

# Introduction to Uplift Modeling

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# Motivation

How can we optimally select customers to be treated by marketing incentives?



We can not **send** and **not send** incentives to the same customers at the same time



# What is Uplift Modeling?

From [Gutierrez, P., & Gérardy, J. Y. \(2017\). "Causal Inference and Uplift Modelling: A Review of the Literature"](#)

- Uplift modeling refers to the set of techniques used to model the incremental impact of an action or treatment on a customer outcome.
- Uplift modeling is therefore both a Causal Inference problem and a Machine Learning one.

# Conditional Average Treatment Effect

- Let  $Y_i^1$  denote person  $i$ 's outcome when it receives the treatment and  $Y_i^0$  when it does not receive the treatment.
- We are interested in understanding the *causal effect*  $Y_i^1 - Y_i^0$  and the *conditional average treatment effect*  $CATE = E[Y_i^1 | X_i] - E[Y_i^0 | X_i]$ , where  $X_i$  is a feature vector of the  $i$ -th person.
- **However, we can not observe them!** 😞

# Uplift

Let  $W_i$  is a binary variable indicating whether person  $i$  received the treatment, so that

$$Y_i^{obs} = Y_i^1 W_i + (1 - W_i) Y_i^0$$

## Unconfoundedness Assumption

If we **assume** that the treatment assignment  $W_i$  is independent of  $Y_i^1$  and  $Y_i^0$  conditional on  $X_i$ , then we can estimate the *CATE* from observational data by computing the empirical counterpart:

$$\mathbf{uplift} = \widehat{CATE} = E[Y_i | X_i, W_i = 1] - E[Y_i | X_i, W_i = 0]$$

# Solo Model

## Training

$$\underbrace{\begin{pmatrix} x_{11} & \cdots & x_{1k} & w_1 \\ \vdots & \ddots & \vdots & \vdots \\ x_{n1} & \cdots & x_{nk} & w_n \end{pmatrix}}_{X \oplus W} \xrightarrow{f} \begin{pmatrix} y_1 \\ \vdots \\ y_n \end{pmatrix}$$

## Uplift Prediction

$$\hat{f} \begin{pmatrix} x_{11} & \cdots & x_{1k} & 1 \\ \vdots & \ddots & \vdots & \vdots \\ x_{m1} & \cdots & x_{mk} & 1 \end{pmatrix} - \hat{f} \begin{pmatrix} x_{11} & \cdots & x_{1k} & 0 \\ \vdots & \ddots & \vdots & \vdots \\ x_{m1} & \cdots & x_{mk} & 0 \end{pmatrix}$$

# Some python implementations

- `causalml`



- `scikit-uplift`



uplift modeling in scikit-learn style in python



## References:

- Gutierrez, P., & Gérardy, J. Y. (2017). "Causal Inference and Uplift Modelling: A Review of the Literature"
- Karlsson, H. (2019) "Uplift Modeling: Identifying Optimal Treatment Group Allocation and Whom to Contact to Maximize Return on Investment"

# Thank you!

More Info: [juanitorduz.github.io/](https://juanitorduz.github.io/)

