicko	f	ho	state	game	game	game	result	score	score	score	recor	durati	atten	price
F19	UNLV	9/14/	Sat	BTN	2:30P	2:46P	1		NV	60208	Evans	IL	W	30-14	30	14	1-1	3:02	37,714	\$36.38
F19	MICH	9/21/	Sat	ABC	11:00	11:06	1		MI	60208	Evans	IL	L	10-31	10	31	1-2	3:18	40,114	\$78.51
F19	OHIO	10/18	Fri	BTN	7:30P	7:40P	1		OH	60208	Evans	IL	L	3-52	3	52	1-5	3:05	47,330	\$98.76
F19	IOWA	10/26	Sat	ESPN	11:00	11:01	1		IA	60208	Evans	IL	L	0-20	0	20	1-6	2:52	42,104	\$69.17
F19	PURD	11/9/	Sat	BTN	11:00	11:01	1		IN	60208	Evans	IL	L	22-24	22	24	1-8	3:19	37,194	\$58.66
F19	UMA	11/16	Sat	BTN	11:00	11:01	1		MA	60208	Evans	IL	W	45-6	45	6	2-8	2:08	29,447	\$30.43
F19	MINN	11/23	Sat	ABC	11:00	11:06	1		MN	60208	Evans	IL	L	22-38	22	38	2-9	3:07	30,246	\$71.61
F18	DUKE	9/8/1	Sat	ESPN	11:00	11:03	1		NC	60208	Evans	IL	L	7-21	7	21	1-1	3:05	40,654	\$49.42
F18	AKRO	9/15/	Sat	BTN	6:30P	6:40P	1		OH	60208	Evans	IL	L	34-39	34	39	1-2	3:49	40,014	\$33.99
F18	MICH	9/29/	Sat	FOX	3:47P	3:47P	1		MI	60208	Evans	IL	L	17-20	17	20	1-3	3:21	47,330	\$92.69
F18	NEBR	10/13	Sat	ABC	11:00	11:06	1		NE	60208	Evans	IL	W	34-31	34	31	3-3	3:32	47,330	\$67.97
F18	WISC	10/27	Sat	FOX	11:00	11:05	1		WI	60208	Evans	IL	W	31-17	31	17	5-3	3:20	47,330	\$77.56
F18	NOTR	11/3/	Sat	ESPN	6:15P	6:20P	1		IN	60208	Evans	IL	L	21-31	21	31	5-4	3:10	47,330	\$105.8
F18	ILLIN	11/24	Sat	BTN	2:30P	2:31P	1		IL	60208	Evans	IL	W	24-16	24	16	8-4	3:00	37,124	\$79.78
F17	NEVA	9/2/1	Sat	BTN	2:30P	2:40P	1		NV	60208	Evans	IL	W	31-20	31	20	1-0	3:24	33,018	\$36.13
F17	BOW	9/16/	Sat	BTN	6:30P	6:40P	1		OH	60208	Evans	IL	W	49-7	49	7	2-1	3:07	33,706	\$29.85
F17	PENN	10/7/	Sat	ABC	11:00	11:06	1		PA	60208	Evans	IL	L	7-31	7	31	2-3	3:17	41,061	\$85.49
F17	IOWA	10/21	Sat	ESPN	11:00	11:01	1		IA	60208	Evans	IL	W	17-10	17	10	4-3	3:10	40,036	\$73.87
F17	MICH	10/28	Sat	ESPN	2:30P	2:35P	1		MI	60208	Evans	IL	W	39-31	39	31	5-3	3:40	39,369	\$77.84
F17	PURD	11/11	Sat	ESPN	6:00P	6:10P	1		IN	60208	Evans	IL	W	23-13	23	13	7-3	3:24	33,765	\$73.10
F17	MINN	11/18	Sat		11:00	11:01	1		MN	60208	Evans	IL	W	39-0	39	0	8-3	2:51	30,014	\$76.50
F16	WEST	9/3/1	Sat	ESPN	11:00	11:01	1		MI	60208	Evans	IL	L	21-22	21	22	0-1	3:13	30,635	\$31.10
F16	ILLIN	9/10/	Sat	BTN	2:30P	2:36P	1		IL	60208	Evans	IL	L	7-9	7	9	0-2	3:16	30,748	\$27.54
F16	DUKE	9/17/	Sat	BTN	7:00P	7:06P	1		NC	60208	Evans	IL	W	24-13	24	13	1-2	3:17	34,464	\$34.40
F16	NEBR	9/24/	Sat	BTN	6:30P	6:42P	1		NE	60208	Evans	IL	L	13-24	13	24	1-3	3:09	40,284	\$67.26
F16	INDIA	10/22	Sat	BTN	11:00	11:01	1		IN	60208	Evans	IL	W	24-14	24	14	4-3	3:34	35,417	\$83.33
F16	WISC	11/5/	Sat	ABC	11:00	11:06	1		WI	60208	Evans	IL	L	7-21	7	21	4-5	3:18	42,016	\$65.54
F16	ILLIN	11/26	Sat	BTN	11:00	11:01	1		IL	60208	Evans	IL	W	42-21	42	21	6-6	2:30	30,022	\$82.62
F15	STAN	9/5/1	Sat	ESPN	11:00	11:01	1		CA	60208	Evans	IL	W	16-6	16	6	1-0	3:00	36,024	\$25.99
F15	EAST	9/12/	Sat	ESPN	3:00P	3:02P	1		IL	60208	Evans	IL	W	41-0	41	0	2-0	2:49	29,131	\$31.97
F15	BALL	9/26/	Sat	BTN	7:00P	7:12P	1		IN	60208	Evans	IL	W	24-19	24	19	4-0	3:32	30,107	\$33.73
F15	MINN	10/3/	Sat	BTN	11:00	11:01	1		MN	60208	Evans	IL	W	27-0	27	0	5-0	2:52	30,044	\$83.05
F15	IOWA	10/17	Sat	ABC/	11:00	11:05	1		IA	60208	Evans	IL	L	10-40	10	40	5-2	3:24	44,135	\$66.50
F15	PENN	11/7/	Sat	ESPN	11:00	11:01	1		PA	60208	Evans	IL	W	23-21	23	21	7-2	3:34	34,116	\$77.30
F15	PURD	11/14	Sat	BTN	11:00	11:01	1		IN	60208	Evans	IL	W	21-14	21	14	8-2	3:14	30,003	\$58.15

SOLUTION = CHARGE INFINITELY HIGH PRICE!



...OR NOT?



SECOND BEST METHODS: PRICING QUASI-EXPERIMENT

A very common technique is to use (linear) regression, but needs some transformation first.

$$\text{Price Elasticity} = \frac{\% \text{ change in demand}}{\% \text{ change in price}}$$



This is a nice way to compare across products, contexts, etc.

$$\text{demand} = \beta_0 + \beta_1 * \text{price}$$



This doesn't give us % - just raw unit changes per price change.

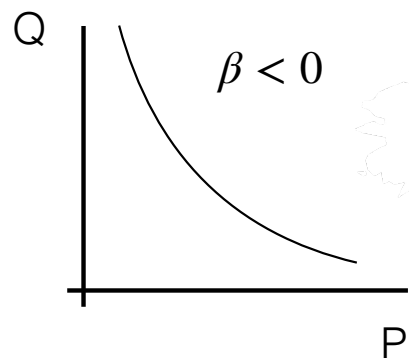
Solution?
Use natural logs...

$$\ln(\text{demand}) = \beta_0 + \beta_1 * \ln(\text{price})$$



Price elasticity... **WHY?**

REGRESSION FOR PRICING



$$Q = \alpha * P^\beta$$

$$\ln Q = \ln \alpha + \beta * \ln P$$



intercept

$$\ln Q = \beta_0 + \beta_1 * \ln P$$

Downward-sloping demand curve

Take natural log + use log rules for simplification

Called "log-log"

Linear regression here gives us the right interpretation

How do I know? Because look at what happens if I differentiate both sides...

$$d(\ln Q) = \beta_1 * d(\ln P)$$

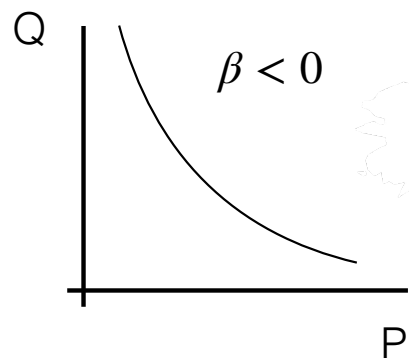
$$dQ/Q = \beta_1 * dP/P \longrightarrow \beta_1 = (dQ/Q)/(dP/P)$$

% change in Q

% change in P

$$\beta_1 = \frac{(\% \text{ change in } Q)}{(\% \text{ change in } P)}$$

REGRESSION FOR PRICING



$$Q = \alpha * P^\beta$$

$$\ln Q = \ln \alpha + \beta * \ln P$$



intercept

$$\ln Q = \beta_0 + \beta_1 * \ln P$$

Downward-sloping demand curve

Take natural log + use log rules for simplification

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Linear regression here gives us the right interpretation

How do I know? Because look at what happens if I differentiate both sides...

And now, with regression analysis, you can include statistical "controls"

$$d(\ln Q) = \beta_1 * d(\ln P)$$

$$dQ/Q = \beta_1 * dP/P$$

% change in Q

% change in P

$$\beta_1 = (dQ/Q) / (dP/P)$$

$$\beta_1 = (\% \text{ change in } Q) / (\% \text{ change in } P)$$

YOUR HW: PRICING CONCESSIONS @ SOLDIER FIELD

HOT DOG PRICING in 2019

Pricing	Price	Games
Full	\$7.25	0
STH (GA)	\$6.50	4
STH (Club Level)	\$5.75	4
STH "Featured Item"	\$3.75	4

← Analysis only for STHs, who are never charged full price if they buy with app

← 4 games total

← 4 games total

YOUR HW: PRICING CONCESSIONS @ SOLDIER FIELD

HOT DOG PRICING in 2019

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Analysis only for STHs, who are never charged full price if they buy with app

4 games total

4 games total

The Bears sell more hot dogs at \$3.75 than at the other two prices... why do you think?
The Bears sell more hot dogs at \$6.50 than at \$5.75... why do you think?