

Signaling Speed & Quality Through Staffing Decisions

INFORMS 2019



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with Serguei Netessine (Wharton)



People Still Shop Offline

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Forbes

10,825 views | Mar 29, 2019, 06:15pm

Consumers Are Spending More Per Visit In-Store than Online. What Does This Mean for Retailers?



Why More Online Retailers Are Opening Brick-And-Mortar Locations

September 26, 2019 · 5:00 AM ET

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Discover/Experience/Fit

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Discover/Experience/Fit

npr

Why More Online Retailers Are Opening Brick-And-Mortar Locations

September 26, 2019 · 5:00 AM ET

RETAIL THERAPY

Before: Sad.



After: sad but in a fabulous outfit



©Sarah Andersen

Emotional Aspect





Perception of Queues



Perception of Queues

Customers join
longer queue

Veeraraghavan & Debo 2009



Long lines signal
high quality

Debo, Rajan, Veeraraghavan 2019

Longer wait,
consume more

Ulku, Hydock, Cui 2019

Perception of Queues



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No effect of queue
length on joining

Aksin, Gencer, Gunes 2019

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Quality vs Speed

Perception of Queues



Modeling
Customers join
longer queue

Veeraraghavan & Debo 2009

Modeling
Long lines signal
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Debo, Rajan, Veeraraghavan 2019

Experiments
Customers join
shorter queue

Conte, Scarsini, Surucu 2016

Experiments
Longer wait,
consume more

Ulku, Hydock, Cui 2019

Experiments
No effect of queue
length on joining

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Empirical

Quality vs Speed

EXIT



TIXE



Staff

Staff

Staff

Staff

Staff

Staff

Staff

Staff

Impact of Staffing

Store associate's availability to help
= most important factors impacting sales

Fisher, Krishnan, Netessine 2006, Ton & Huckman
2008, Kesavan, Staats, Gilland 2014, Kesavan,
Deshpande, Lee 2014, Ton 2011, Mani, Kesavan,
Swaminathan 2015



Impact of Staffing

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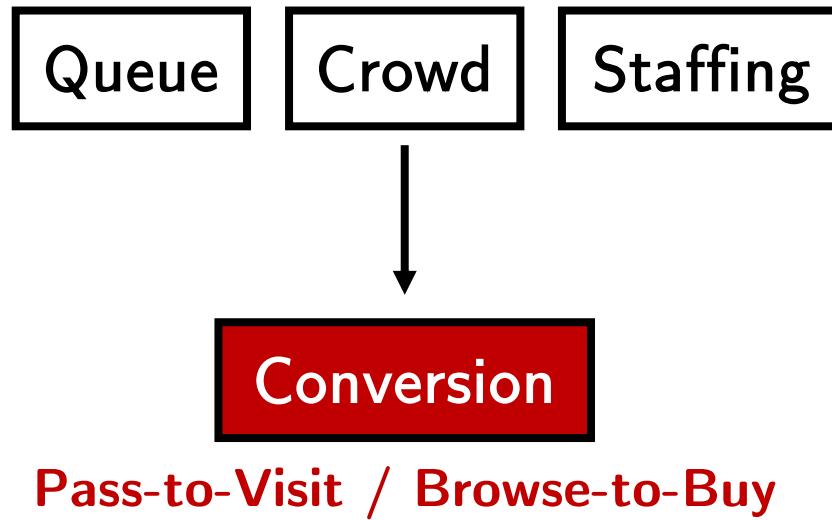
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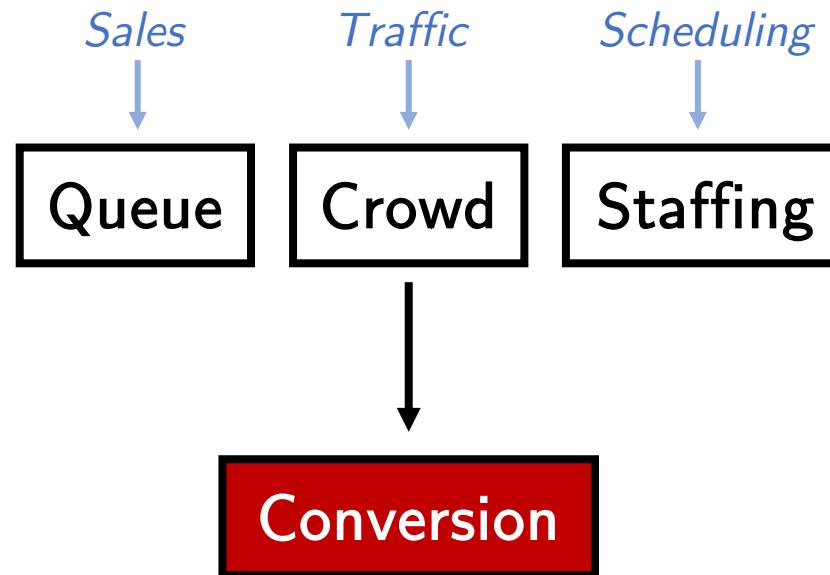
More proactive salesperson
-> higher store perception + higher sales
+ higher conversion from browsers to buyers

Naylor & Frank 2000, Fisher 2014,
Chang, Oliva, Perdikaki 2016

Our Paper



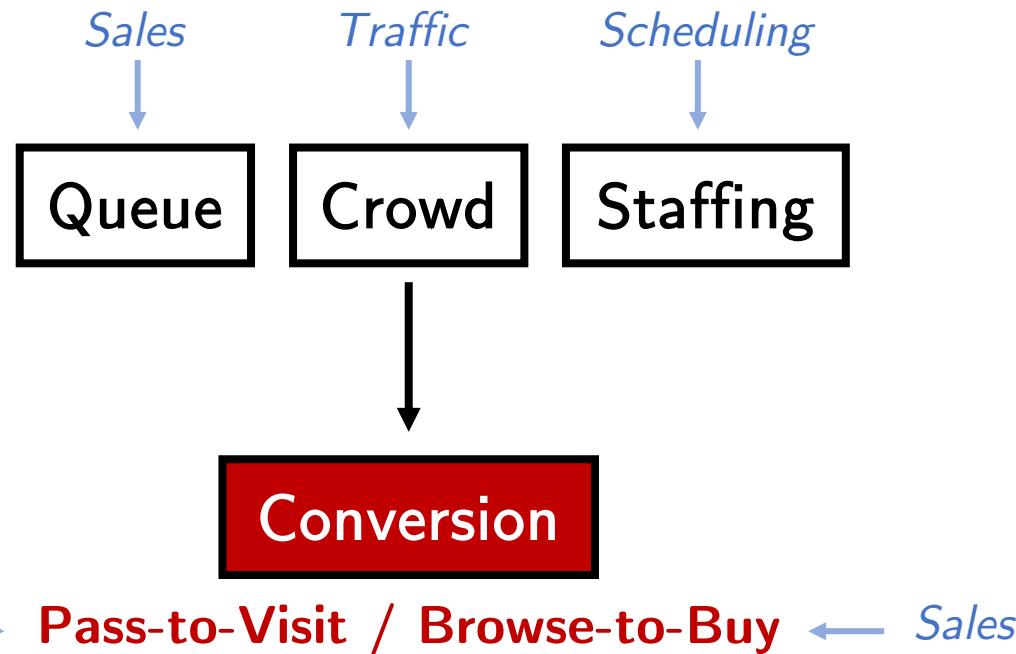
Our Paper



Pass-to-Visit / Browse-to-Buy

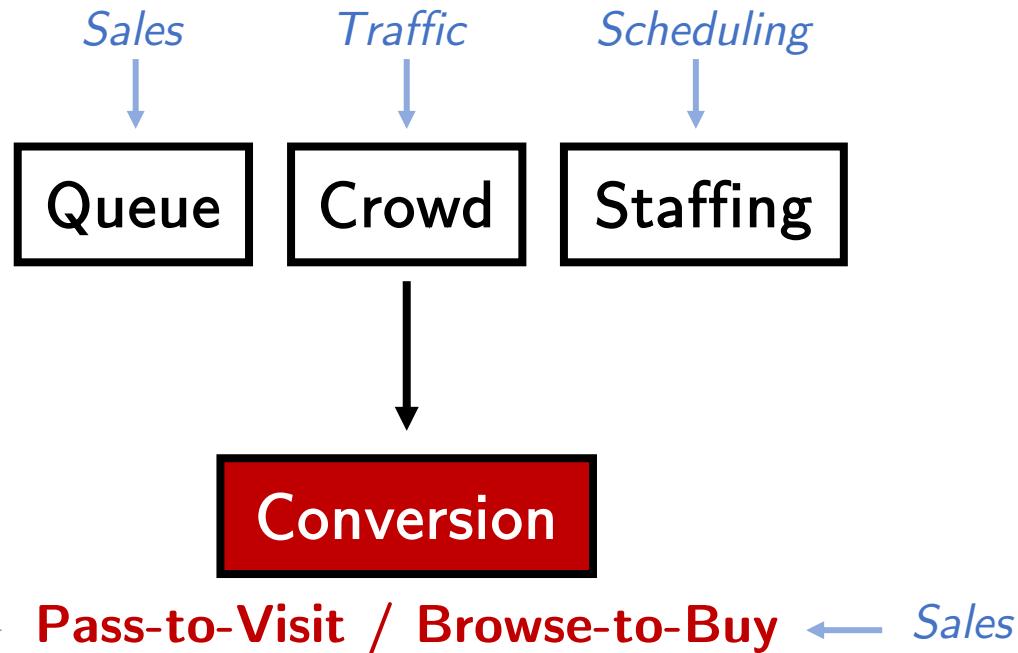
Today: *Shoe Retail*
Data/Inference

Our Paper



Today: *Shoe Retail*
Data/Inference

Our Paper



Today:

Shoe Retail *Econometrics/Matched Pairs*
Data/Inference Preliminary Analysis

Footwear Industry



\$79.86B
2017 total revenue

42.6%
Spending on shoes

Footwear Industry



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86%
More than half of purchases
at physical stores (2018)



Footwear Industry



\$79.86B
2017 total revenue

42.6%
Spending on shoes



86%
More than half of purchases
at physical stores (2018)

70%

Frustrated with in-store
experience the last 6 months

Data

US Shoe Retail Chain

- Athletic footwear and apparel retail chain
- 136 stores in the US (majority in CA and TX)

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- 136 stores in the US (majority in CA and TX)
- “separated itself from the competition by making sales secondary to the customer.”

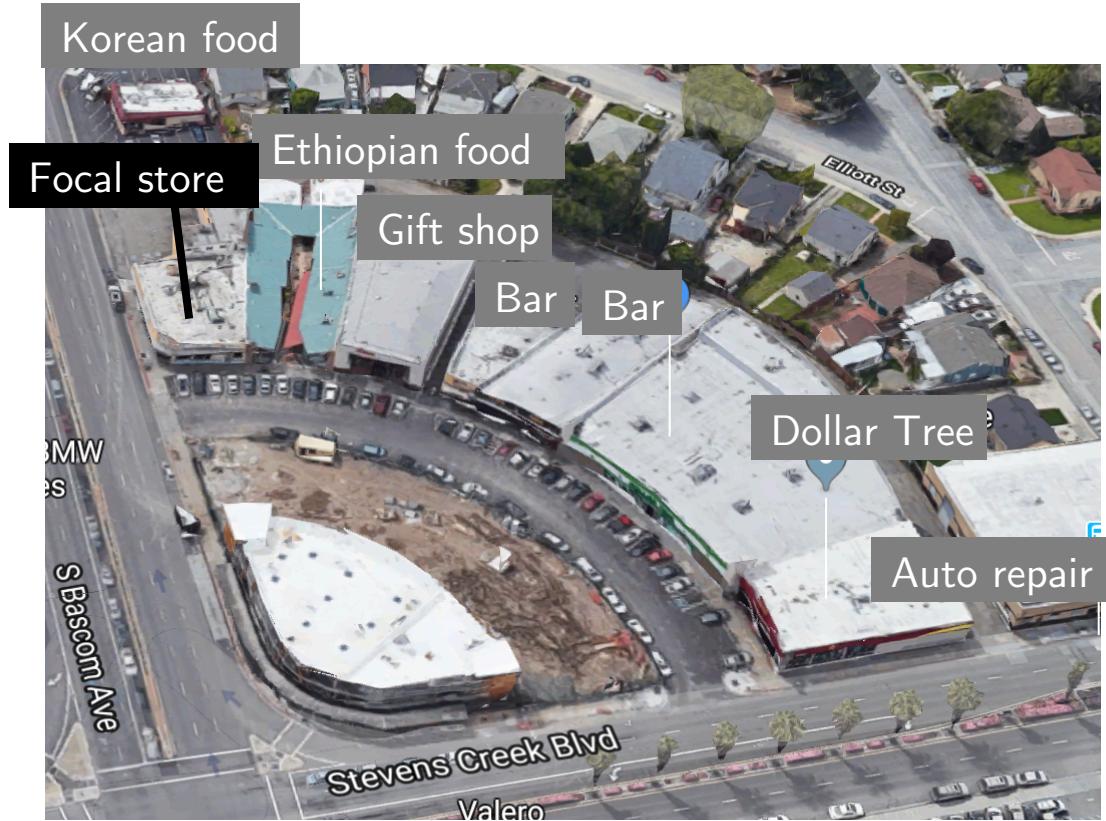
Data

US Shoe Retail Chain

- Athletic footwear and apparel retail chain
- 136 stores in the US (majority in CA and TX)
- “separated itself from the competition by making sales secondary to the customer.”
- **Unique data:** Traffic Sales Staffing Schedule

Data Single Store Study

- San Jose, California
- 2014/12 to 2018/5



Data Single Store Study

- San Jose, California
- 2014/12 to 2018/5



“[Felix](#), the store manager is always there making customers feel like family and is willing to help in any way possible.” in 2 reviews

★★★★★ 5/25/2019

1 check-in

Everyone at this store was very friendly and attentive. Everyone that I encountered were knowledgeable about the their shoes and let me know all the great deals. I ended up grabbing a pair of the bone white Jordan 1. They even sprayed it down with Superior Proofer to keep it white longer!

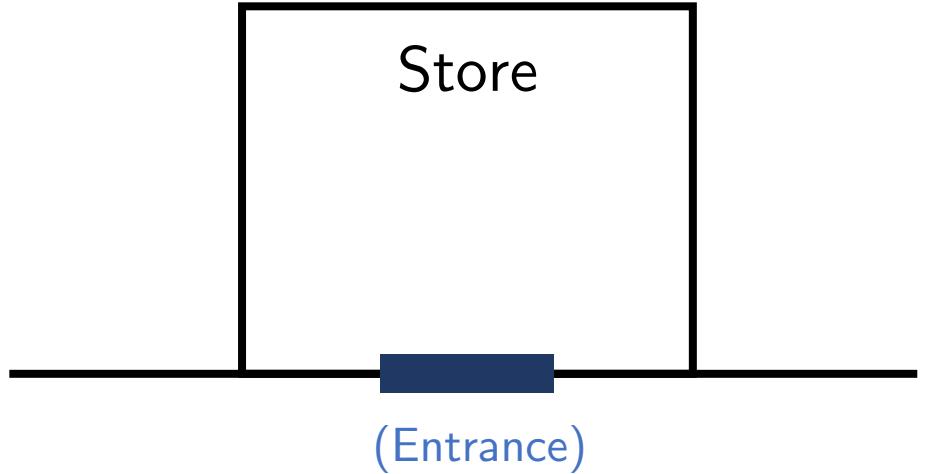
★★★★★ 10/10/2019

Thanks to Diddy and staff for helping me get a clean pair of Classic Vans... if it weren't for my big ol feet I would've grabbed a pair of Air Max. Lol Unfortunately the store didn't have my size. Love the customer service, again thanks to Diddy. Wide selection of sneakers.

Data Traffic

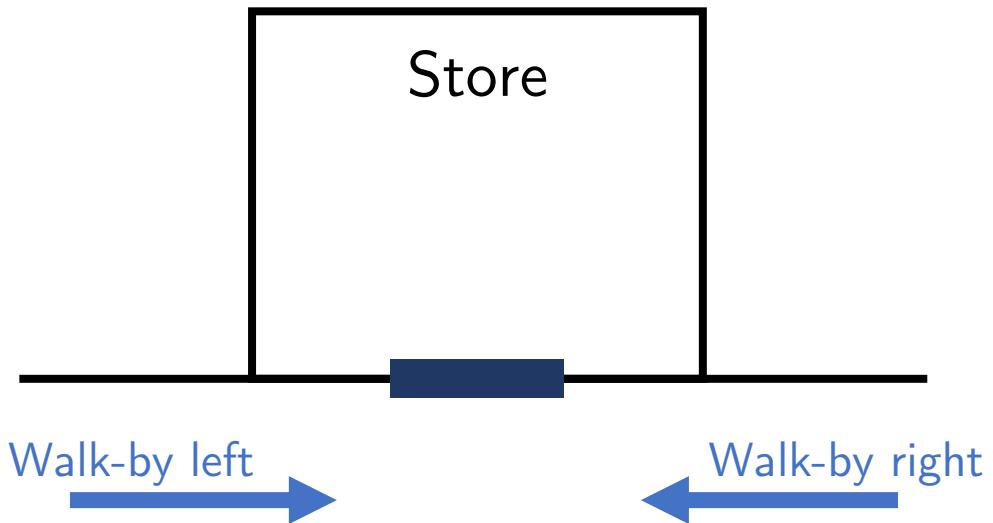
(Top View)

- Every 15 minutes



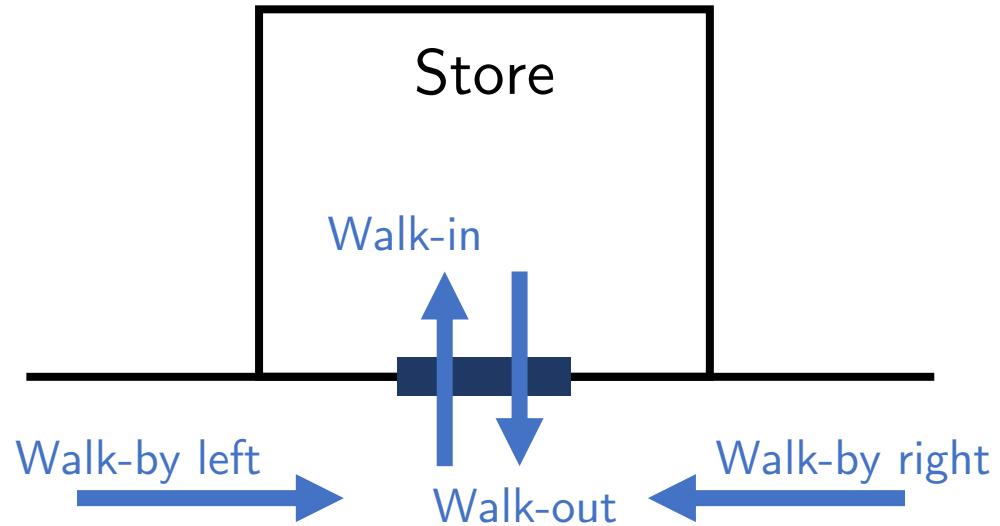
Data Traffic

- Every 15 minutes



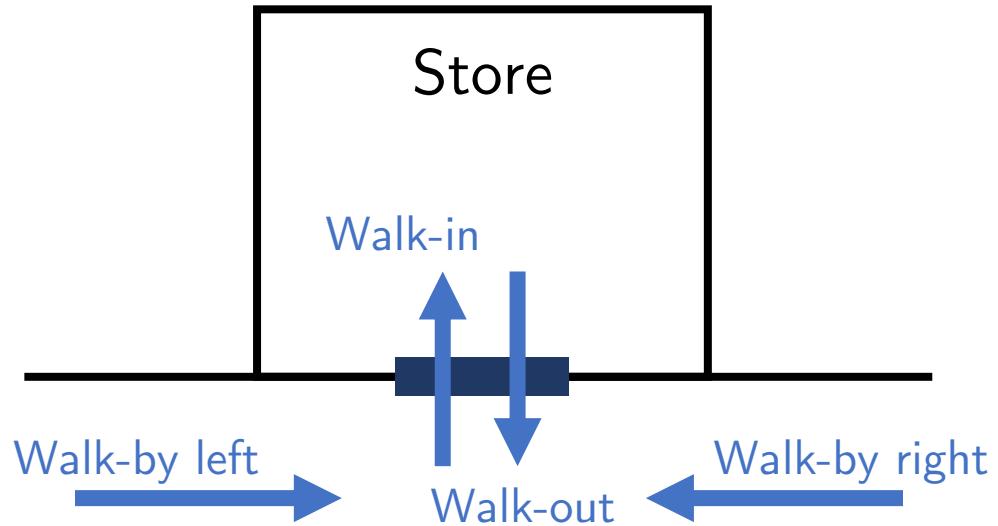
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- Every 15 minutes



Data Traffic

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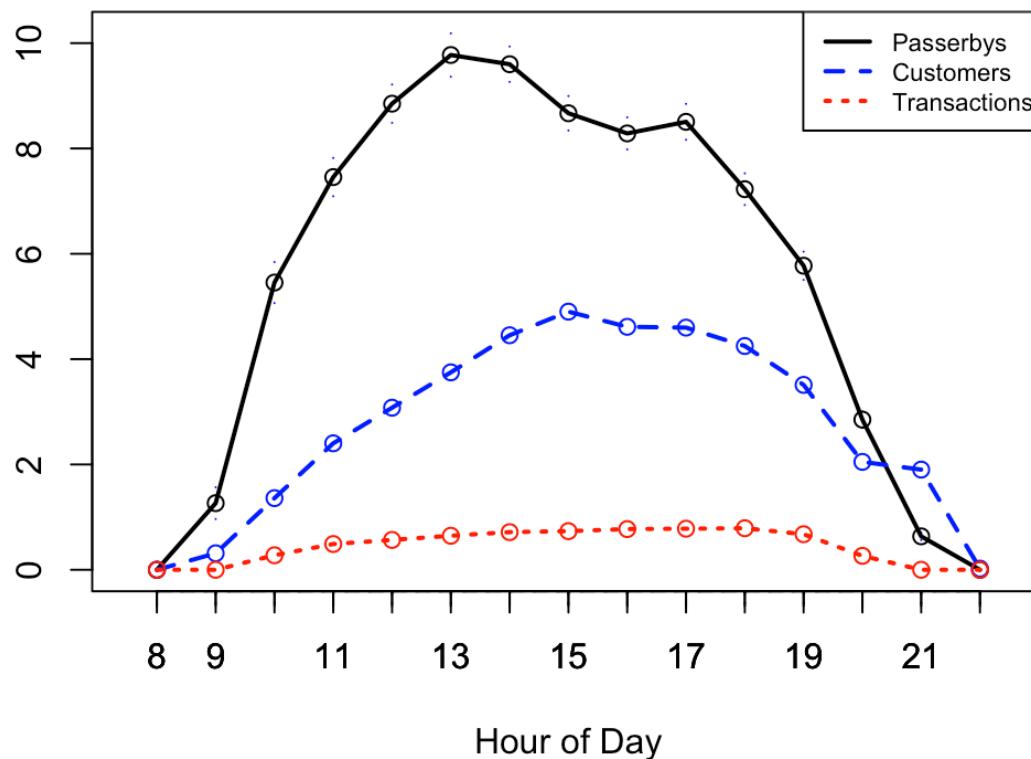


- We can infer
 - The number of customers inside the store every 15 minutes
 - The conversion rate of passerby visiting the store

Inference

Crowd and Conversion

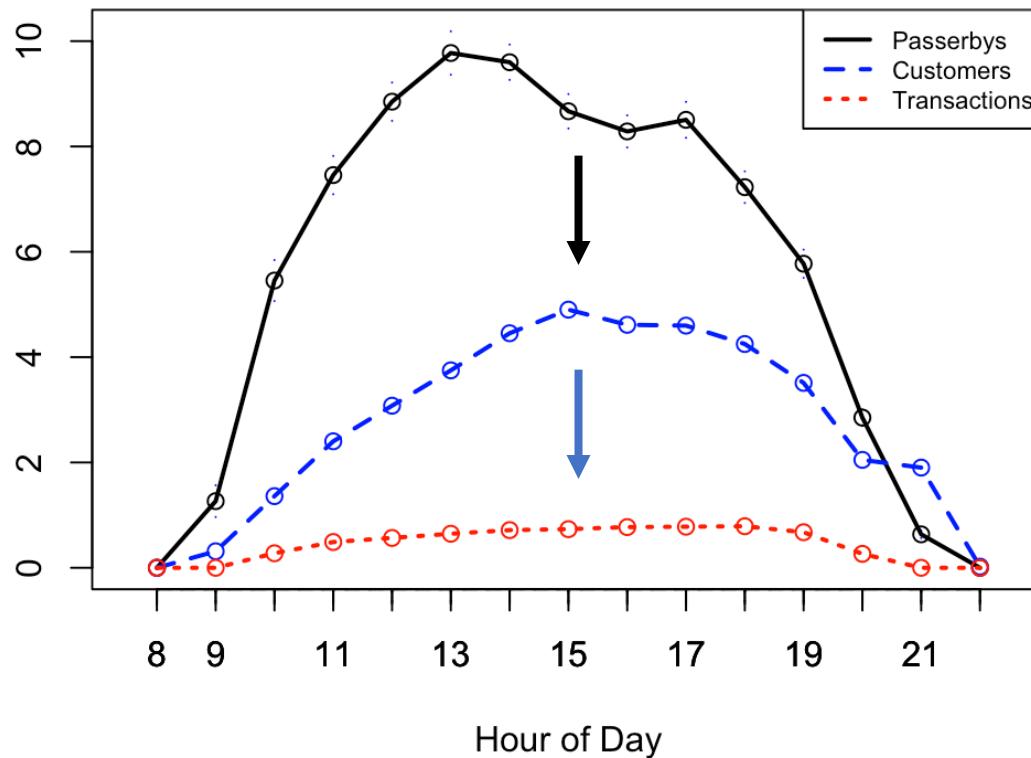
Customers: 0-37, mean: 3.28, sd: 3.37, 23% no customers



Inference

Crowd and Conversion

Customers: 0-37, mean: 3.28, sd: 3.37, 23% no customers



Mean conversion: 37.02% (visit), 18.16% (buy)

Data Sales

- Item-level log

- Transaction ID (assume 1 transaction/unique customer)
- Employee ID (who was at the register)
- Item description, quantity (negative if returns), price
- Timestamp

5,256 unique products

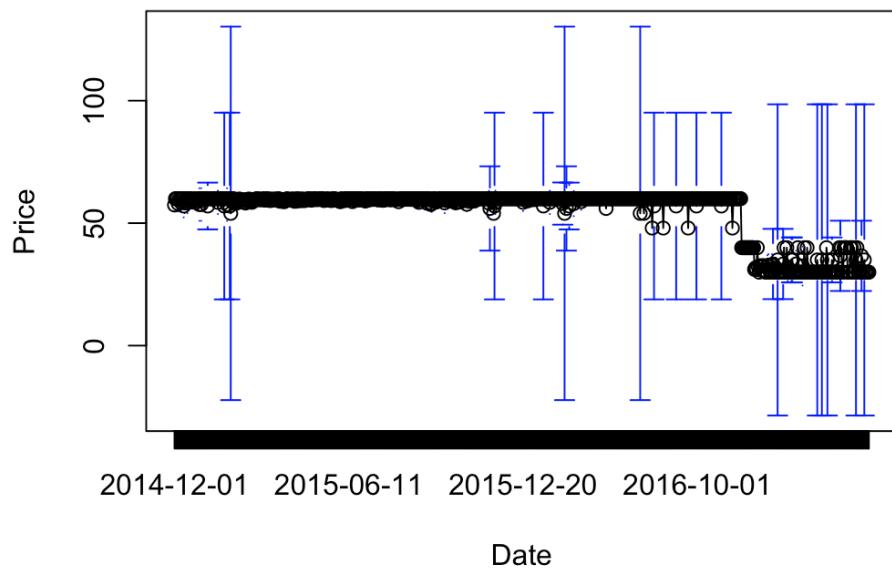
Data Sales

5,256 unique products

- Item-level log
 - Transaction ID (assume 1 transaction/unique customer)
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 - Item description, quantity (negative if returns), price
 - Timestamp
- We can infer
 - Price trajectories of each product
 - Queueing characteristics

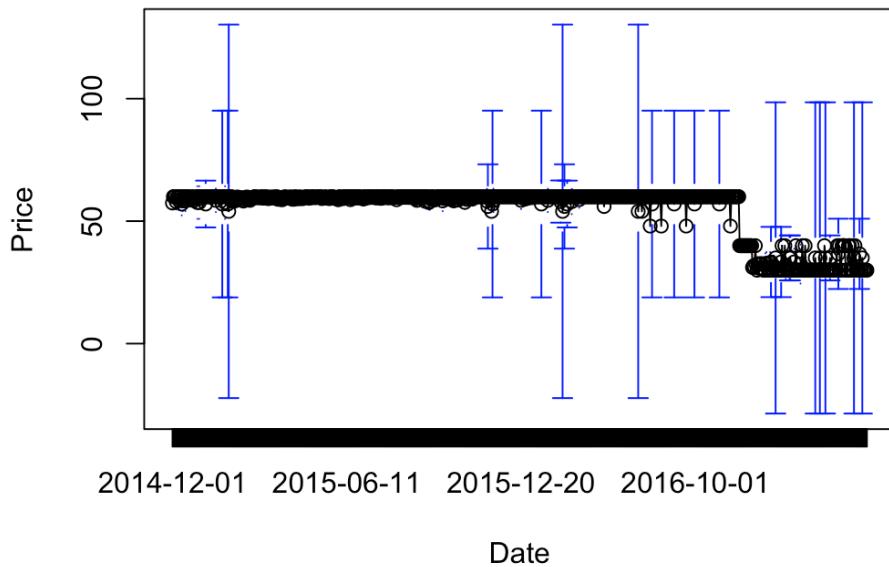
Inference

Promotions



Inference

Promotions

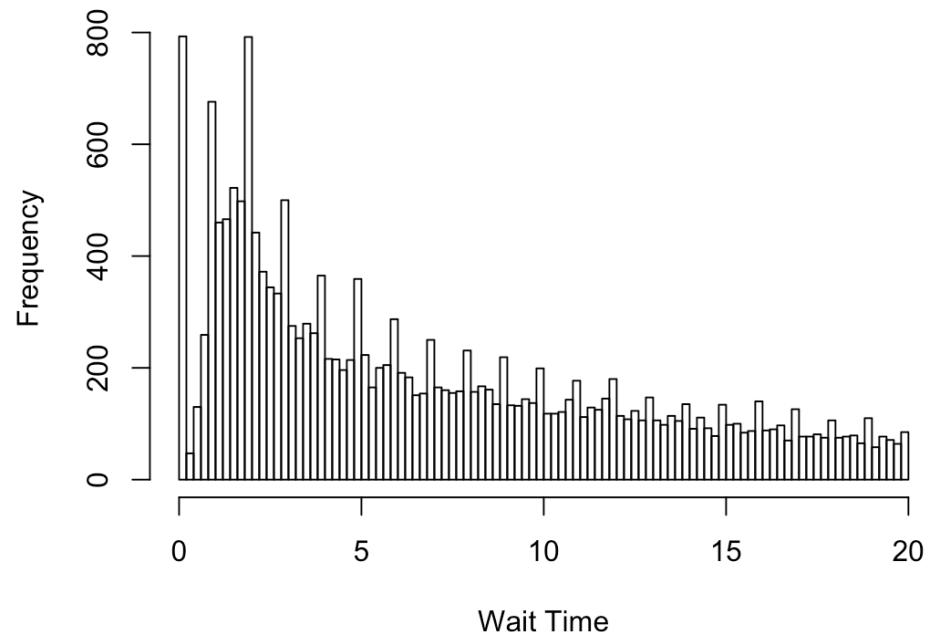


- On average, 22% of transactions have a discounted product.
- Prices:
 - 59% of items only 1 price
 - 29% with 2, 9% with 3
- Discount level:
 - Mean: 31.43%
 - Median: 27.28%

Inference

Queueing Characteristics

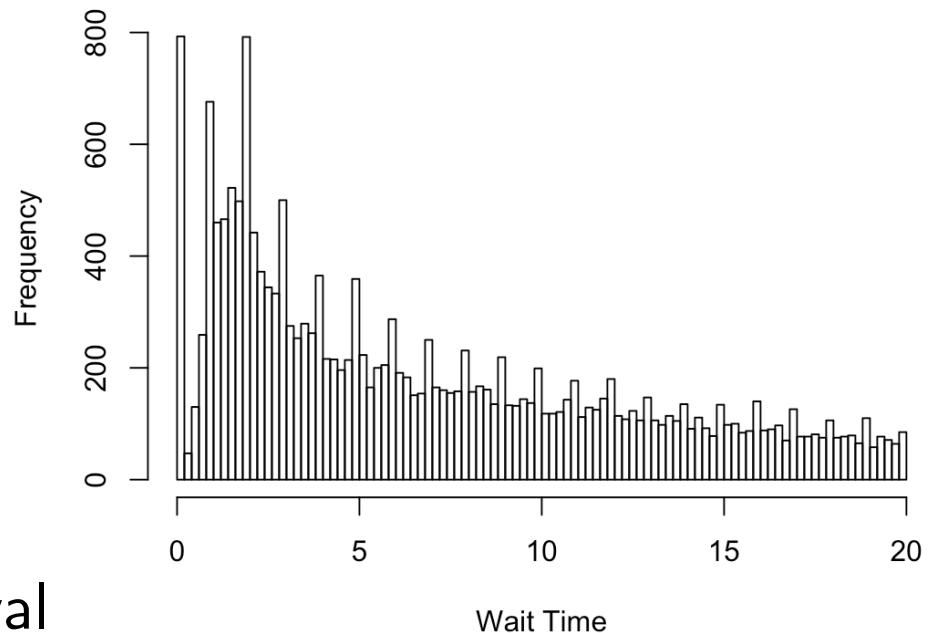
- Inspired by Bertsimas & Servi (1987)
- 42% wait time at most 5 minutes.



Inference

Queueing Characteristics

- Inspired by Bertsimas & Servi (1987)
- 42% wait time at most 5 minutes
- For this talk, we'll use **the number of transactions** in the interval as a proxy for queue length.



Data Staffing Schedule

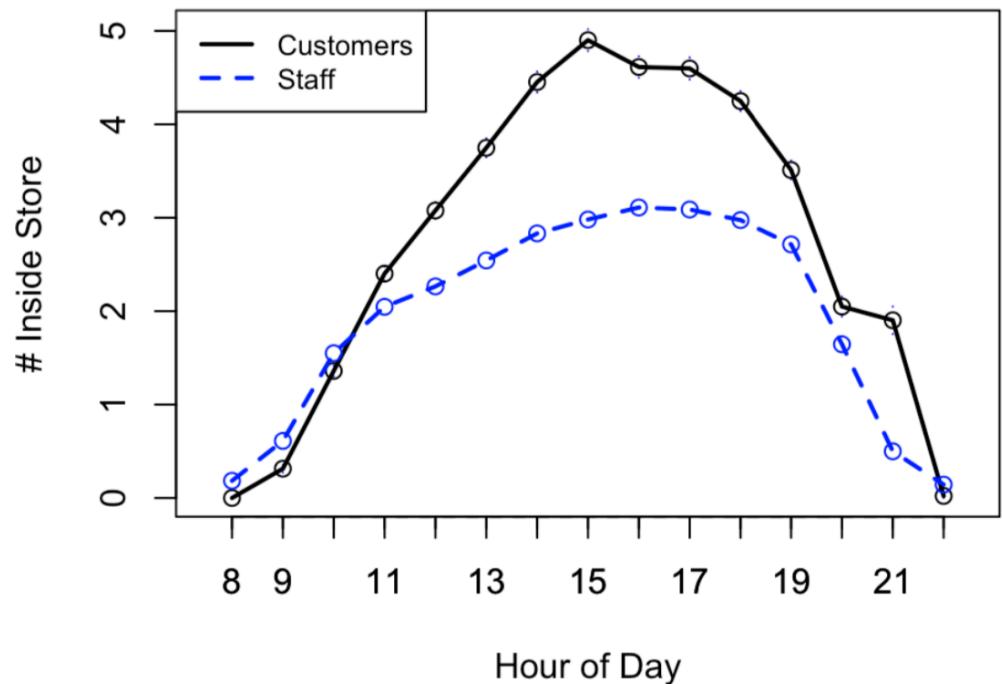
- Employee-level data
 - Time in and time out of every employee of the store
 - Employee ID
 - Employee name
- 70 unique employee

Data

Staffing Schedule

- Employee-level data
 - Time in and time out of every employee of the store
 - Employee ID
 - Employee name
- We can infer
 - # active staff
 - Work duration

70 unique employee

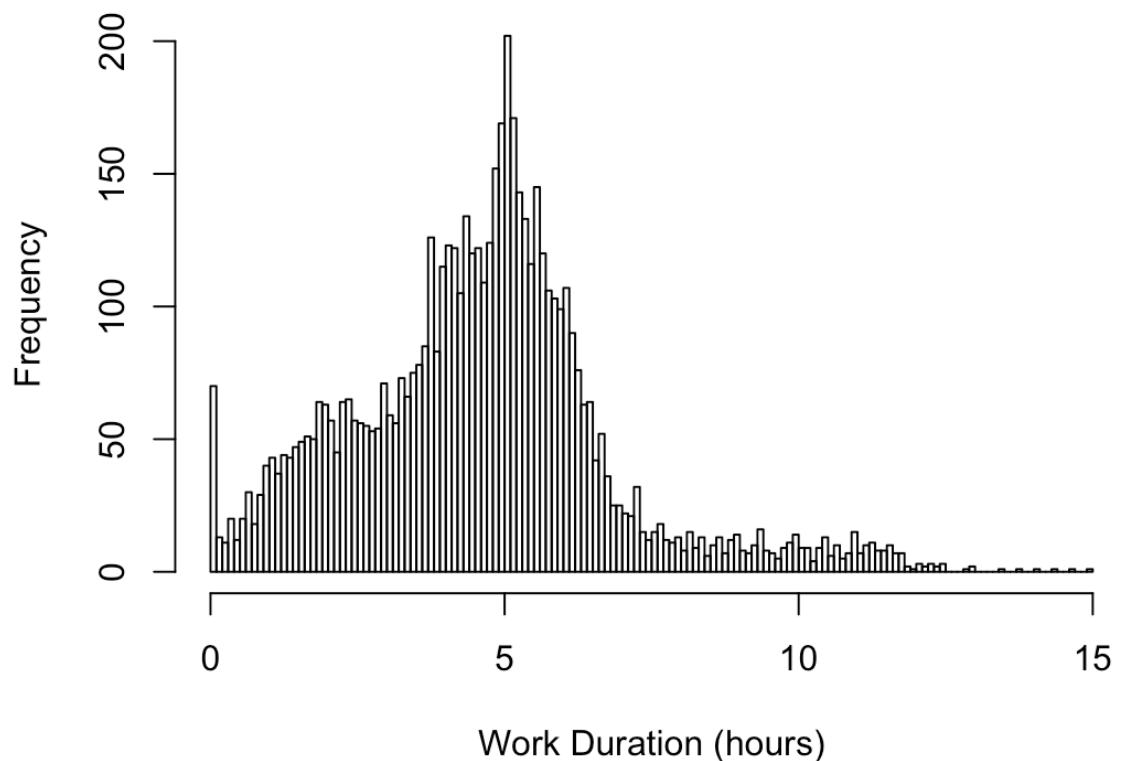


Data

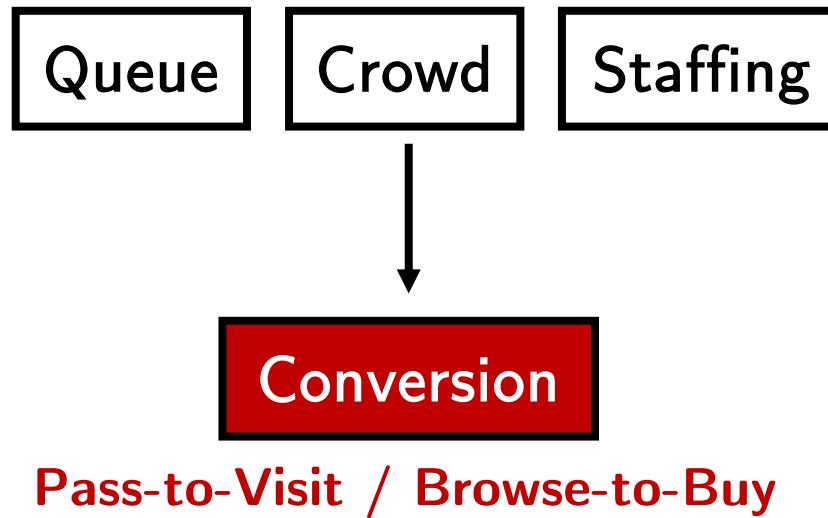
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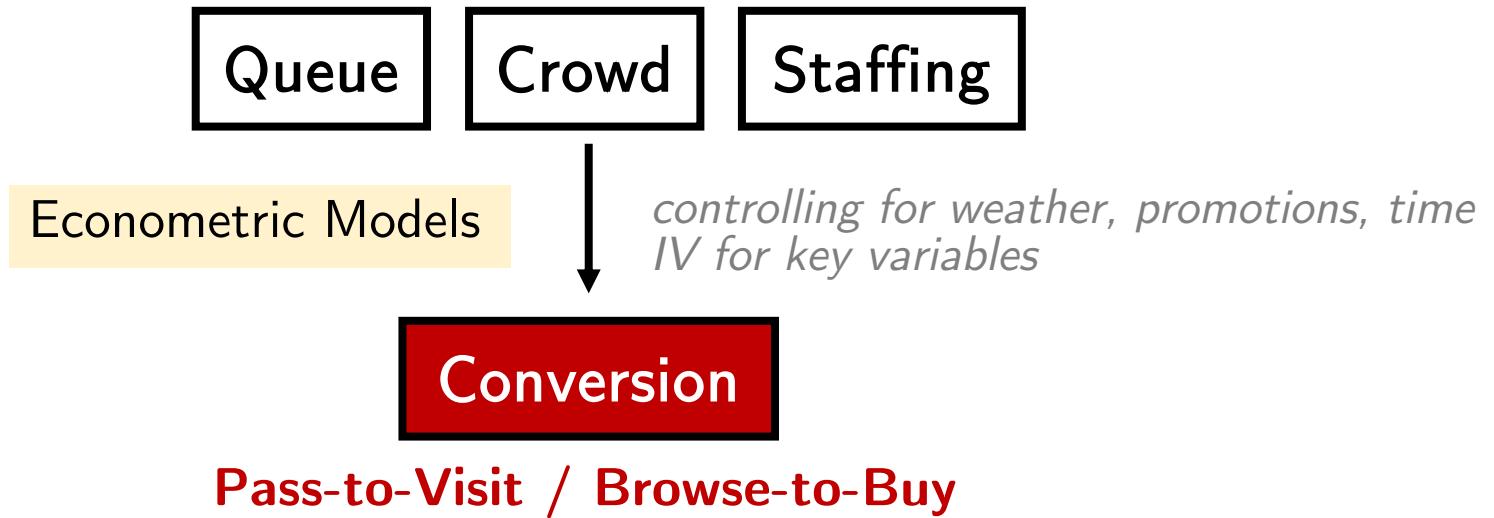
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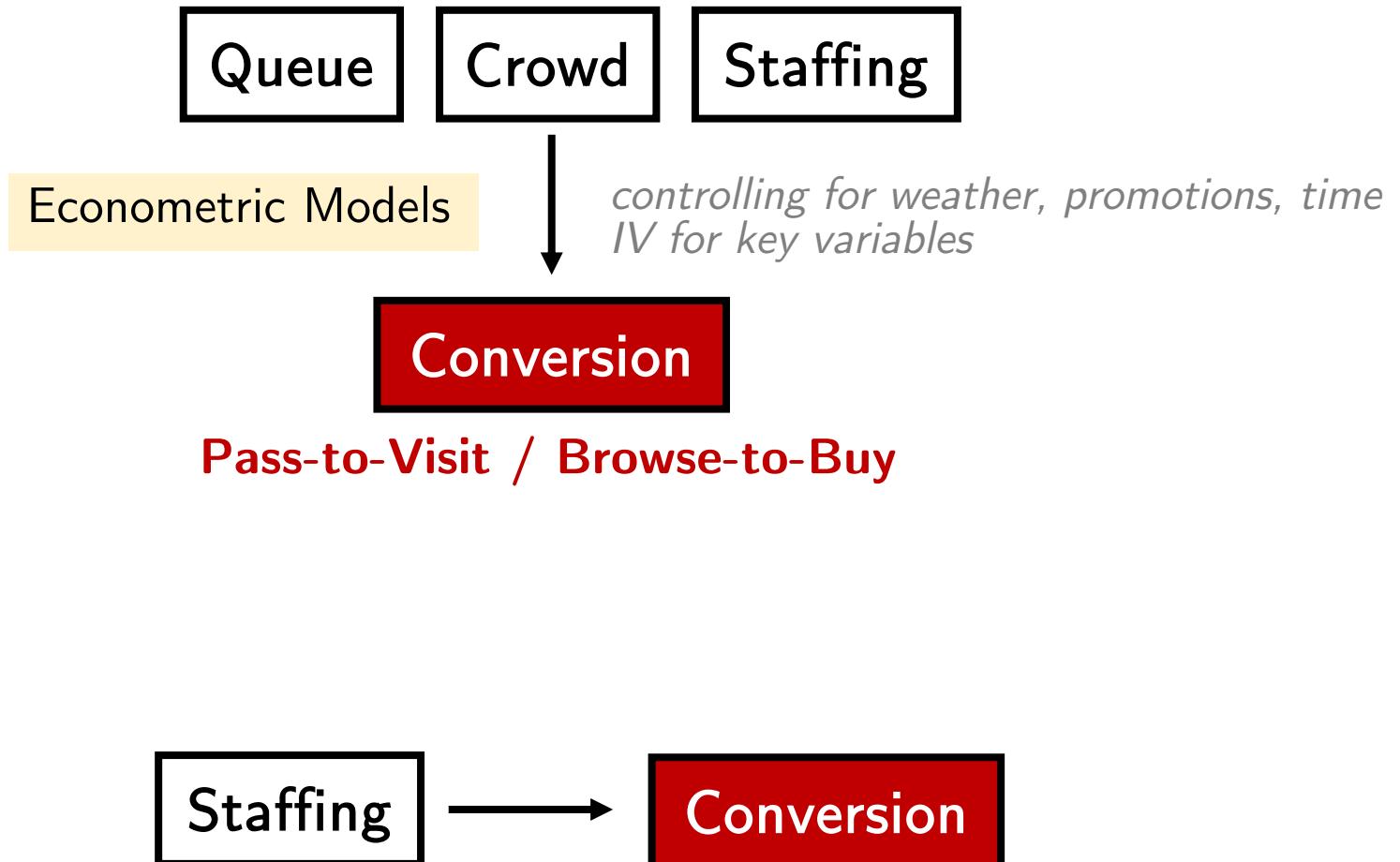
Approach Overview



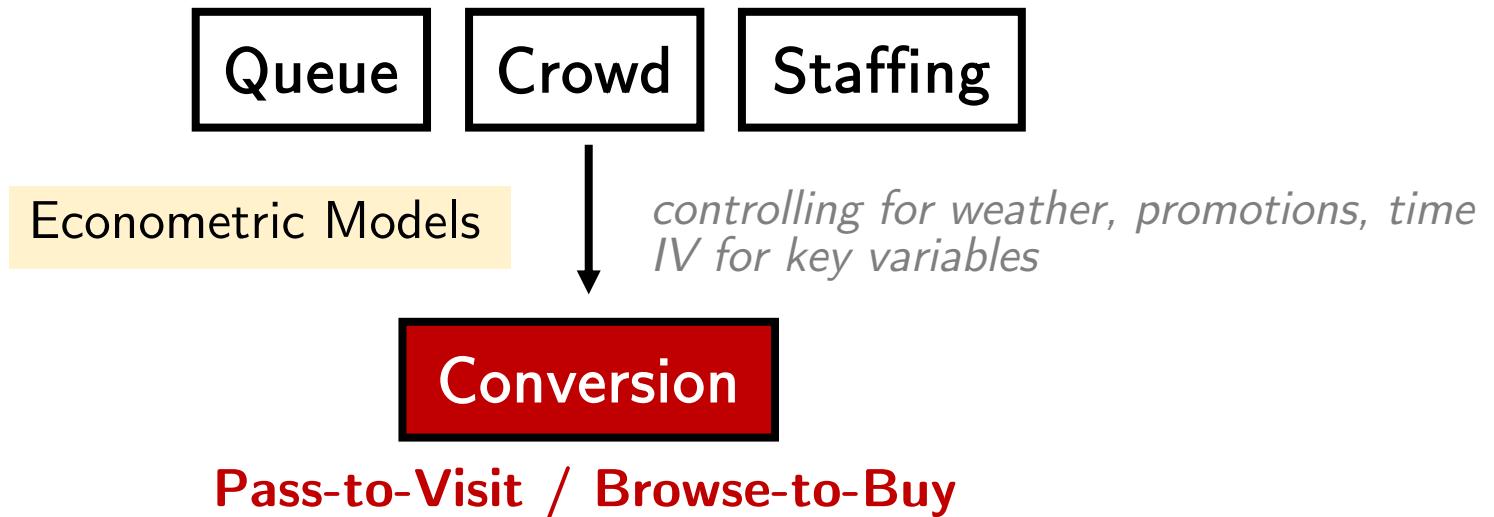
Approach Overview



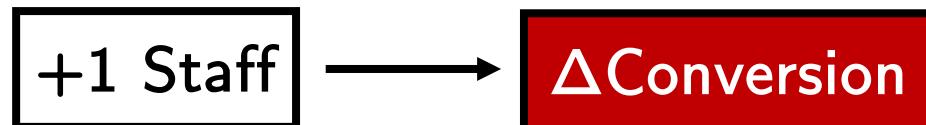
Approach Overview



Approach Overview



Matched Pairs Experiment *Propensity score caliper matching*



Approach Econometric Models

- Beta regression models for conversion rates

Pass-to-Visit Conversion

Browse-to-Buy Conversion

Queue

Crowd

Staffing

Crowd

Staffing

Approach Econometric Models

- Beta regression models for conversion rates

Pass-to-Visit Conversion

Browse-to-Buy Conversion

Queue

Crowd

Staffing

Crowd

Staffing

Controls: Daily Promotions, Weather (Clear/Cloudy/Rainy)
Time Fixed Effects (Hour/Day of Week/Month)

Approach Econometric Models

- Beta regression models for conversion rates

Pass-to-Visit Conversion

Queue

Crowd

Staffing

Browse-to-Buy Conversion

Crowd

Staffing

IV: Lagged values from
the same day of last week

IV: Lagged values from
the same day of last week

2SLS and 2SRI

Controls: Daily Promotions, Weather (Clear/Cloudy/Rainy)
Time Fixed Effects (Hour/Day of Week/Month)

Results Pass-to-Visit

<i>Pass-to-Visit Conversion</i>		
	<i>OLS</i>	<i>beta</i>
	(1)	(2)
Crowd	0.036*** (0.006)	0.116*** (0.024)
Queue	-0.060** (0.030)	-0.211* (0.126)
Staffing	0.050*** (0.008)	0.270*** (0.032)
Promotions	0.214*** (0.022)	0.565*** (0.090)
Constant	-0.166*** (0.062)	-2.871*** (0.249)
Weather Control	Y	Y
Day Control	Y	Y
Hour Control	Y	Y
Month Control	Y	Y
Observations	35,536	35,536
R ²	0.042	0.045
Adjusted R ²	0.041	

Note:

*p<0.1; **p<0.05; ***p<0.01

Results

Pass-to-Visit

Change in
log odds

Crowd +

+12%***

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Change in
log odds

Crowd +

+12%***

Queue -

-19%*

Staffing +

+31%***

Results

Browse-to-Buy

<i>Browse-to-Buy Conversion</i>		
	<i>OLS</i>	<i>Beta</i>
	(1)	(2)
Crowd	-0.076*** (0.001)	-0.322*** (0.003)
Staffing	0.015*** (0.002)	0.055*** (0.007)
Promotions	-0.010 (0.006)	-0.035 (0.022)
Constant	0.780*** (0.015)	1.118*** (0.053)
Weather Control	Y	Y
Day Control	Y	Y
Hour Control	Y	Y
Month Control	Y	Y
Observations	14,724	14,724
R ²	0.475	0.502
Adjusted R ²	0.474	

Note:

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Results

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Crowd -

Change in
log odds

-28%***

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Change in
log odds

Crowd -

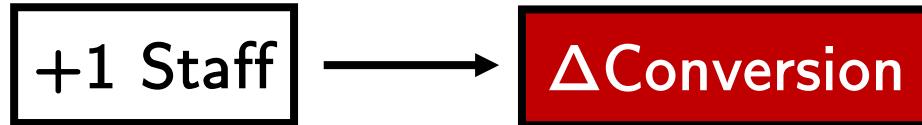
-28%***

Staffing +

+6%***

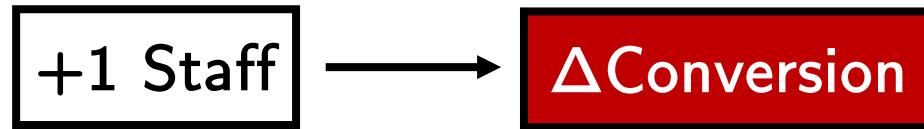
Approach

Matched Pairs Experiment



Approach

Matched Pairs Experiment



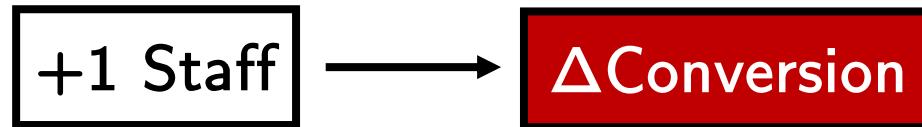
Observations:



Similar propensity score of having **N** staff

Approach

Matched Pairs Experiment



Observations:



Similar propensity score of having **N** staff

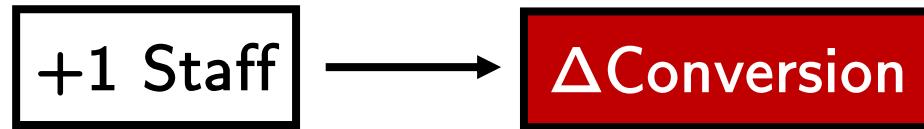
Within a caliper of $0.5 * \text{sd}(\text{PS})$, otherwise slightly violated
Covariates matched with rank-based Mahalanobis distance

$$(\mathbf{x}_k - \mathbf{x}_l)^T \hat{\Sigma}^{-1} (\mathbf{x}_k - \mathbf{x}_l)$$

Propensity Score Caliper Matching with
Rank-Based Mahalanobis Distance

Approach

Matched Pairs Experiment



Observations:

A

B

Same predicted propensity of having **N** staff

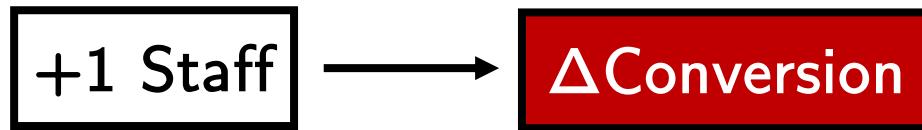
Actual staff:

N

N+1

Approach

Matched Pairs Experiment

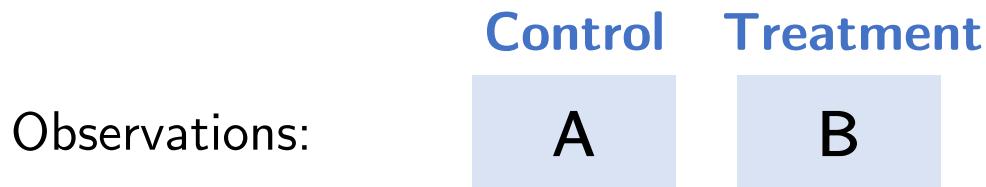
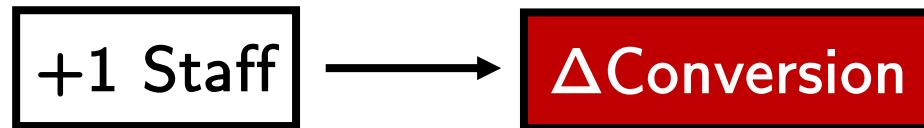


Same predicted propensity of having **N** staff

Actual staff: N N+1

Approach

Matched Pairs Experiment



Same predicted propensity of having N staff

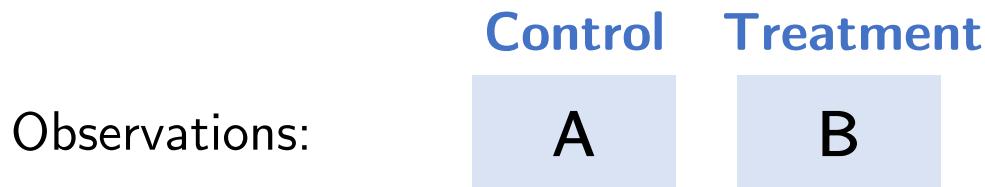
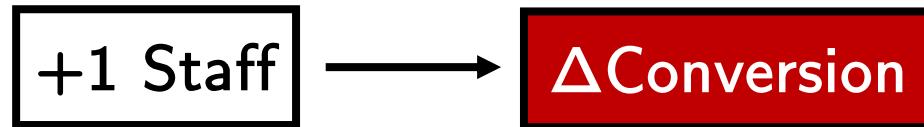
Actual staff: N $N+1$

Conversion: C_A C_B

Difference in Conversion

Approach

Matched Pairs Experiment



Same predicted propensity of having **N** staff

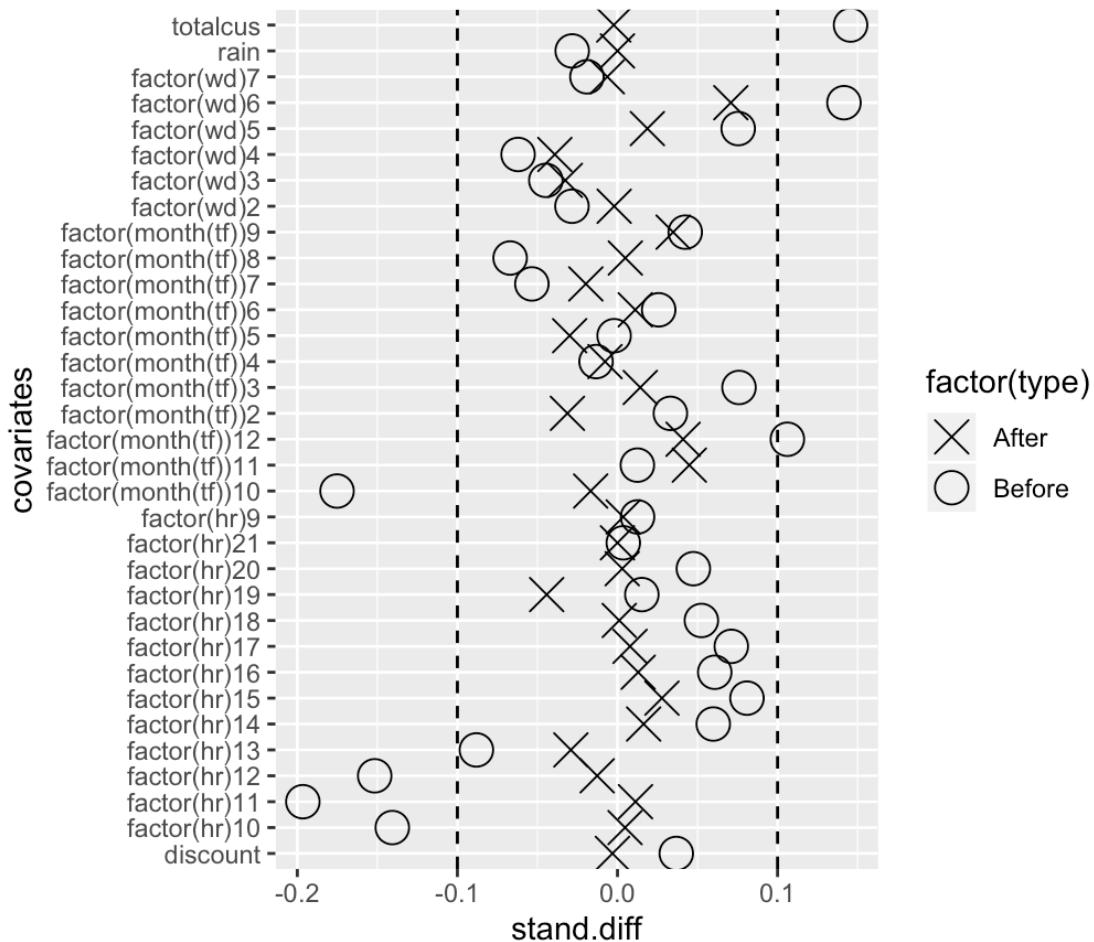
Actual staff: 3 4

Conversion: C_A C_B

Difference in Conversion

Approach

Matched Pairs Experiment



N = 16,833

Control: 11,362
Treated: 5,466

5,466 matched pairs

Results

Matched Pairs Experiment

Control



Treatment: +1 Staff

Pass-to-Visit

+1.71%

[0.86%, 2.55%]

Results

Matched Pairs Experiment

Control



Treatment: +1 Staff

Pass-to-Visit

+1.71%

[0.86%, 2.55%]

Browse-to-Buy

-1.23%

[-2.50%, 0.05%]

On-Going Work

- Address further potential endogeneity concerns
- Extend the analysis to the entire chain
- Incorporate competition from nearby stores
- Test the insights in controlled experiment

Summary

How queue, crowd, and staffing level affect customer's conversion?

- Unique data on traffic, sales, and scheduling (shoe retail)
- Econometric models of visit and purchase conversions

