



ACME MANUFACTURING

DIGITAL ANALYTICS & CAUSAL INFERENCE

ISOM 599R - Project 2

Synthetic Control and Geo Testing

Presented By:

Group 3: Efe Comu, Jordan Meacham, Innocent Mukoki, Zhizhi Wang



Executive Summary:

JEZI Co. Consulting group conducted a geo-holdout causal inference experiment for ACME Manufacturing to evaluate the national impact of Google's Performance Max (PMAX) campaign on ACME Manufacturing's order volume. Using a two-stage synthetic control methodology, we quantified the difference in national orders had the campaign been universally deployed. The results revealed an average weekly lift of **26.4K additional orders**, translating to **\$5.29M in weekly revenue** and **\$1.59M in profit**. This effect is statistically significant with a p-value of 0, indicating strong evidence of the PMAX campaign's effectiveness.

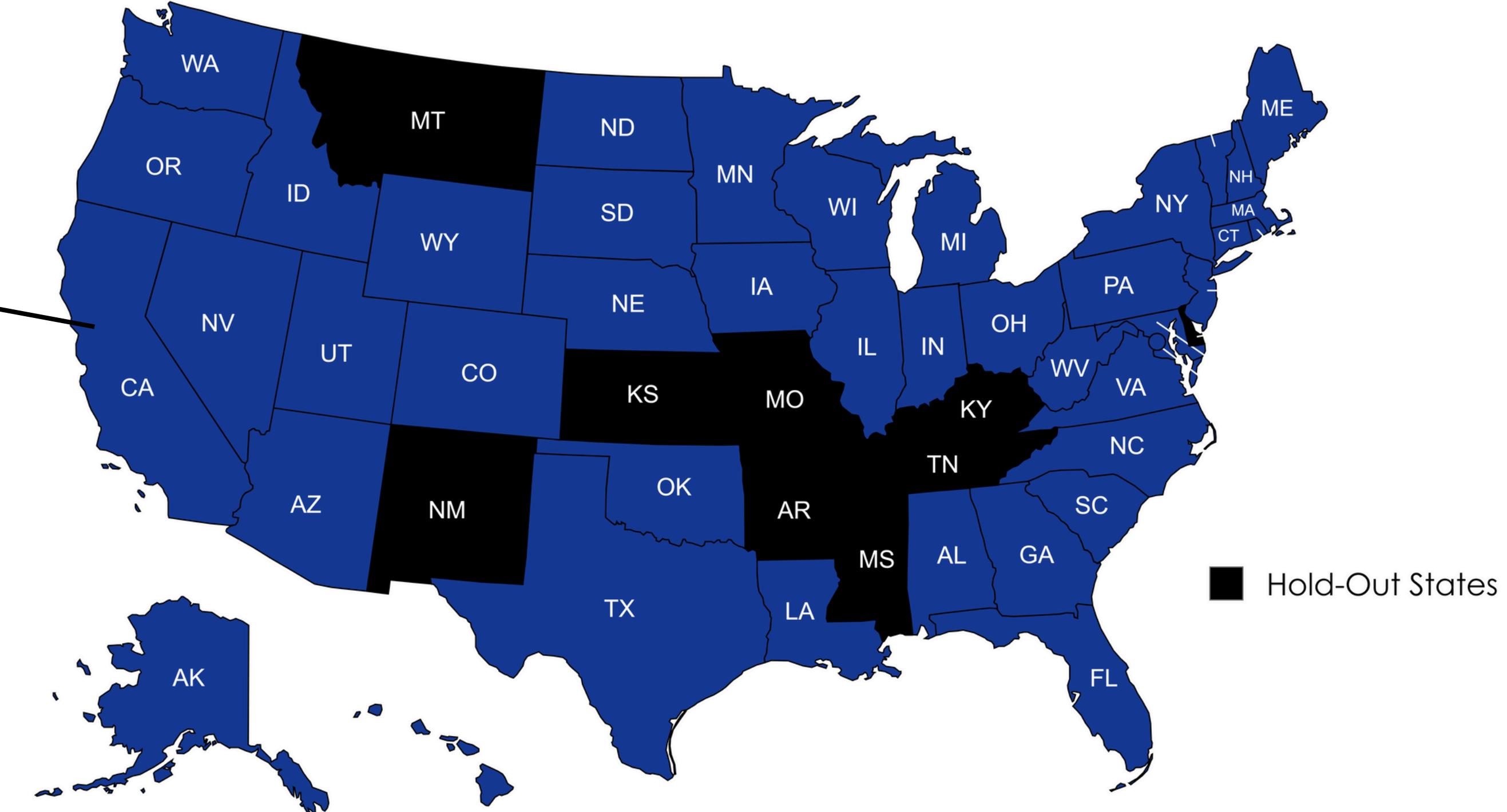
Business Problem

ACME sought to determine whether Google PMAX advertising causally increased order volume. Given the limitations of randomization at scale, ACME adopted a **geo-holdout strategy**: holding out select states from the campaign to estimate its impact using observational data and synthetic controls.

The challenge was to reliably estimate the incremental effect of the campaign across all U.S. markets.

Geo - Holdout Testing Strategy

The PMAX campaign will be launched in the **blue** states and will go dark (be withheld) in the **black** states



Data Description

ACMEOrdersData

- Two years (104 weeks) of weekly, state-level order data from ACME across all 50 US states and Washington, DC.
- This data is the pre-treatment data, which is the typical order level before the campaign was deployed.

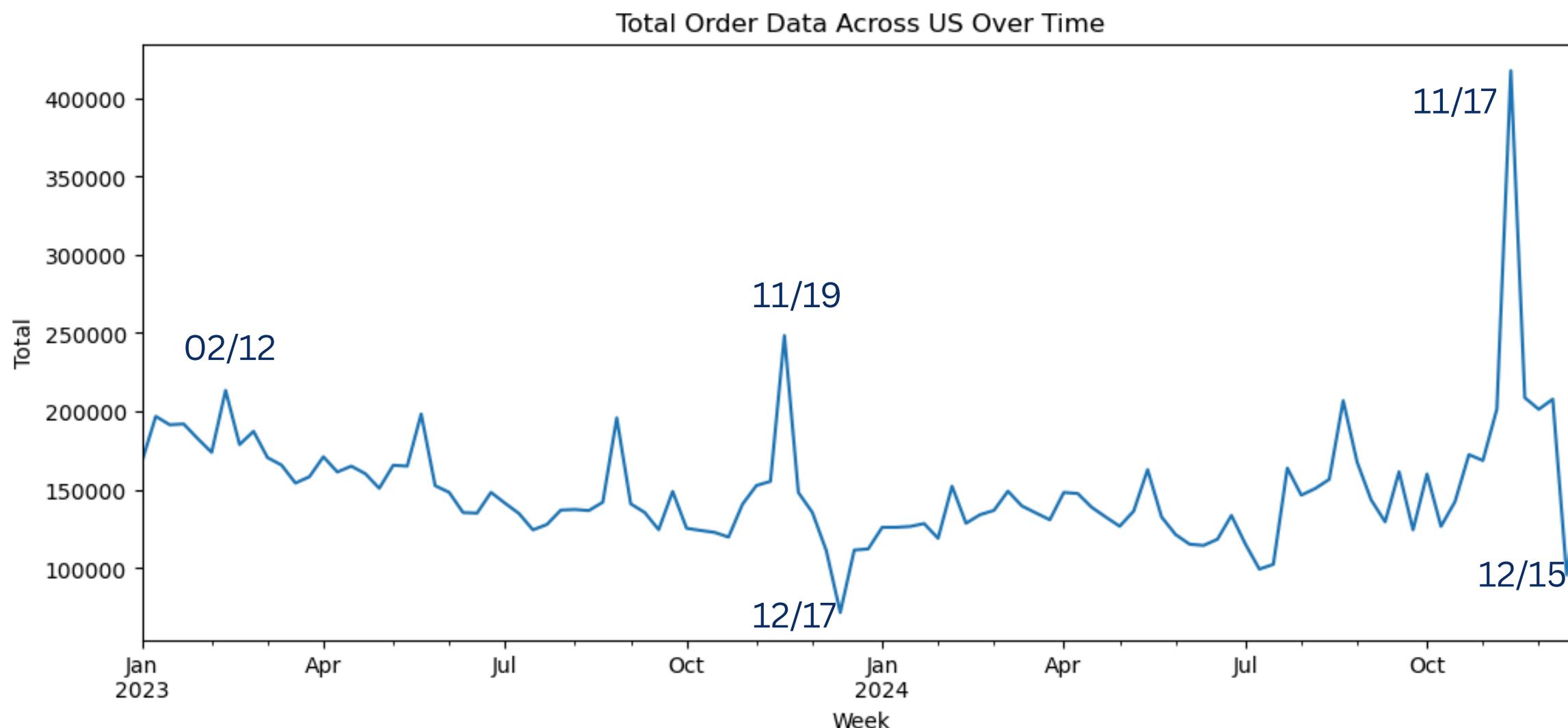
ACME - TreatmentPeriodOrders

- Treatment period (5 weeks) of weekly, state-level ACME order data for all 50 US states and Washington, DC.
- This data represents the treatment period (post-campaign launch), where we can see orders from when the campaign was deployed and, likewise, withheld.

Business Assumptions

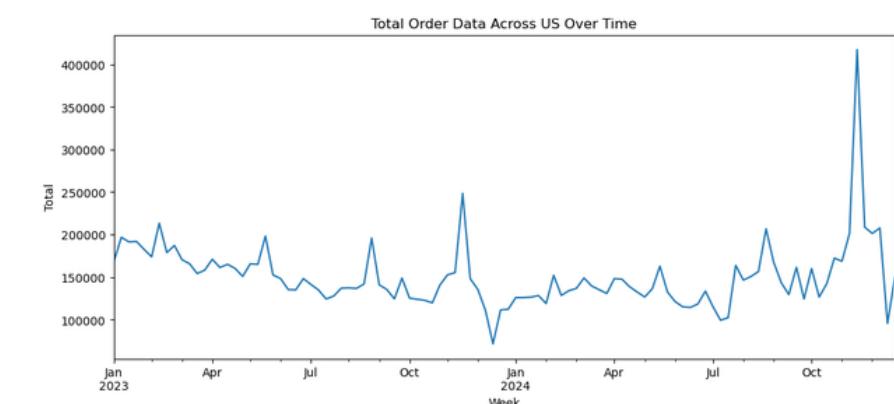
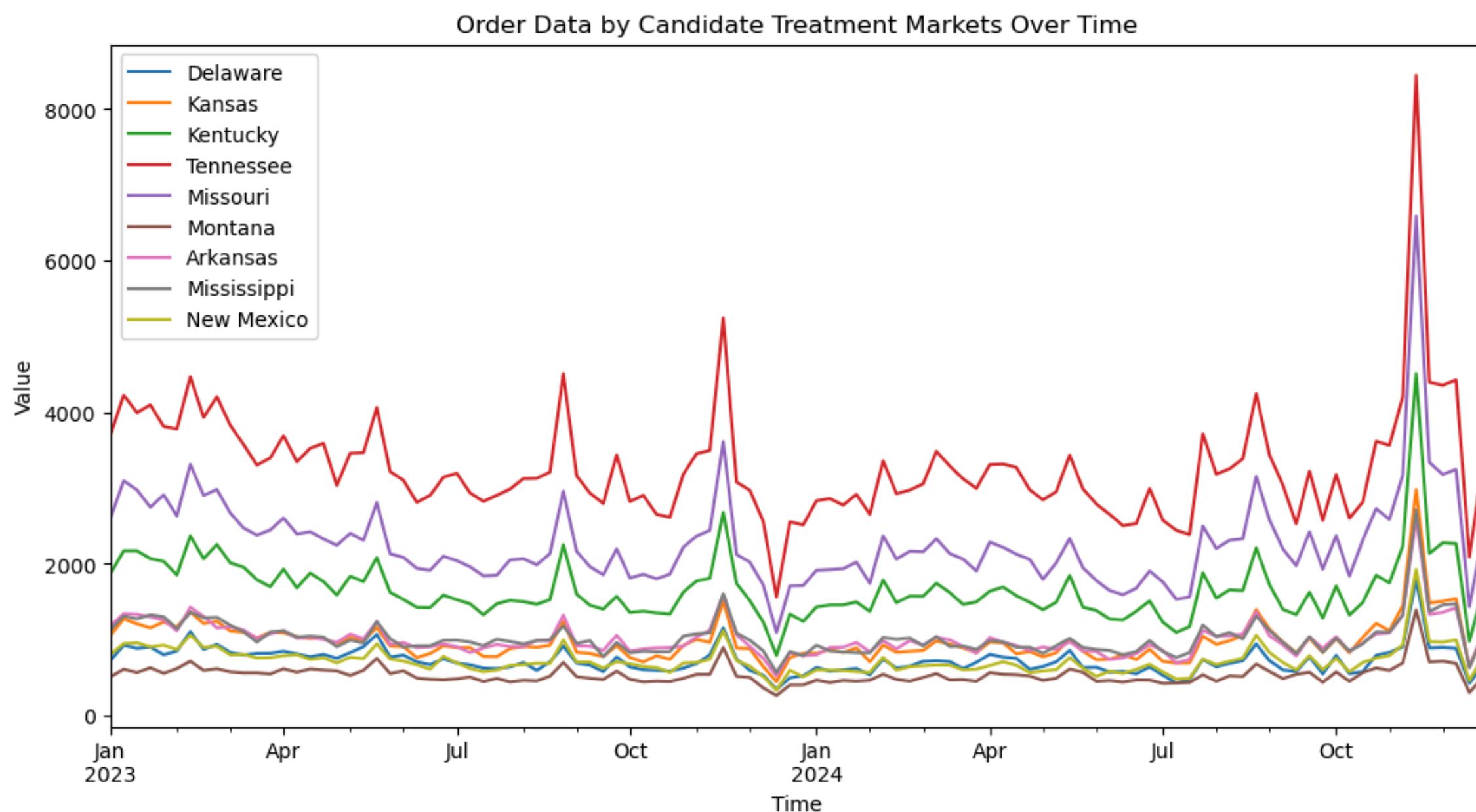
- Each order is valued at **\$200**, with a **30% profit margin** - each order equates to **\$60 profit**

Exploratory Data Analysis



	State	Average
0	California	14550.423077
1	Florida	13592.134615
2	Texas	10917.769231
3	New York	10866.701923
4	Pennsylvania	6012.057692
5	New Jersey	5638.961538
6	North Carolina	5491.336538
7	Georgia	5428.778846
8	Illinois	5335.269231
9	Ohio	4934.788462

Exploratory Data Analysis

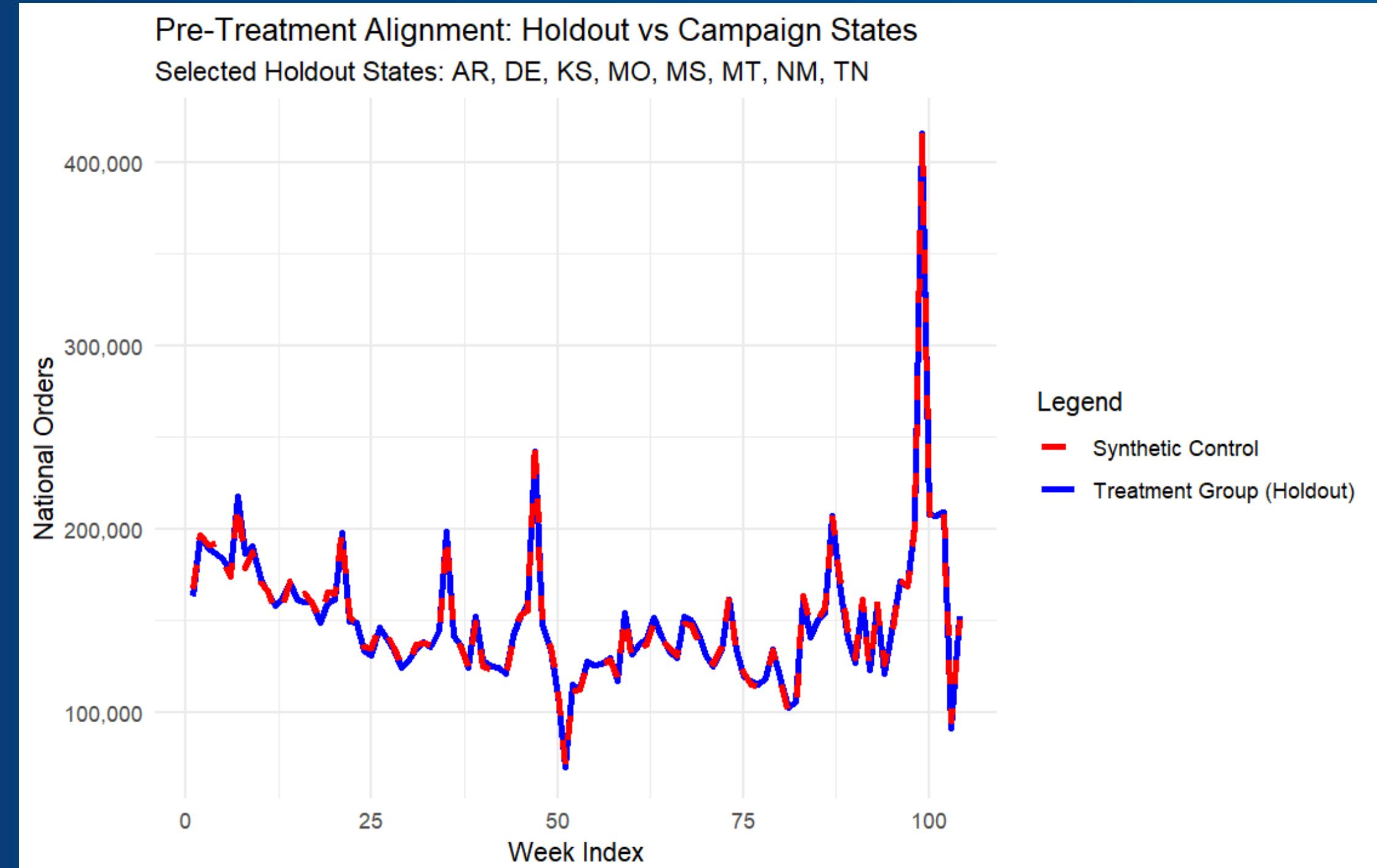


State	Average	Rank
Tennessee	3280.269231	15
Missouri	2277.721154	22
Kentucky	1662.278846	28
Mississippi	1021.932692	33
Arkansas	1009.826923	34
Kansas	974.865385	35
Delaware	720.903846	39
New Mexico	720.067308	40
Montana	533.057692	44

Experiment Design

Selecting the Treatment States

- **Geo - Holdout Design:** 9 states withheld from the campaign
- **LASSO Selection:** From LASSO, we resulted in 8/9 states + their optimal weights that best match national pre-treatment trends
- **Sparse & Interpretable:** Unused state (Kentucky) was dropped due to its coefficient being shrunk to 0
- **Fit Quality:** Pre-Treatment R-Squared = 0.991 → very high alignment
- **Why it matters:** Enables valid causal inference via synthetic control

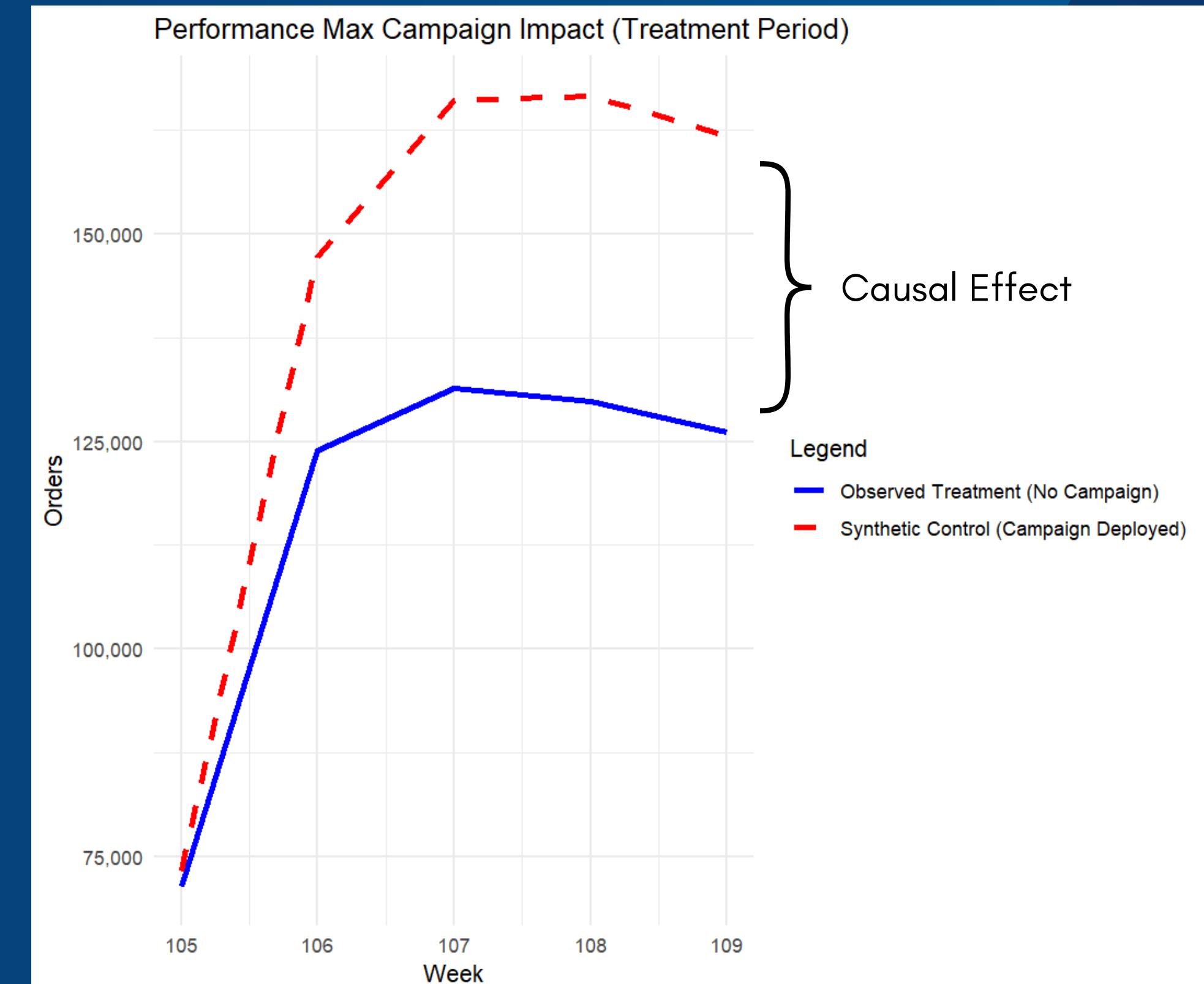


Experiment Outcome

Post-campaign, the observed holdout group **underperformed** the synthetic control built from the treated (campaign-active) states.

This consistent underperformance, visible week after week, shows that **the campaign had a strong positive effect on order volume.**

- Markets where the campaign was deployed **consistently outperformed** holdout markets
- Visible weekly gap between lines = Causal Effect
- Effect observed **immediately** upon campaign start



Effect Computation

We computed the national average weekly effect by comparing two models:

- (A) One trained on the 8 holdout states (no campaign)
- (B) One trained on synthetic control states (with campaign)

National Weekly Effect = No Campaign (A) - With Campaign (B)

National Average Weekly Effect = Average(National Weekly Effect)

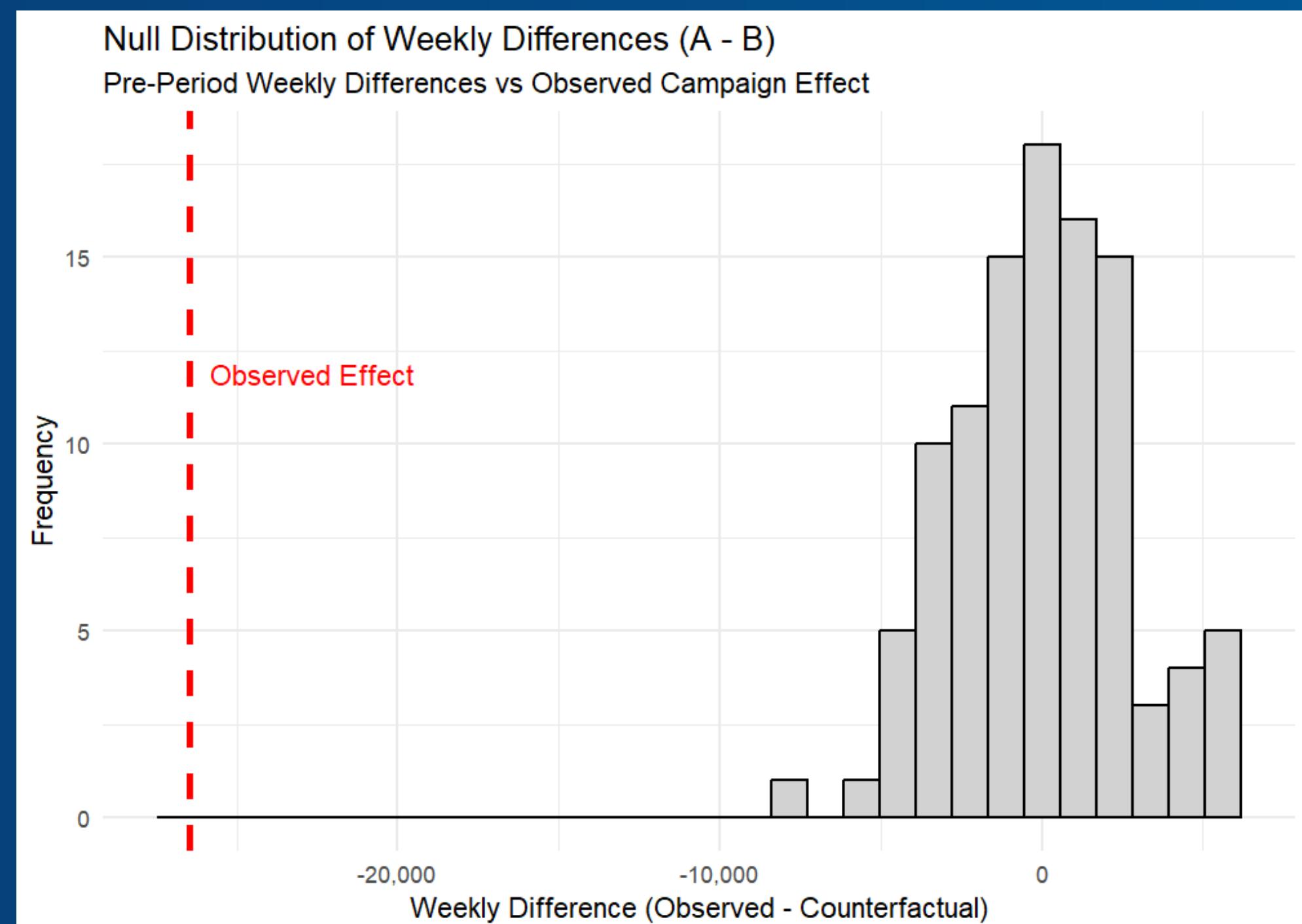
Metric	National Average Weekly Effect
Orders	-26,448.46
Revenue (x \$200)	-\$5,289,692.50
Profit (x 30%)	-\$1,586,907.75

Each week, ACME would have captured ~ 26.4K **additional orders** if the campaign had been run in holdout markets.

Hypothesis Test

How we tested our causal claim:

1. Construct a Null Distribution of Weekly Differences
 - Take the difference between the two national time series (A - B) during the pre-treatment period
 - Simulates “normal” week-to-week fluctuations
2. Compare to the Observed Treatment Effect
3. Empirical P-Value Calculation
 - Proportion of pre-treatment weekly differences that were as large/larger than the observed effect
 - **Empirical p-value = 0**
 - No week in the pre-period came close to this effect size
4. Reject Null Hypothesis of No Campaign Effect



Final Results & Conclusion

- ✓ **Strong Causal Evidence** that the Google Performance Max Campaign led to a significant increase in national-level orders for ACME
- ✓ Difference between holdout (no campaign) and synthetic national model (with campaign) is both **large** and **statistically significant**
- ✓ Empirical p-value = 0: The observed lift is well outside the range of historical fluctuations, allowing us to reject the null hypothesis of no campaign effect

Metric	With Campaign	Without Campaign	Difference	National Average <u>Weekly Effect</u> (Difference / 5)
Total Orders	715,069	582,827	132,242	26,448
Total Revenue (x \$200)	143,013,800	116,565,345	26,448,456	\$5,289,693
Total Profit (x 30%)	42,904,140	34,969,603	7,934,537	\$1,586,908



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**THANK YOU
FOR YOUR ATTENTION**



References

- Brodersen, K. H., Gallusser, F., Koehler, J., Remy, N., & Scott, S. L. (2015). *Inferring causal impact using Bayesian structural time-series models*. Annals of Applied Statistics, 9(1), 247–274.
- Lim, A. (2025). *Synthetic Controls Aren't Enough: Rethinking Geo-Experimentation for Causal Inference*. Measured Analytics Journal.
- Tibshirani, R. (1996). *Regression shrinkage and selection via the Lasso*. Journal of the Royal Statistical Society: Series B, 58(1), 267–288.