AC297r: IACS Capstone Project

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Impact of Fast Shipping on Sales

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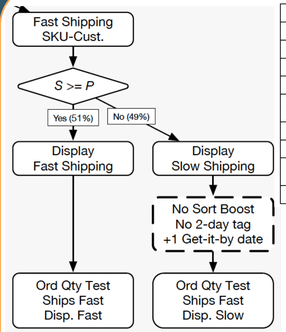
Overview and Objectives

1) **Estimate the average boost in sales** on different scopes
2) **Measure the marginal effect of sales boost**: how the sales boost changes as the portion of products offered with fast shipping increases.
3) **Identify key product characteristics** that will make the product sales **more sensitive to fast shipping.**

Experimental Design



Item	S-value	Fast Shipping	Attr
Couch X	25	False	...
Couch X	25	True	...
Couch X	26	False	...
Couch X	26	True	...
⋮	⋮	⋮	⋮
Couch X	75	True	...
Chair Z	25	False	...
⋮	⋮	⋮	⋮
Chair Z	75	True	...

Attributes: 1) Impression count
2) Average sort rank
3) Product display page click count
4) Order count
5) Quantities ordered
6) Other generic product attributes…

Treatment Effect Definition

- $Y_i(t_i)$: observed outcome for the chosen treatment → number of orders (numord), the quantity ordered (qtyord), etc.
- t_i: the treatment → fast shipping flag (0 or 1)
- x_i : covariates used for heterogeneity (i.e., the variable that interacts with the treatment) → **S-value**
- w_i : other parameters that might affect our response variables → generic product attributes like previous sales, rating, price, etc.

We assume the outcome **Y** is linear in the treatment vector, and we assume the following structure for our target quantity **τ** (heterogeneous treatment effect):

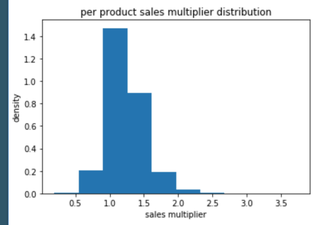
$$Y = H(X,W)T + g(X,W,\epsilon)$$
$$T = f(X,W,\eta)$$
$$\tau(t1,t0,x) = E[H(X,W) \mid X = x](t_1 - t_0)$$

Here **η** and **ϵ** are noise factor added, and **H, g, f** are functions.

Task 1: average boost in sales

Aggregation: total number of orders

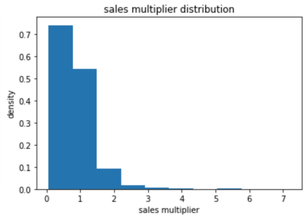
25% more sales



Issues:
Not factoring in the increase product exposure due to the sort-boost effect of fast-shipping.

Conversion rate: nb. of orders / nb. of impressions

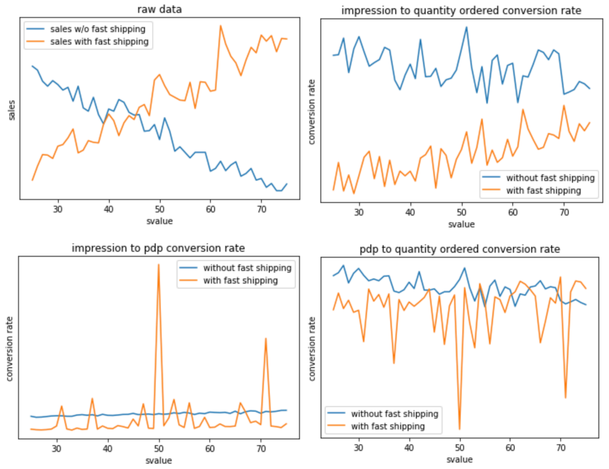
46% more sales



Issues:
Only 30% products receive sales boost under this framework. Estimate only applies to these products.

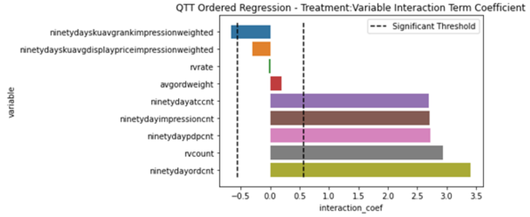
Task 2: impact of S-value

How various quantities of interest change as S-value changes:



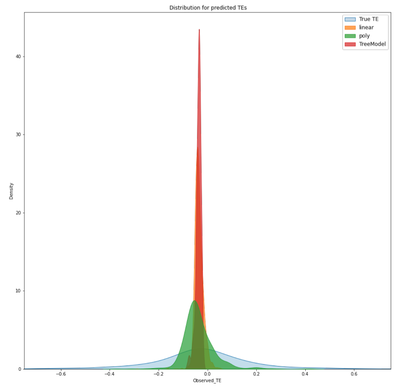
Task 3: important product features

Treatment Effect: absolute increase in number of orders
Baseline Model -- Linear Regression



Treatment Effect: increase in conversion rate
Model Performance Comparison

Variable	Model	MSE Score	95% Confidence Interval Accuracy
$TE(log(\frac{N_{atc}}{N_{pdp}}))$	Causal Forest	0.097	15.8%
$TE(log(\frac{N_{atc}}{N_{impression}}))$	Causal Forest	0.087	17.2%
$TE(log(\frac{N_{atc}}{N_{impression}}))$	LinearDRL with Polynomial Feature	0.06	42%



Coefficient Results

	point_estimate	stderr	zstat	pvalue	ci_lower	ci_upper
ninetydayskuavgdisplaypriceimpressionweighted	-0.004	0.018	-0.2	0.841	-0.033	0.026
ninetydayskuavgrankimpressionweighted	0.014	0.056	0.254	0.8	-0.077	0.105
rvrate	-0.02	0.019	-1.043	0.297	-0.052	0.012
avgordweight	0.006	0.016	0.4	0.689	-0.02	0.033
ninetydayordcnt	-0.023	0.017	-1.324	0.186	-0.061	0.006
ninetydayskuavgdisplaypriceimpressionweighted ninetydayskuavgrankimpressionweighted	-0.014	0.03	-0.462	0.644	-0.063	0.035
ninetydayskuavgdisplaypriceimpressionweighted rvrate	0.01	0.022	0.432	0.666	-0.027	0.046
ninetydayskuavgdisplaypriceimpressionweighted avgordweight	-0.004	0.006	-0.642	0.521	-0.013	0.006
ninetydayskuavgdisplaypriceimpressionweighted ninetydayordcnt	0.004	0.008	0.56	0.576	-0.008	0.017
ninetydayskuavgrankimpressionweighted rvrate	0.022	0.034	0.635	0.526	-0.034	0.078
ninetydayskuavgrankimpressionweighted avgordweight	-0.013	0.028	-0.461	0.645	-0.059	0.033
ninetydayskuavgrankimpressionweighted ninetydayordcnt	-0.029	0.026	-1.096	0.273	-0.071	0.014
rvrate avgordweight	-0.002	0.015	-0.11	0.913	-0.027	0.023
rvrate ninetydayordcnt	-0.004	0.01	-0.413	0.68	-0.021	0.013
avgordweight ninetydayordcnt	-0.001	0.006	-0.187	0.852	-0.012	0.009

Key findings: For popular products, adding fast shipping label won't have a significant contribution in boosting conversion rate.

Conclusion

Aggregation-based approach:

1. **25%** increase in sales.

2. We can expect that order number and quantities sold scale **linearly** as s-value increases.

Conversion rate-based approach:

1. **46%** more sales for products whose conversion rates does not degrade with fast-shipping.

2. The effect of fast-shipping has a much larger impact on the **conversion rate from product display page clicks to quantities ordered**, than the conversion rate from the impression to product display page clicks. The conversion rate from impression to quantities ordered with fast-shipping increases as s-value increases.

3. For popular products, adding fast shipping label won't have a significant contribution in boosting conversion rate.

Acknowledgements

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Reference

1. Chipman, H. et al. "BART: Bayesian Additive Regression Trees." *The Annals of Applied Statistics* 4 (2010): 266-298.
2. Wagner, S. and S. Athey. "Estimation and Inference of Heterogeneous Treatment Effects using Random Forests." *Journal of the American Statistical Association* 113 (2015): 1228 - 1242.
3. EconML: Python SDK, developed by the ALICE team at MSR New England
4. GRF: Generalized Random Forest, a pluggable package for forest-based statistical estimation and inference.