

Unit Selection Based on Counterfactual Logic for Business Decision Making

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Abstract

Many AI supported business decisions require selecting a subset of units such as customers, users, accounts, regions, or organizational entities for targeted actions including promotions, retention offers, recommendations, or resource allocation. The core difficulty in these settings is that the desired behavior of a unit is inherently counterfactual. Decision makers are interested in units that would respond positively if an action were applied and negatively if it were not, even though only one of these outcomes can ever be observed. Standard approaches in business analytics, including A/B testing, uplift modeling, and predictive scoring, do not explicitly represent this counterfactual structure and can therefore lead to inefficient or misleading selection decisions.

We formulate unit selection using structural causal models and counterfactual logic (Li and Pearl 2019, 2022b, 2024). Instead of ranking units solely by predicted outcomes, we characterize each unit by its latent response pattern under alternative actions. These patterns include units that benefit only when an action is applied, units that respond regardless of whether an action is taken, units that never respond, and units that may respond negatively to intervention. While these response patterns are not directly observable, they provide a principled basis for defining decision value and align naturally with business objectives such as maximizing profit, engagement, or satisfaction.

We define a value based objective function that assigns explicit benefits and costs to each possible response pattern, reflecting how managers actually evaluate interventions in practice. This formulation makes clear that selection rules based solely on differences between treatment and control outcomes need not align with decision value. In particular, a large treatment effect may be driven by units that would have responded even without intervention, while units whose behavior truly depends on the action remain indistinguishable under standard evaluation criteria. This mismatch explains why commonly used heuristics can lead to inefficient or even counterproductive targeting decisions (Li and Pearl 2022a).

In general business environments, these latent response patterns are not identifiable from data. Rather than attempt-

ing to recover them directly, we show that the proposed counterfactual objective can be bounded using experimental and observational information. We further characterize special cases in which the counterfactual objective simplifies and coincides with standard A/B test based selection rules, thereby clarifying when such heuristics can be justified and when they cannot.

We illustrate the proposed framework using business scenarios such as customer retention and online advertising. These examples show that selection based on counterfactual value can lead to different targeting decisions than those obtained from standard A/B test based methods. In particular, units with favorable observed treatment effects are not necessarily those that yield the highest expected benefit once costs and unintended responses are taken into account. The results demonstrate that ignoring the counterfactual structure of the problem can lead to inefficient allocation of interventions.

Finally, the formulation clarifies the distinction between prediction and decision making in unit selection. Predictive models estimate observed outcomes, whereas selection decisions depend on unobserved outcomes under alternative actions that cannot be jointly observed, even in randomized experiments. By expressing the selection problem directly in counterfactual terms and linking it to explicit cost and benefit assessments, the framework provides a principled basis for evaluating selection strategies in business settings.

References

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