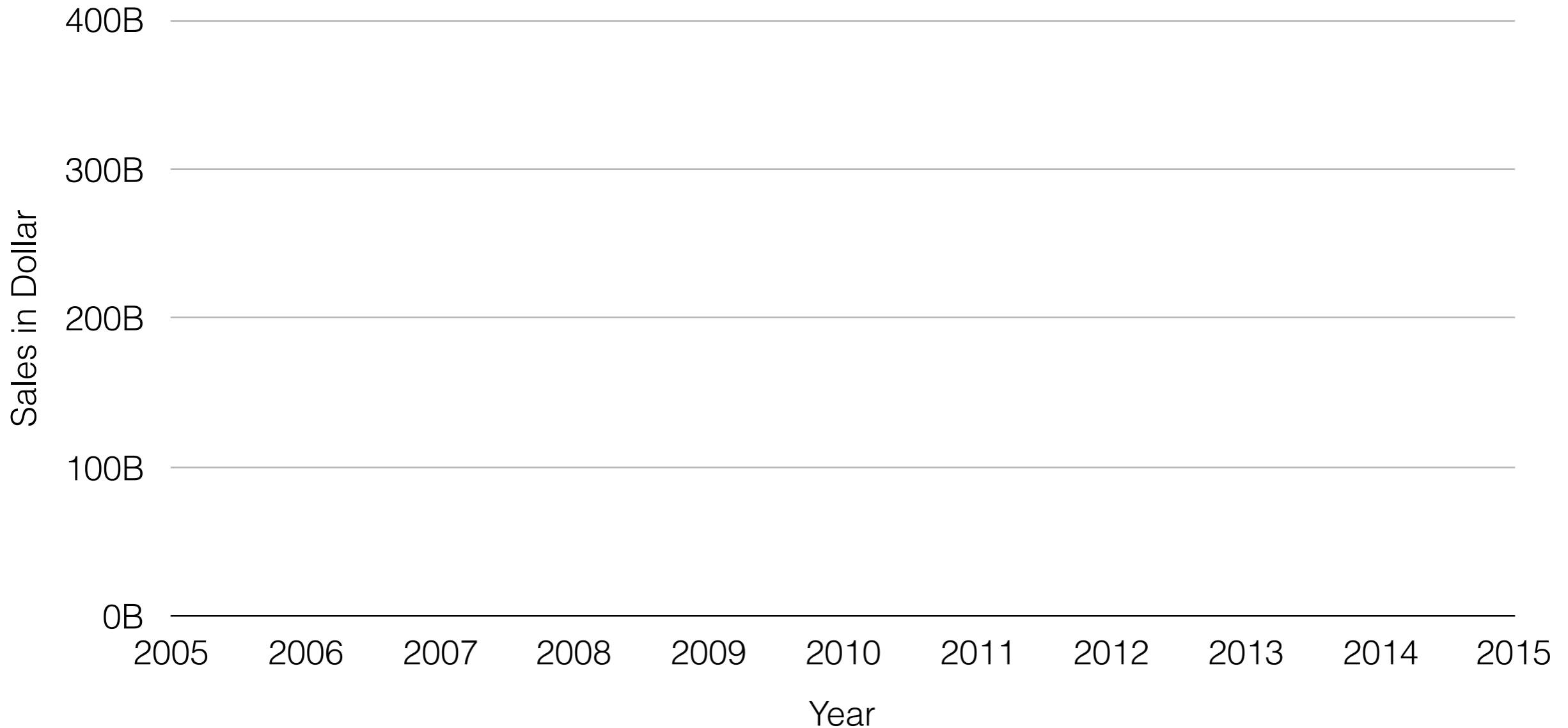# An Empirical Analysis of Algorithmic Pricing on Amazon Marketplace

Le Chen, Alan Mislove, Christo Wilson
Northeastern University
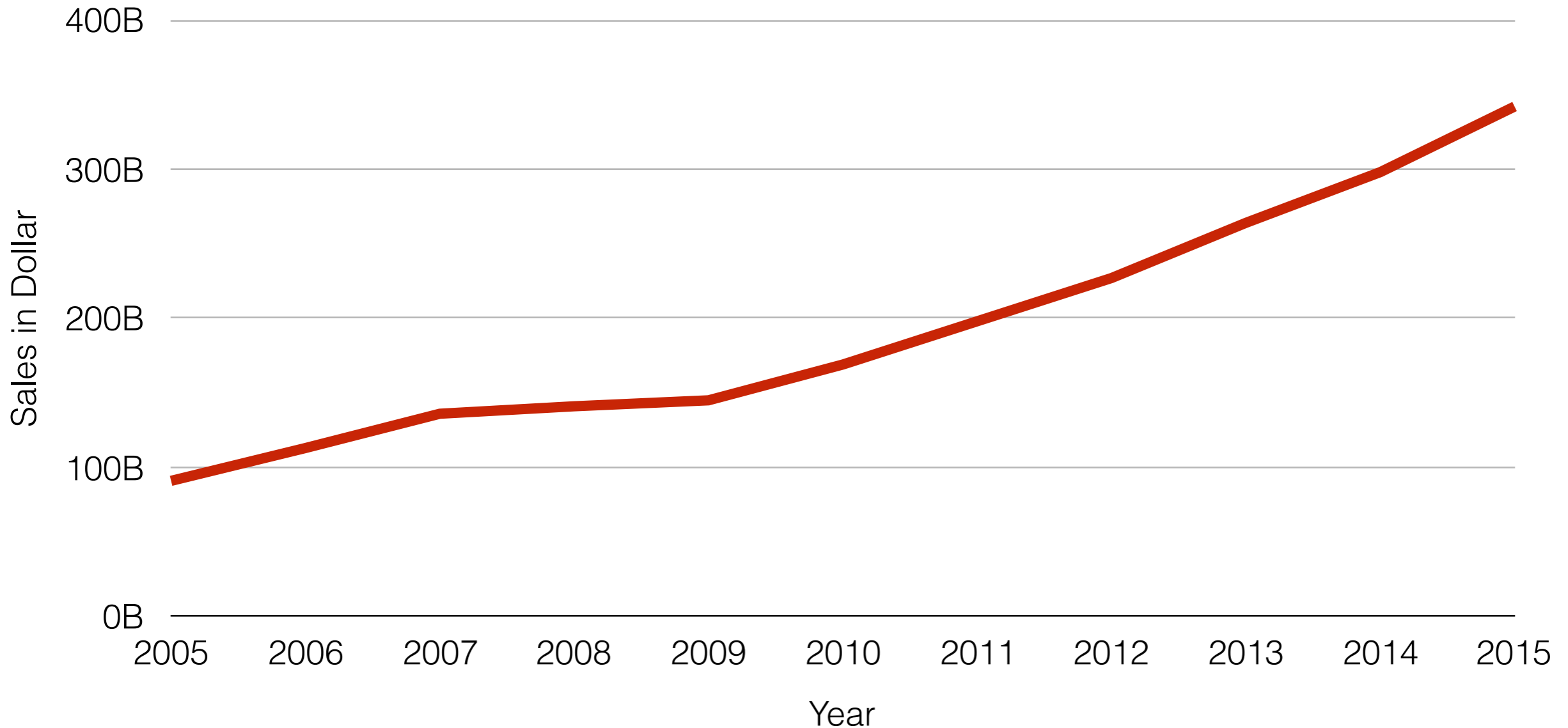
The rise of e-commerce

E-commerce Sales over time (US Commerce Department)

The rise of e-commerce

E-commerce Sales over time (US Commerce Department)

Algorithmic pricing

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- Dynamic pricing algorithms or Revenue/Yield Management

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- Use softwares to update prices in real time

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Problems in algorithmic pricing
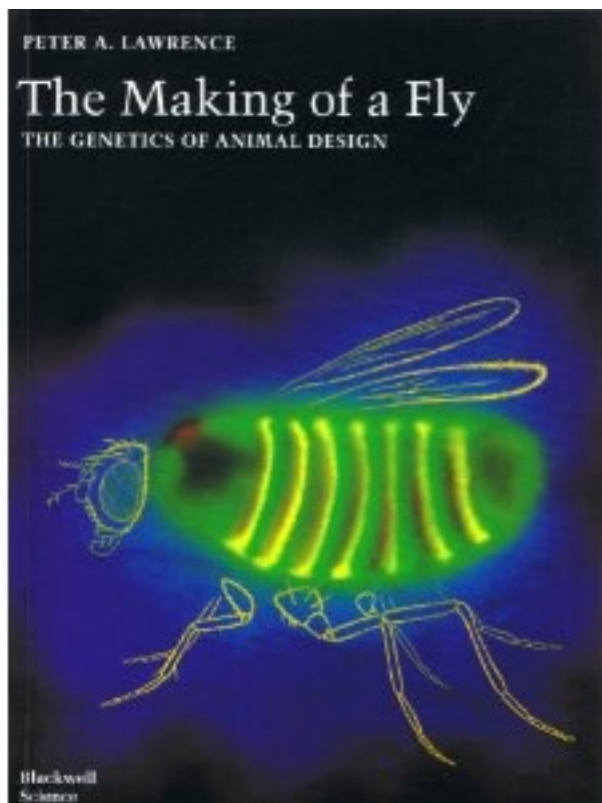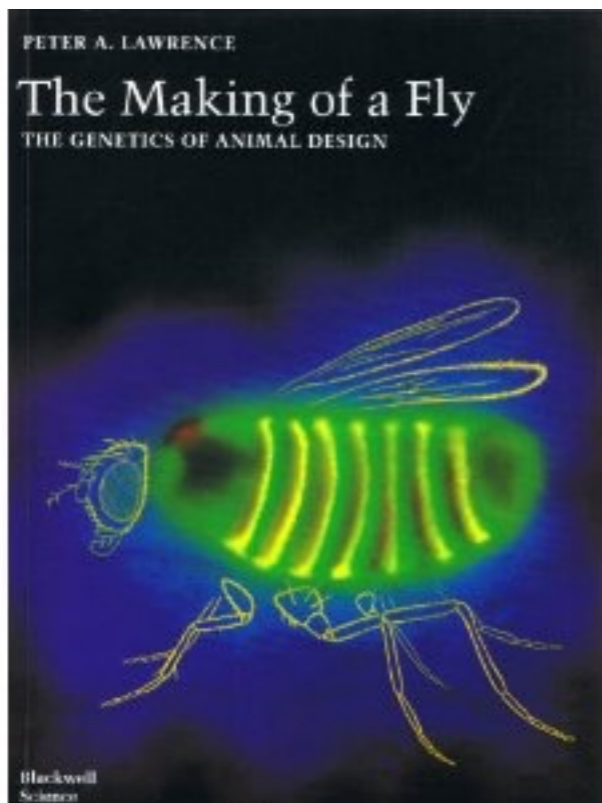
Problems in algorithmic pricing

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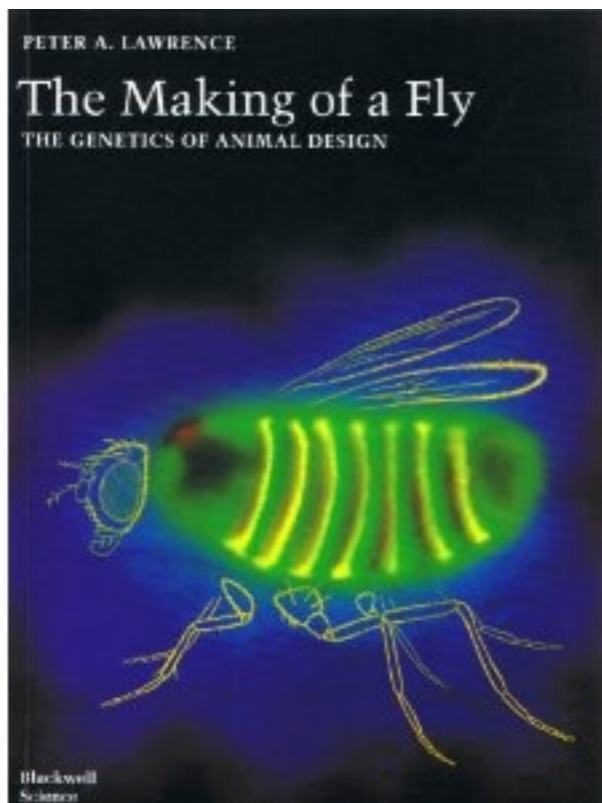
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New 1-2 of 2 offers

Price + Shipping	Condition
$1,730,045.91 + $3.99 shipping	New

$2,198,177.95 + $3.99 shipping	New

Problems in algorithmic pricing

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Problems in algorithmic pricing

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- Price of seller 1
  = 0.998 * (price of seller 2)

4

Problems in algorithmic pricing

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- Price of seller 2
  = 1.27 * (price of seller 1)

4

Problems in algorithmic pricing

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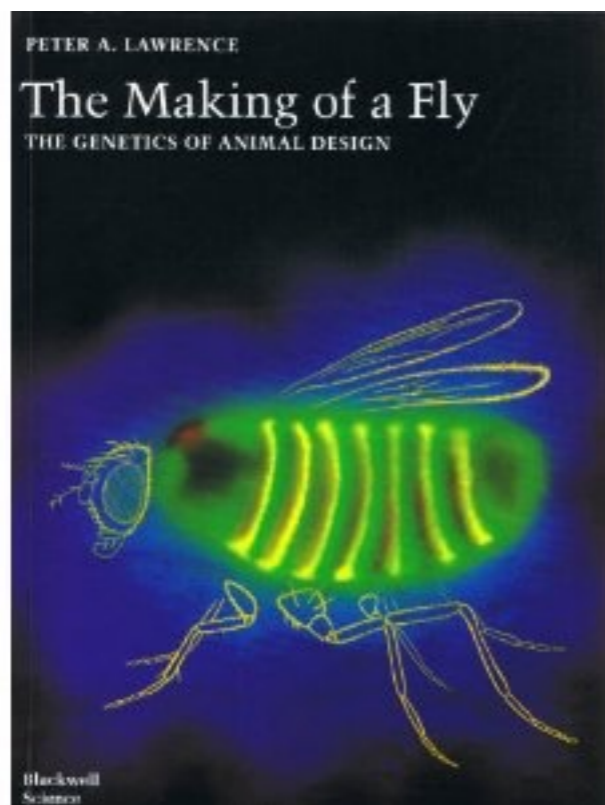
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- 0.998 * 1.27 > 1

New 1-2 of 2 offers

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4
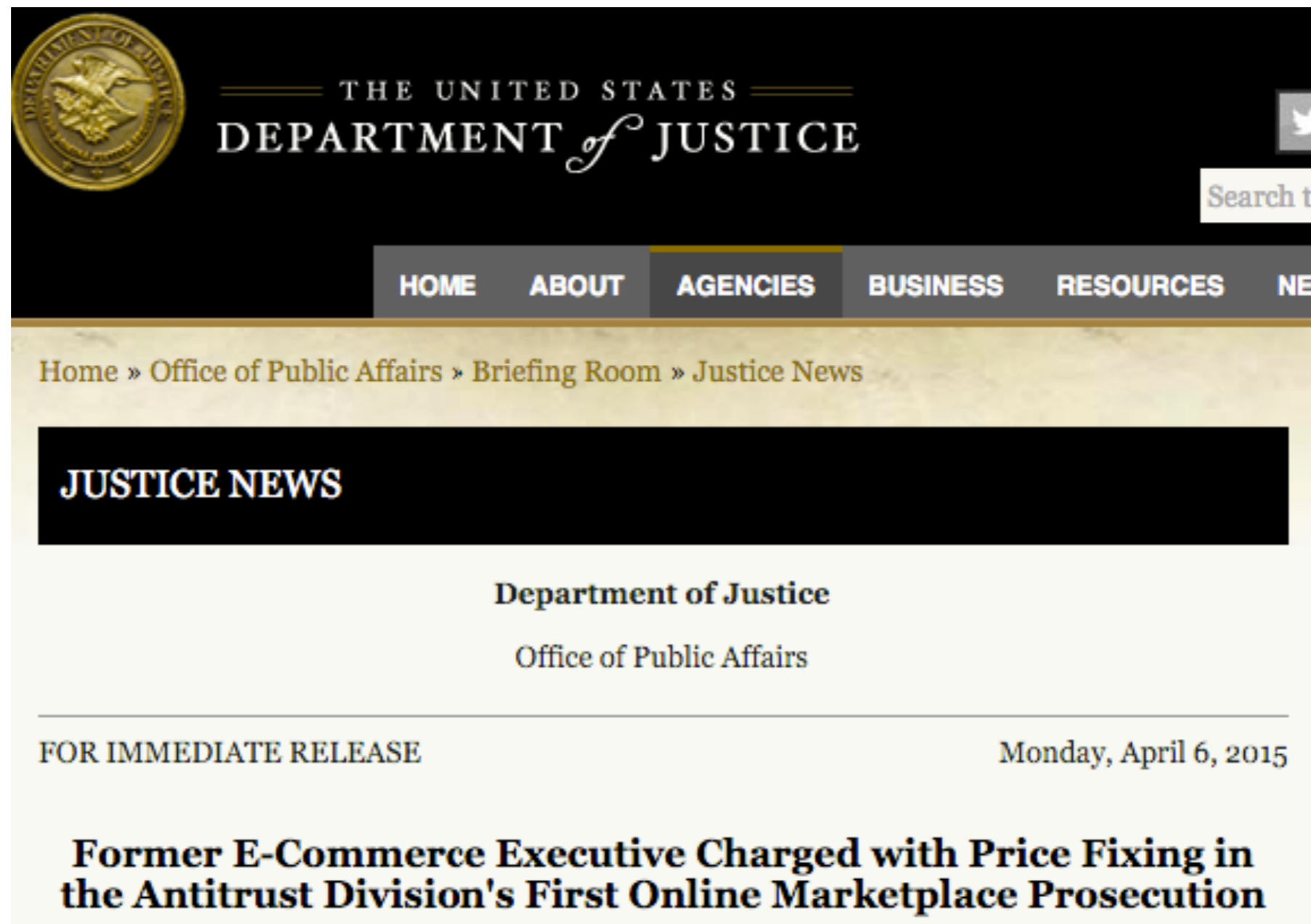
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FOR IMMEDIATE RELEASE   Monday, April 6, 2015

Former E-Commerce Executive Charged with Price Fixing in the Antitrust Division's First Online Marketplace Prosecution

Goal of this study

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- Feedback loops of algorithms

Outline of Amazon study

- Introduction

- Data collection

- The Buy Box

- Algorithmic pricing detection and analysis

- Summary

Data collection

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- Focus on the marketplace on **amazon**

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  - Largest e-commerce site in the US and Europe

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    ‣ Near real-time price/product update

    ‣ Aggregated price information for product

Data collection

Data collection

- Buy Box

List Price: ~~$79.99~~
Price: **$55.21** **& FREE Shipping**. Details
You Save: $24.78 (31%)

Qty: 1

☐ Yes, I want **FREE Two-Day Shipping** with Amazon Prime

Add to Cart

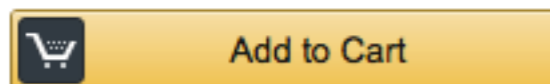Turn on 1-Click ordering for this browser

28 used & new from $49.49

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Data collection

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- Seller pages

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82% of sales go to the Buy Box…

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- Seller pages

82% of sales go to the Buy Box…
Win the Buy Box!

Data collection

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- Cover Buy Box and seller pages

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- First crawl

    - 09/2014 — 12/2014, crawl every 25 minutes

    - 837 best selling products, all seller pages

Data collection

- Cover Buy Box and seller pages

- First crawl

  - 09/2014 — 12/2014, crawl every 25 minutes

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- Second crawl

  - 08/2015 — 09/2015, crawl every 25 minutes

  - 1000 best selling products, first two seller pages

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Key questions

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- What features does Amazon use for choosing the winner of Buy Box?

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- Can we predict the winner of Buy Box?

Buy Box features

Buy Box features

- Features Amazon considers for each seller

  - Pricing: competing prices

  - Availability: stock of product, plan for vacations

  - Fulfillment: shipping fees, Fulfilled By Amazon (FBA)

  - Customer service: rating, positive feedbacks

Buy Box features

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- Random forest

Buy Box winner prediction
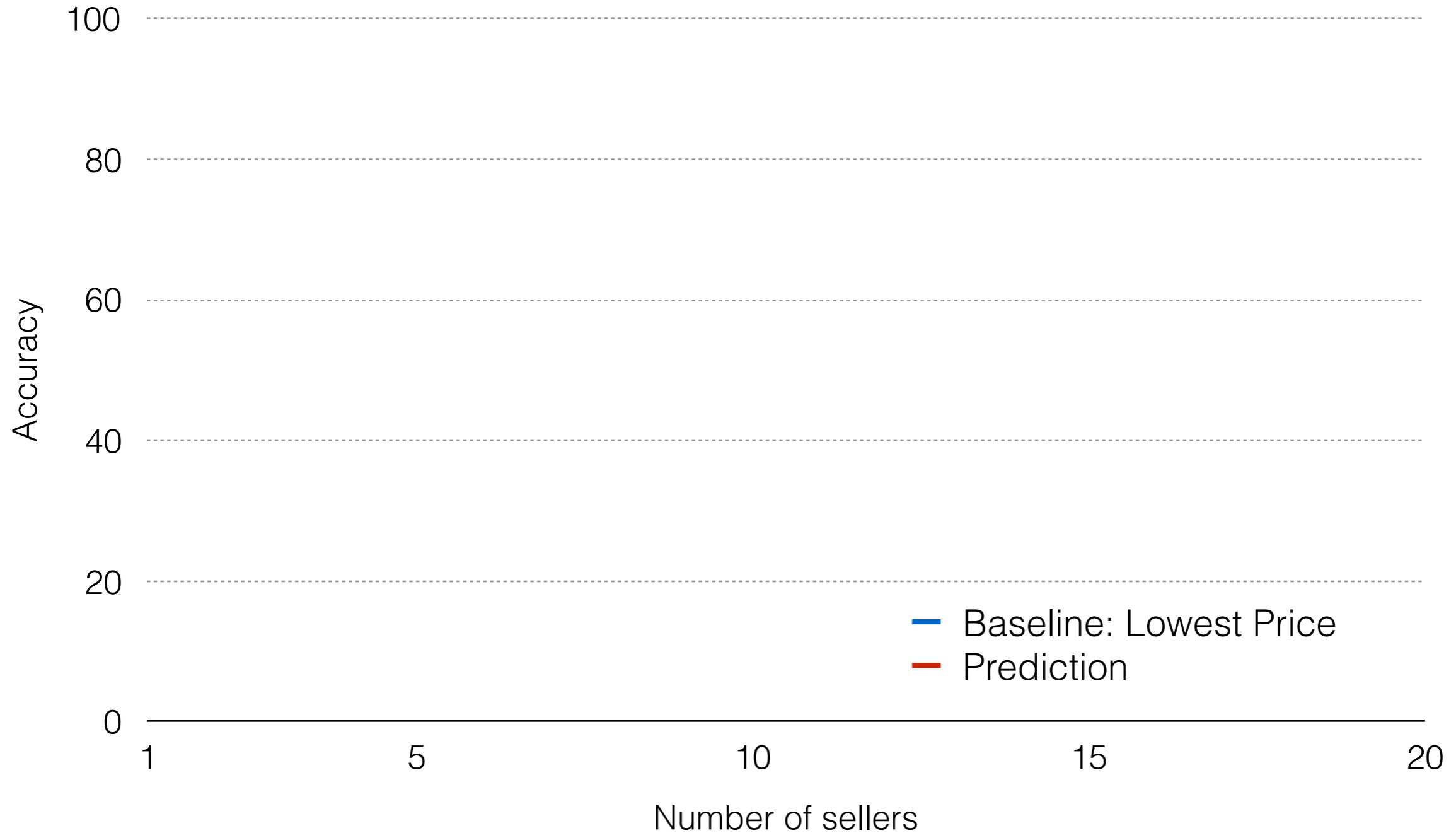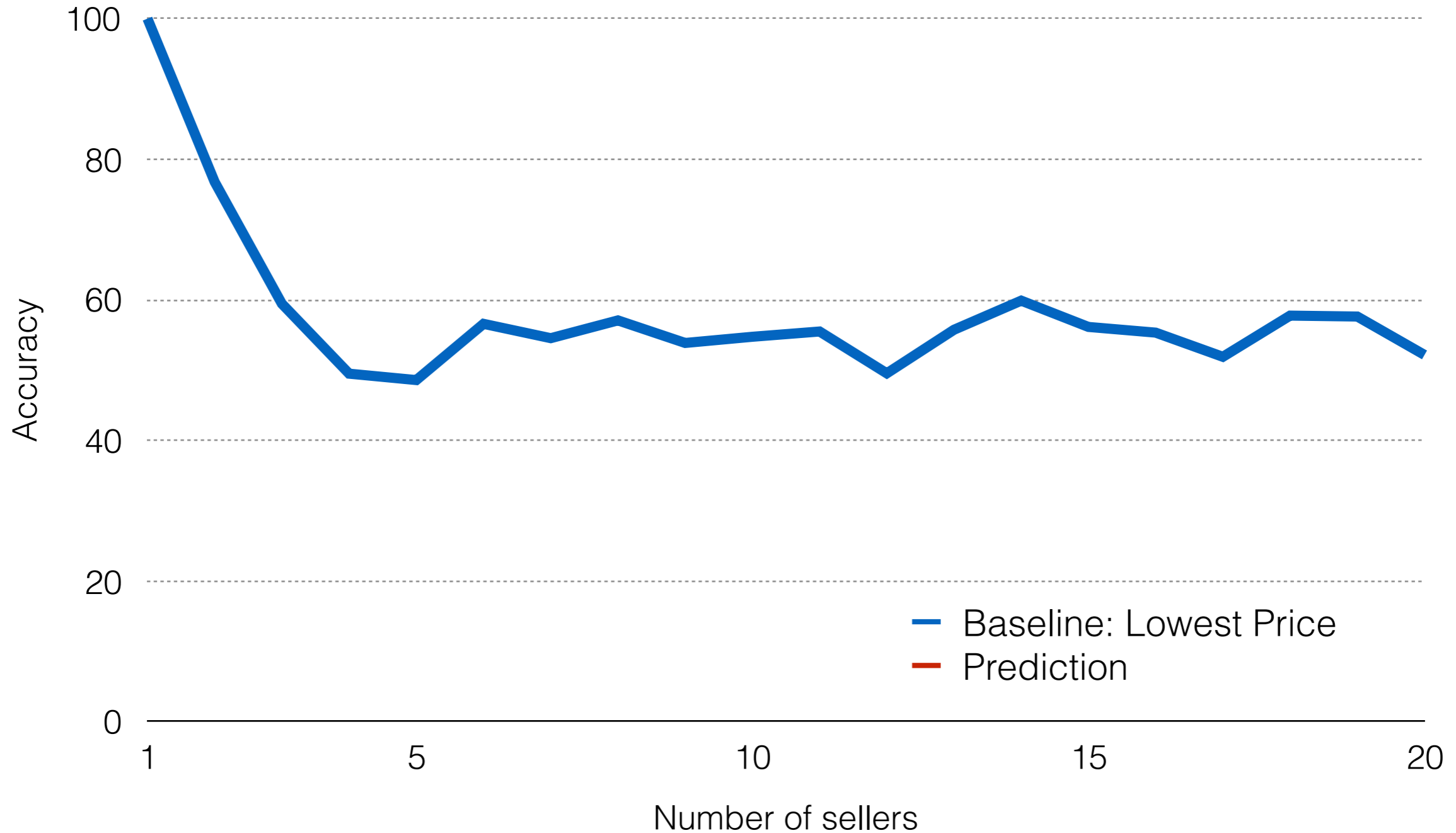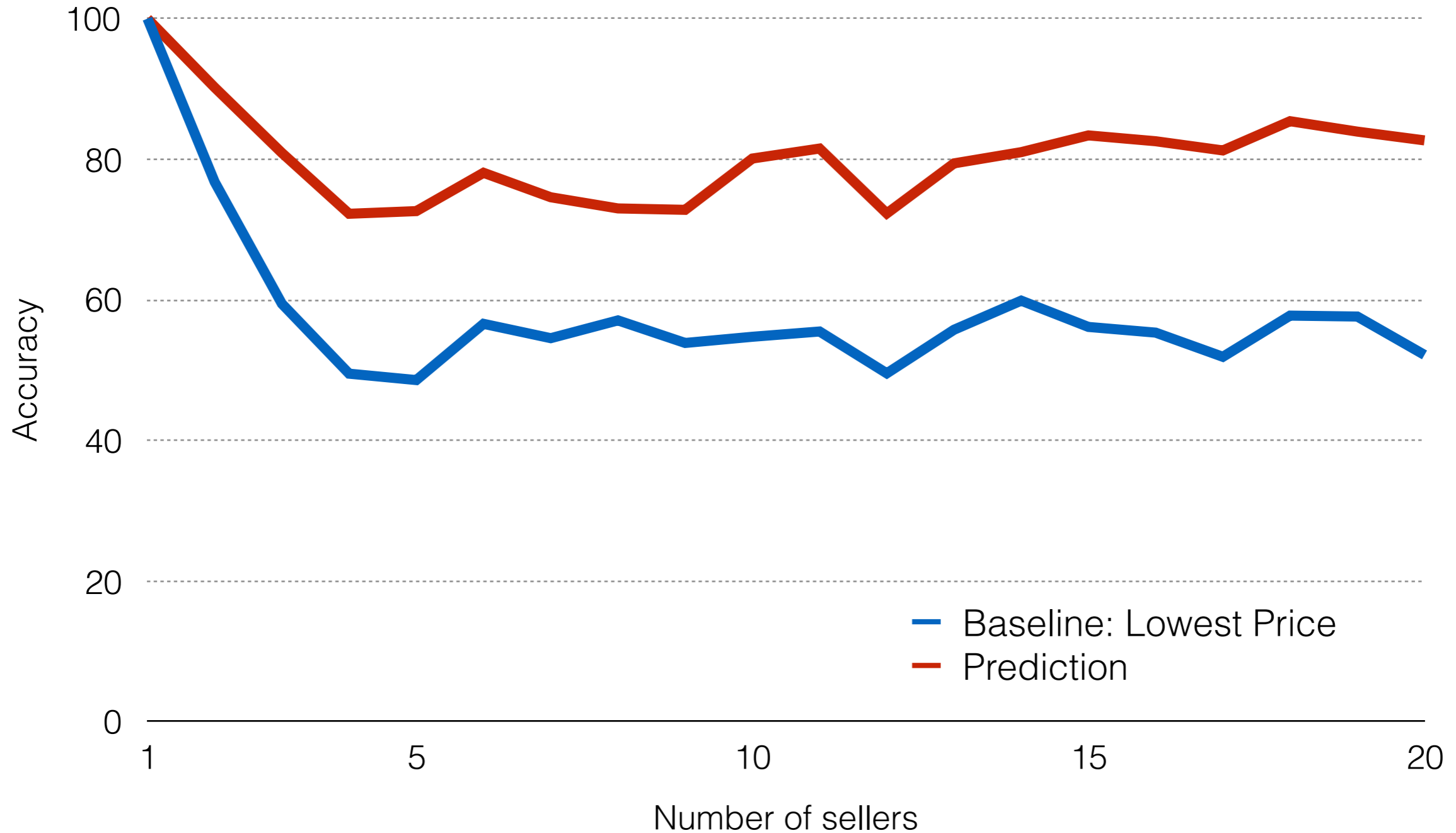
Accuracy (y-axis): 0, 20, 40, 60, 80, 100

Number of sellers (x-axis): 1, 5, 10, 15, 20

— Baseline: Lowest Price
— Prediction

Buy Box winner prediction

Buy Box winner prediction

Accuracy vs. Number of sellers

- Baseline: Lowest Price
- Prediction

Buy Box winner prediction
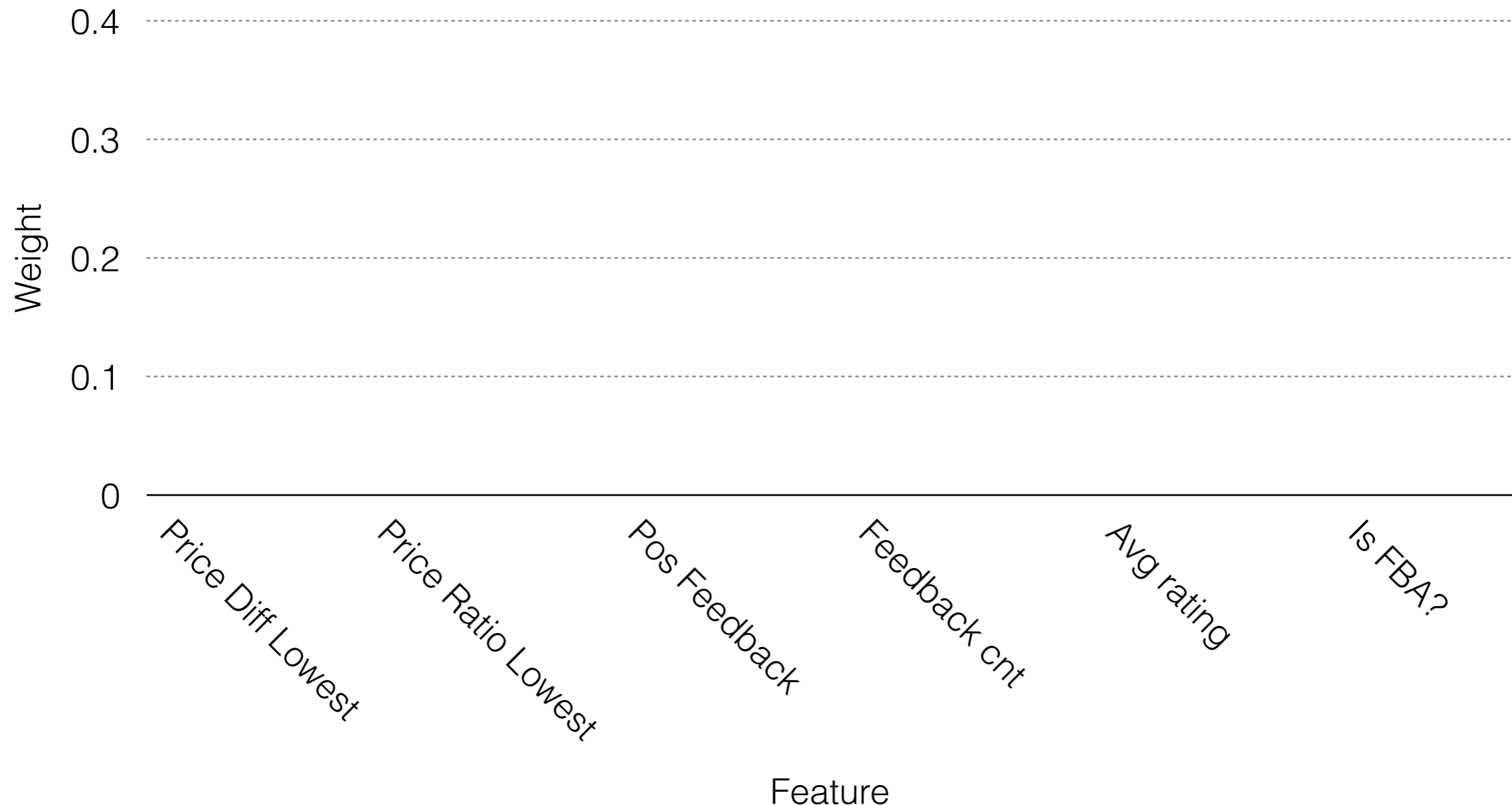
- Feature weights

Buy Box winner prediction
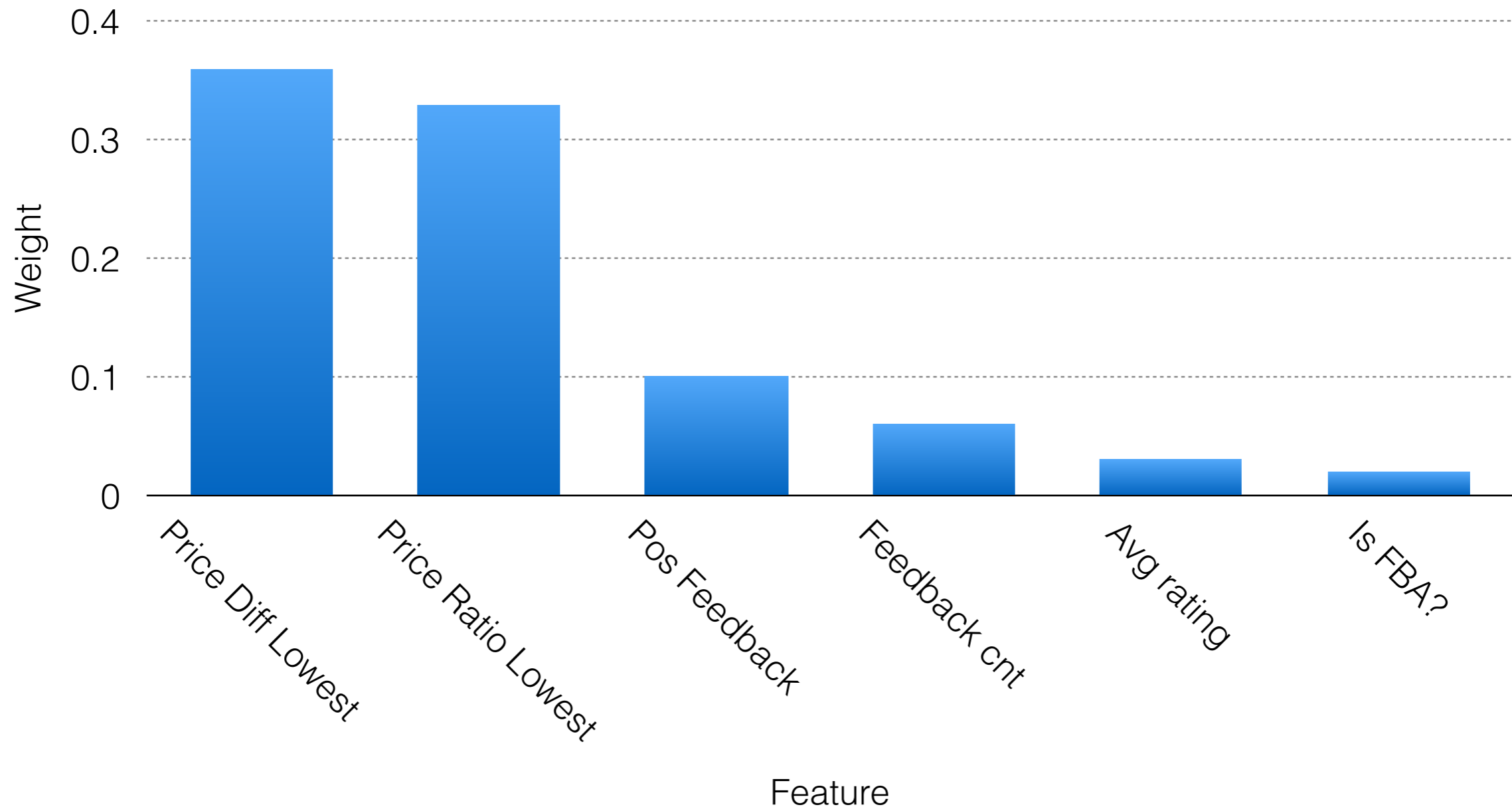
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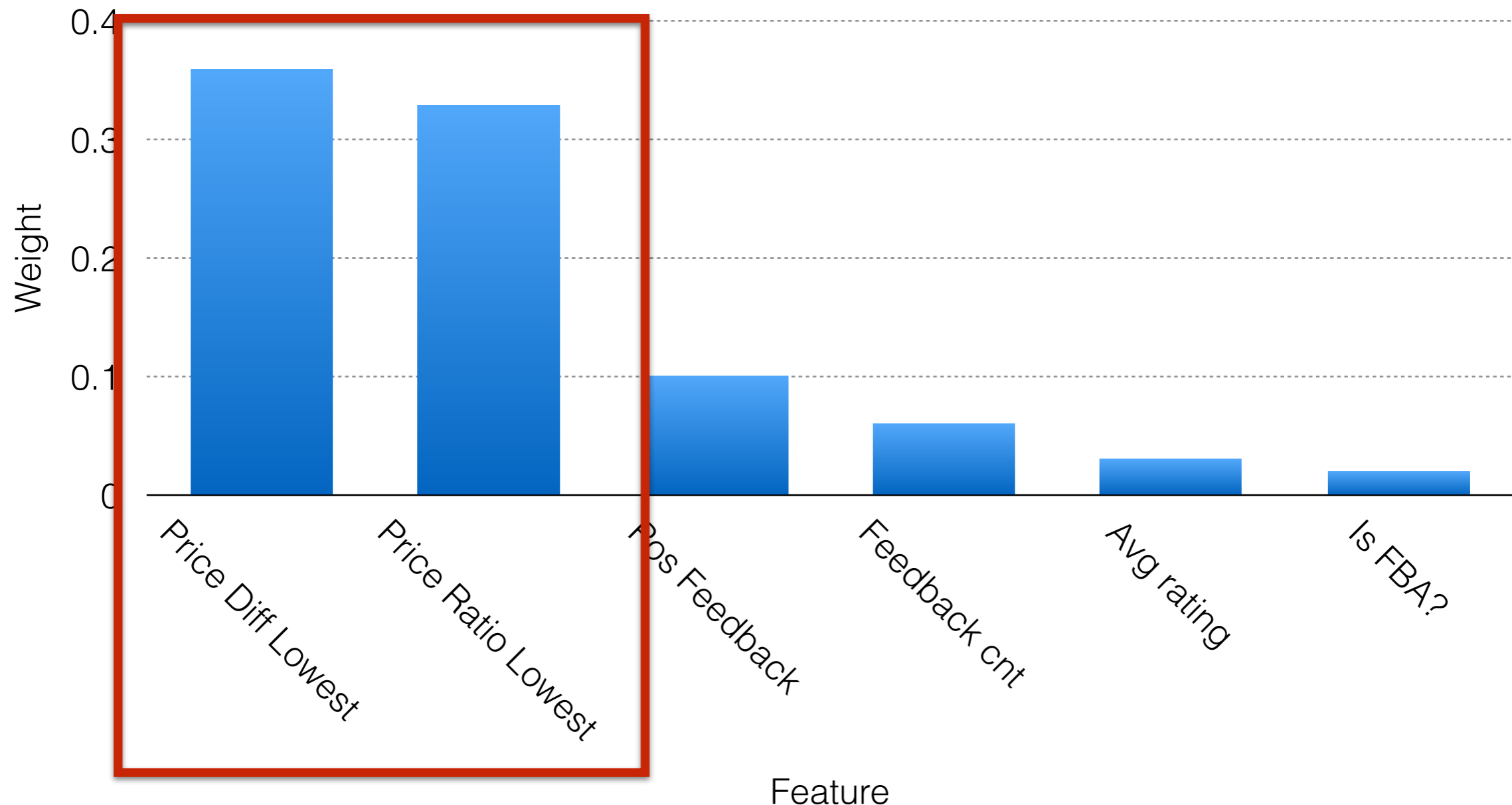
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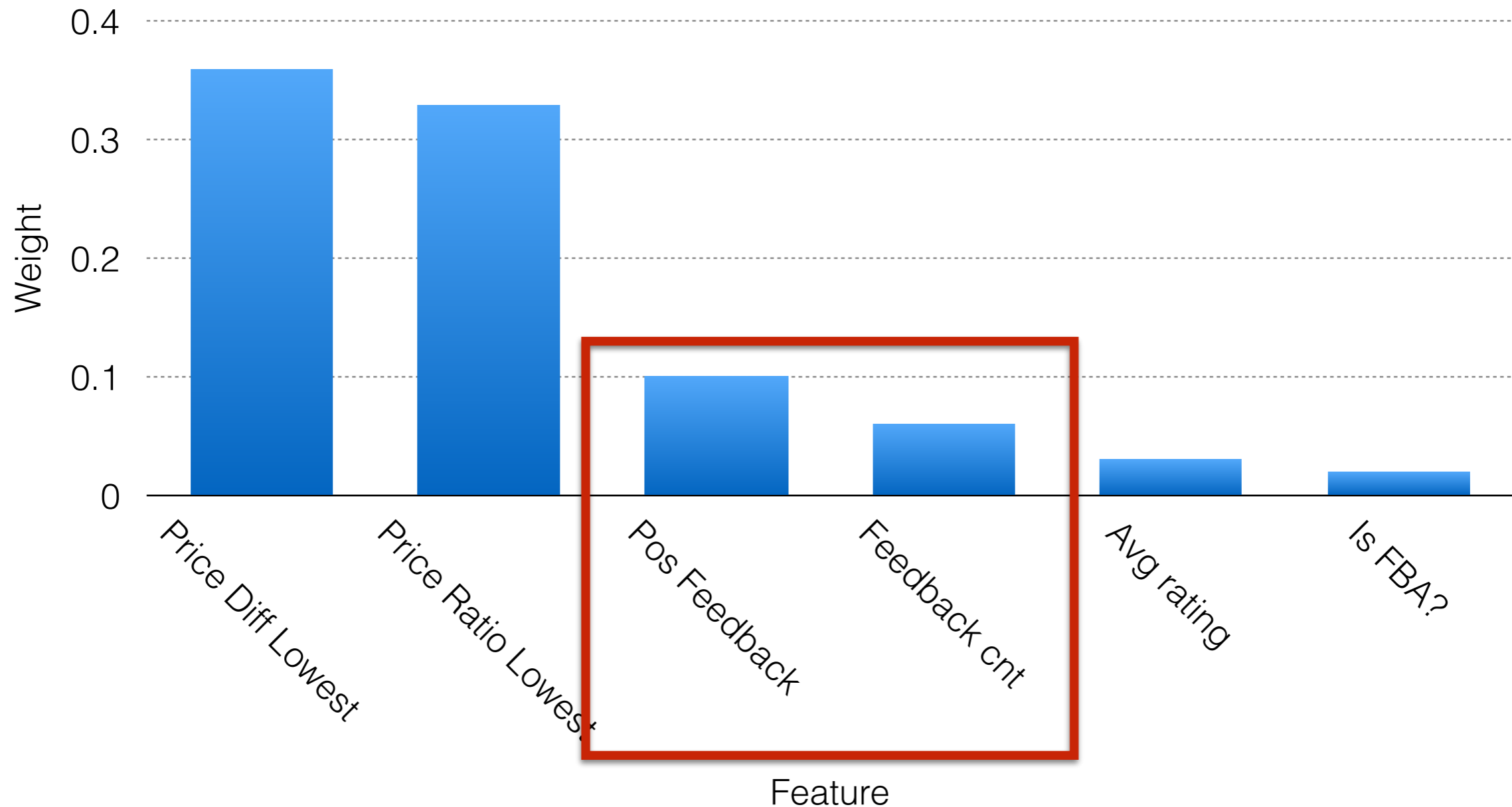
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- What are the different behaviors between the algo sellers and non-algo sellers?

Algorithmic pricing detection

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- How can algo sellers stay competitive?

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- How can algo sellers stay competitive?

  - Matching to a "competitive" price

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Algorithmic pricing detection

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  - Second lowest price

  - Amazon price

Algorithmic pricing detection
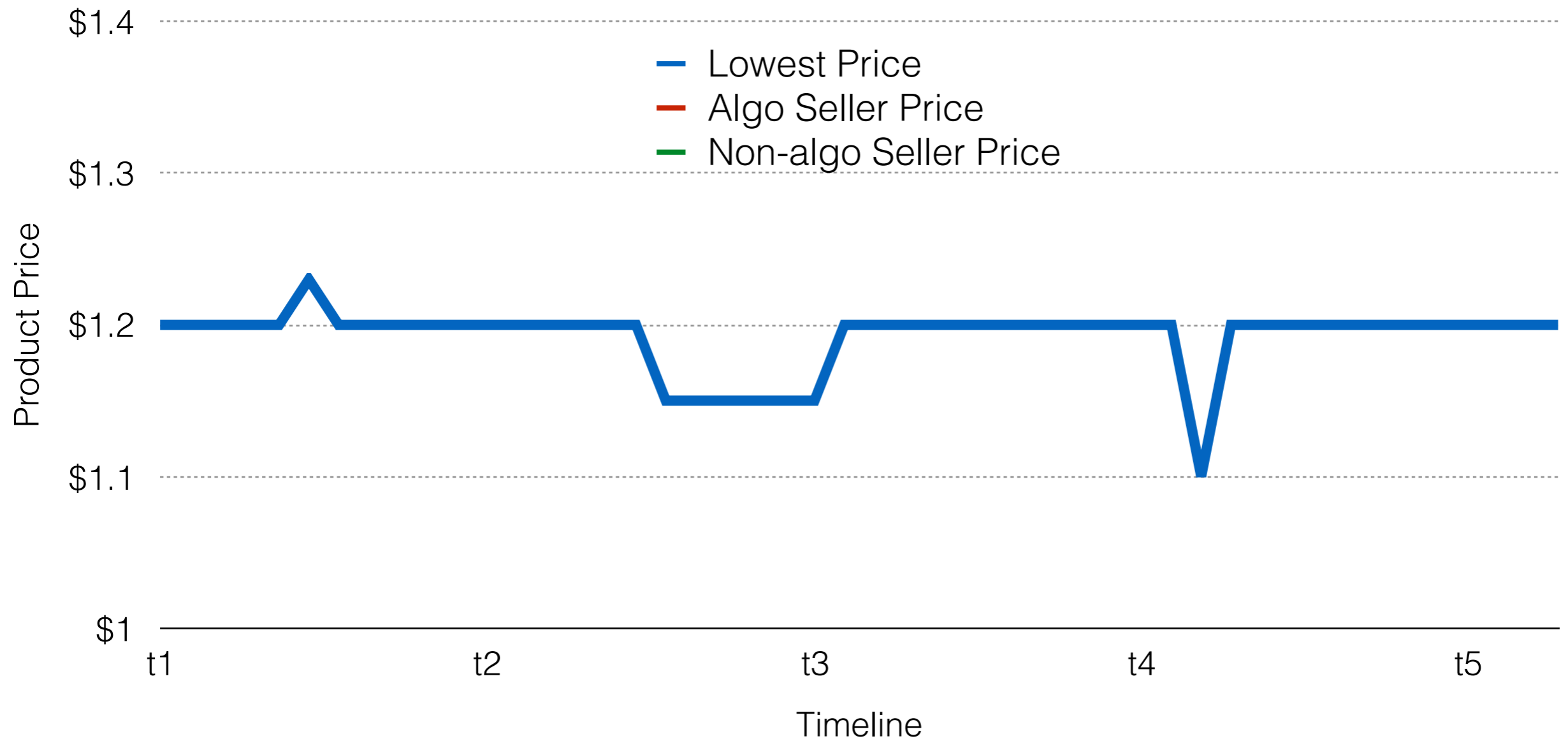
Legend:
— Lowest Price
— Algo Seller Price
— Non-algo Seller Price

Product Price axis: $1, $1.1, $1.2, $1.3, $1.4

Timeline axis: t1, t2, t3, t4, t5

Algorithmic pricing detection

Algorithmic pricing detection

Legend:
- Lowest Price
- Algo Seller Price
- Non-algo Seller Price

Y-axis: Product Price ($1, $1.1, $1.2, $1.3, $1.4)

X-axis: Timeline (t1, t2, t3, t4, t5)

Algorithmic pricing detection

Algorithmic pricing detection

Algorithmic pricing detection

- Detection criteria

  - Spearman's rank correlation between seller and target price

    ‣ Product must have more than 1 seller

  - Correlation coefficient >= 0.7

  - p-value <= 0.05

  - Number of price changes >= 20

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- Discovered 543 sellers covering 513 products

    - 2.4% of total sellers

    - 31% of the bestselling products
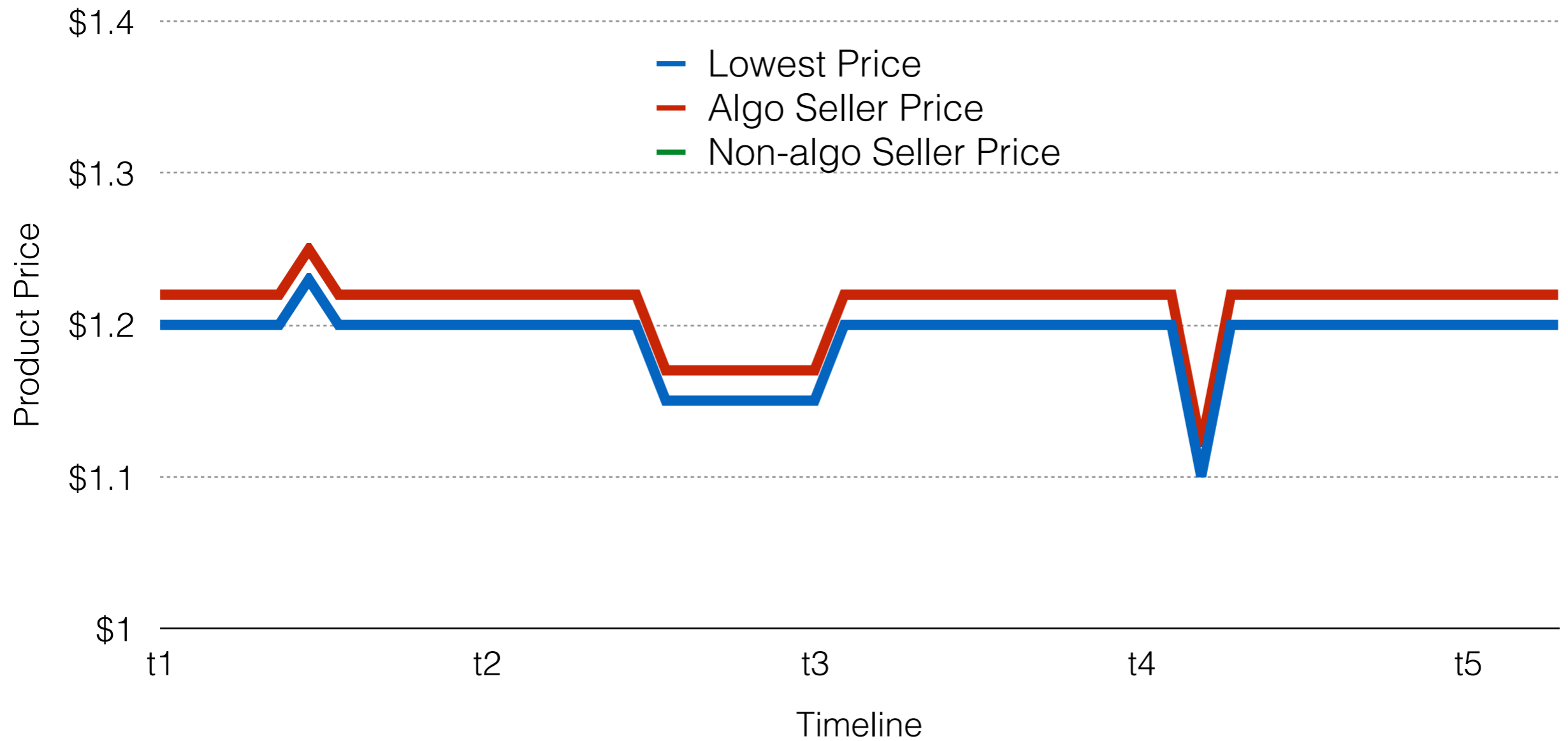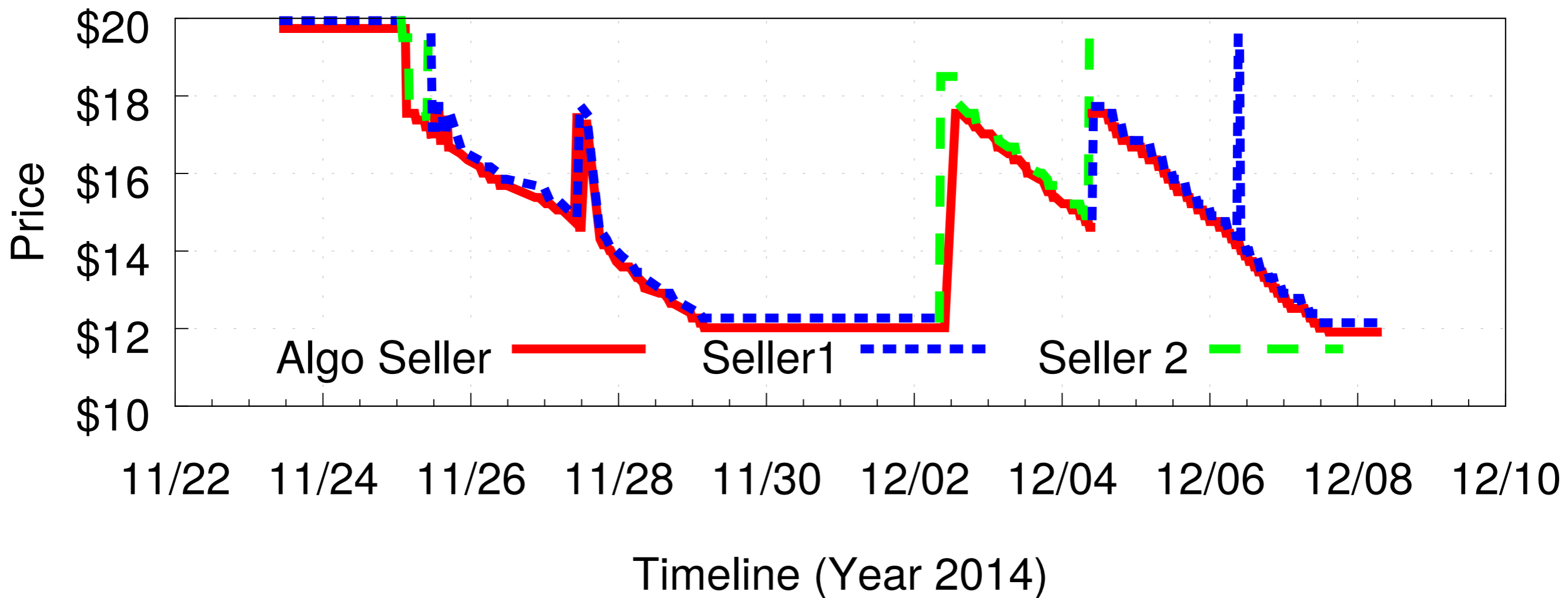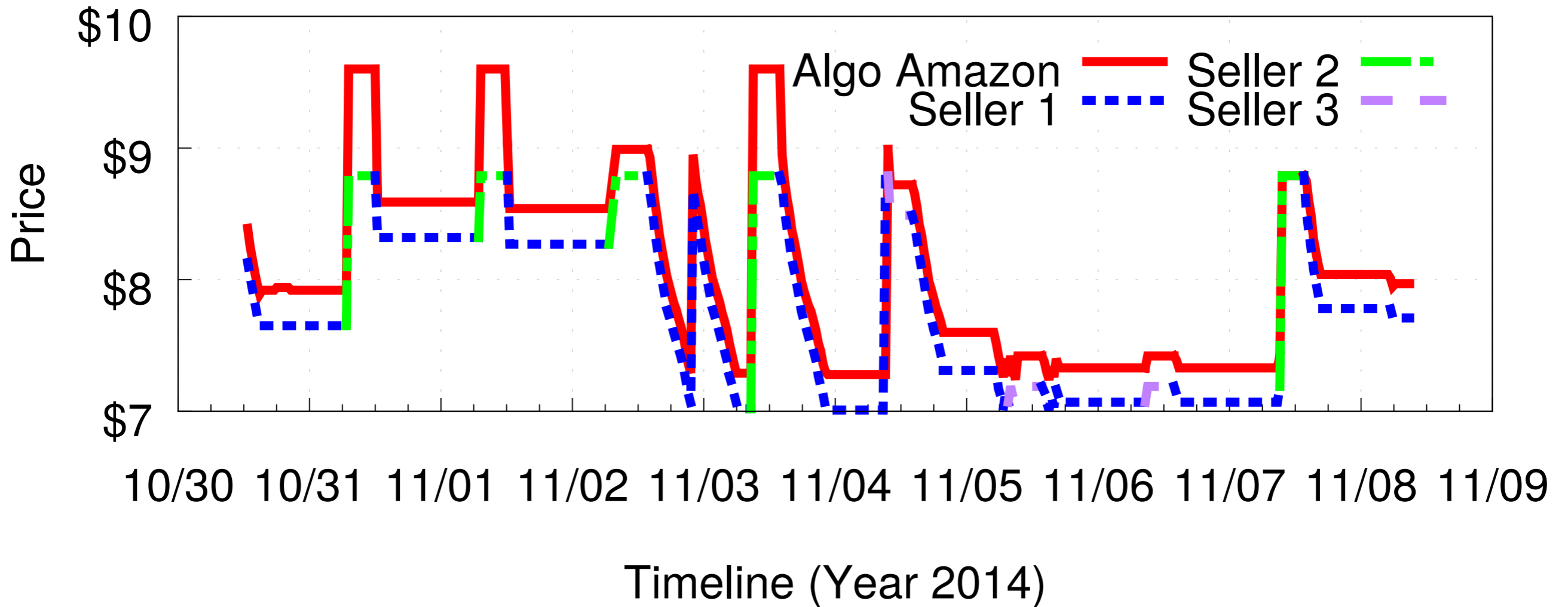
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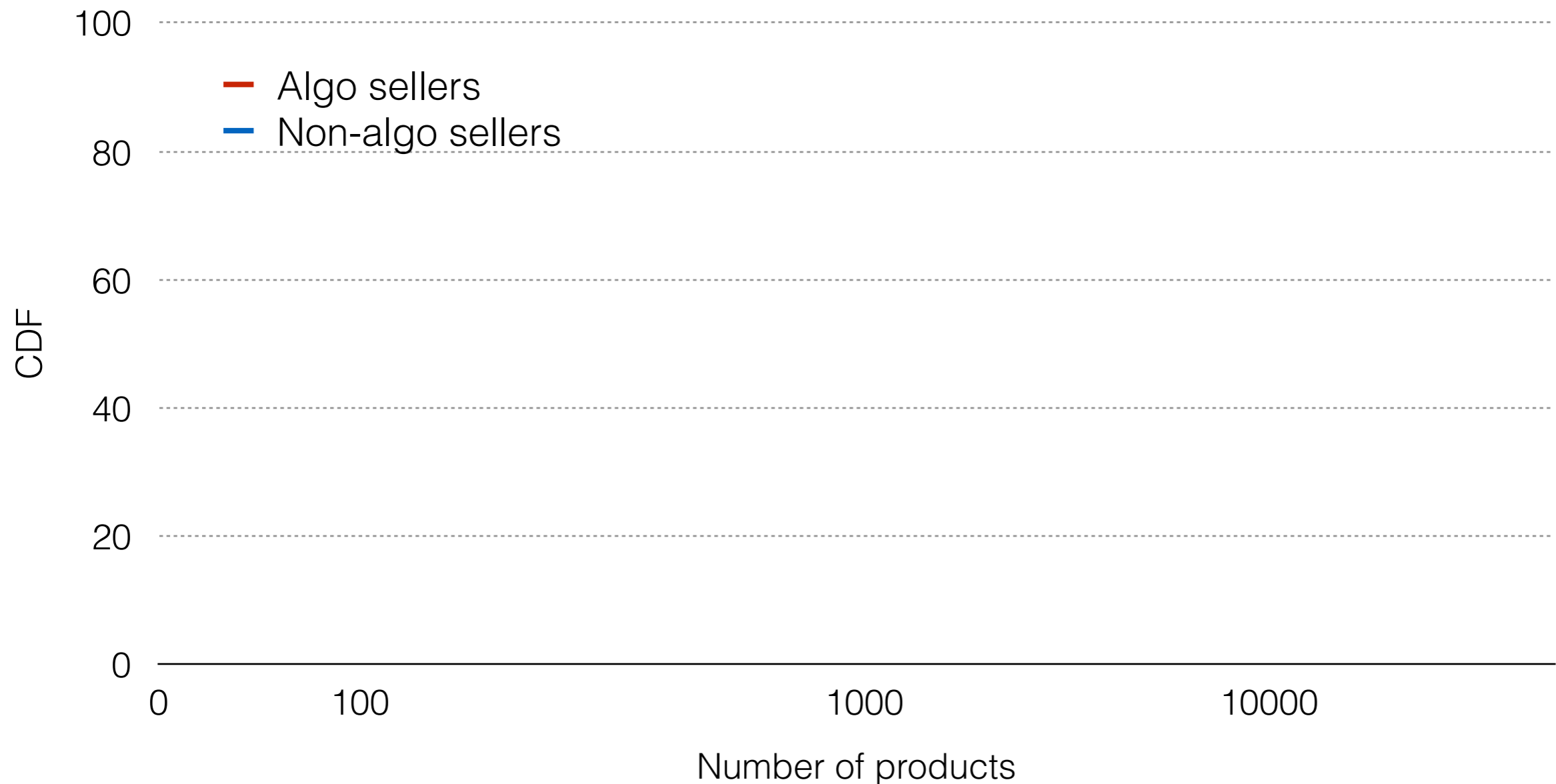
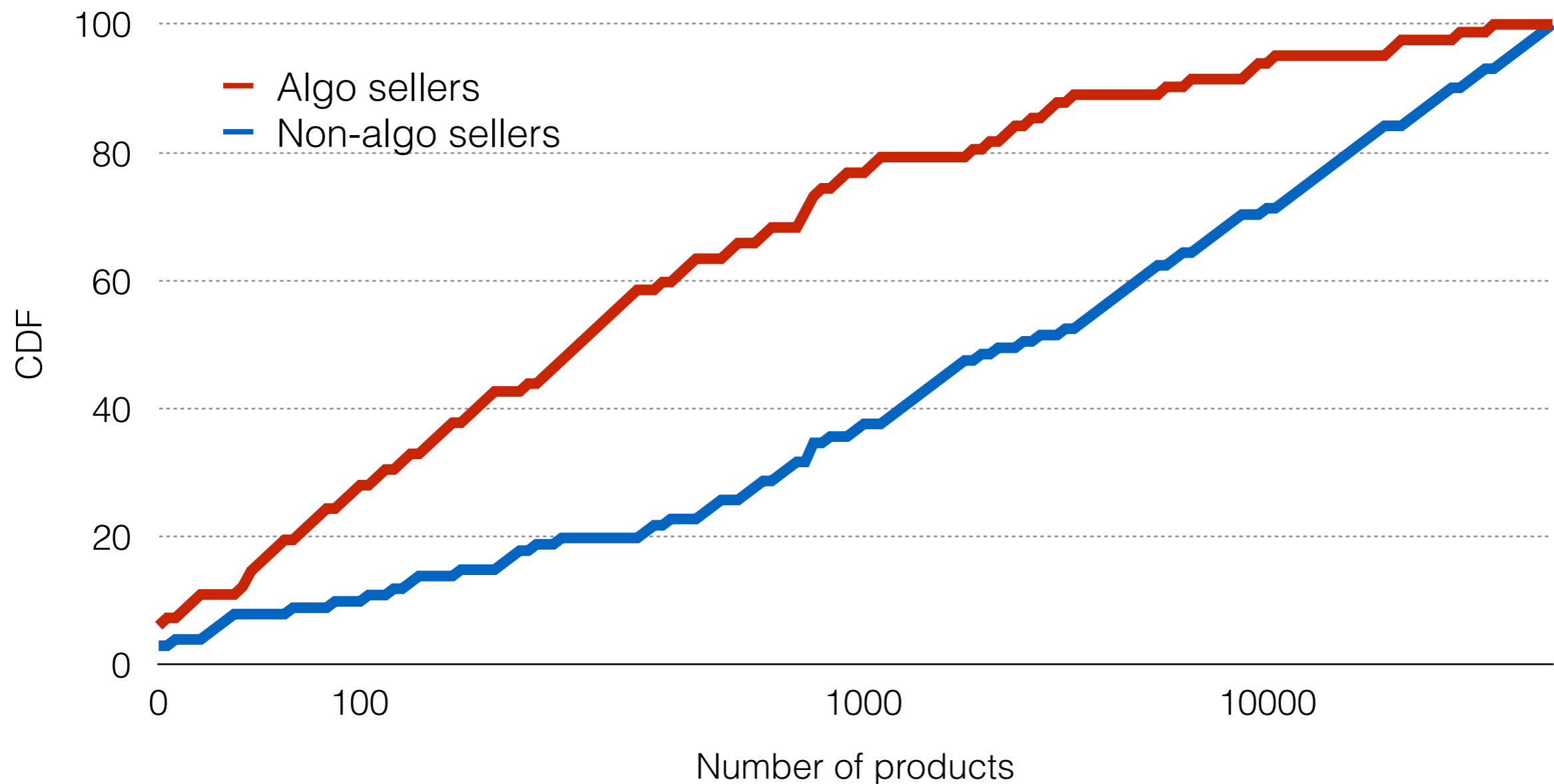# Algorithmic pricing detection

Behaviors of algo-sellers

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- Number of products sold by algo/non-algo sellers

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Behaviors of algo-sellers

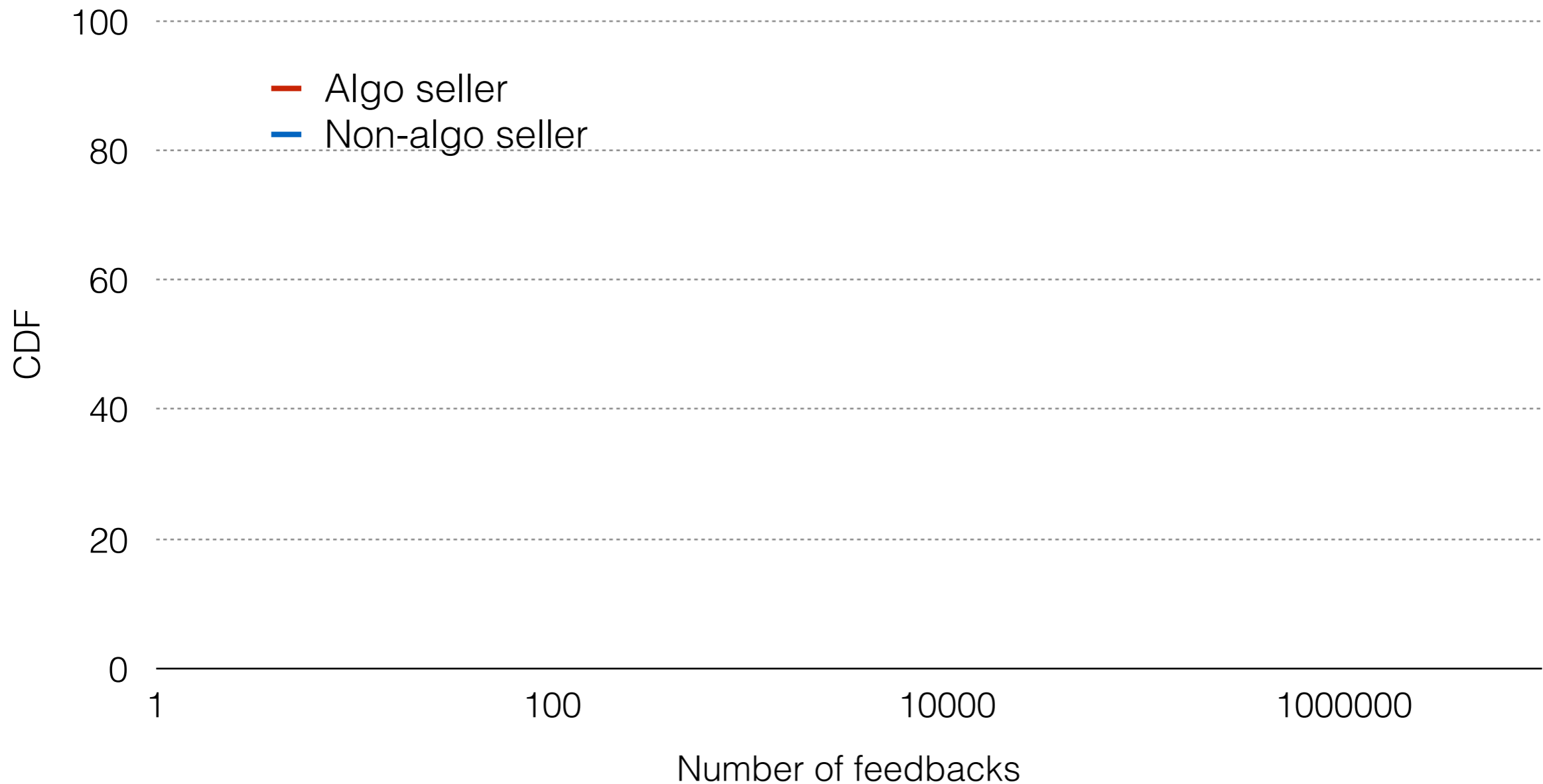- Number of products sold by algo/non-algo sellers

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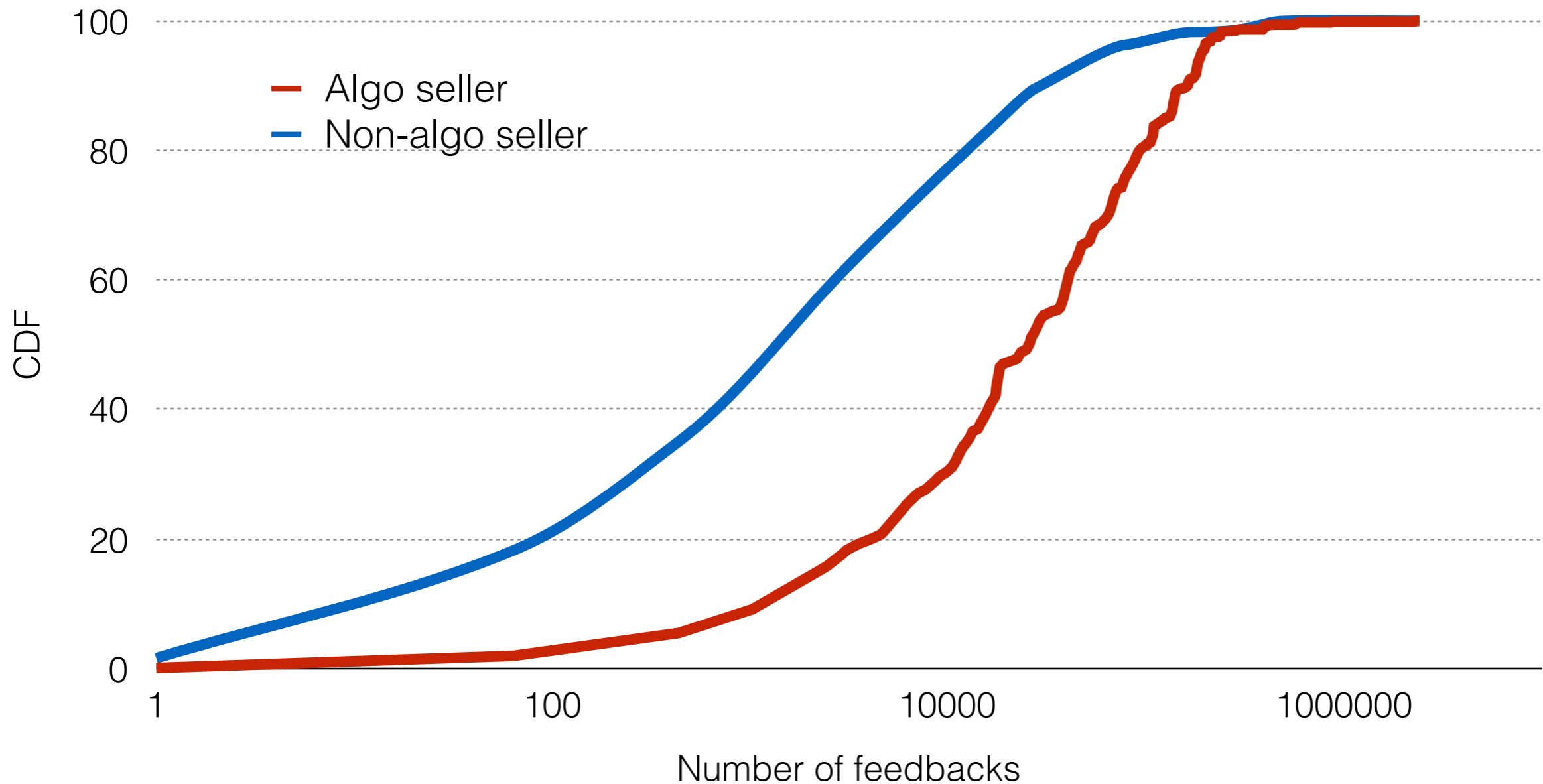
Behaviors of algo-sellers

- Feedbacks received for algo/non-algo sellers

Behaviors of algo-sellers

- Feedbacks received for algo/non-algo sellers

CDF (y-axis): 0, 20, 40, 60, 80, 100

Number of feedbacks (x-axis): 1, 100, 10000, 1000000

Legend:
— Algo seller
— Non-algo seller

Behaviors of algo-sellers

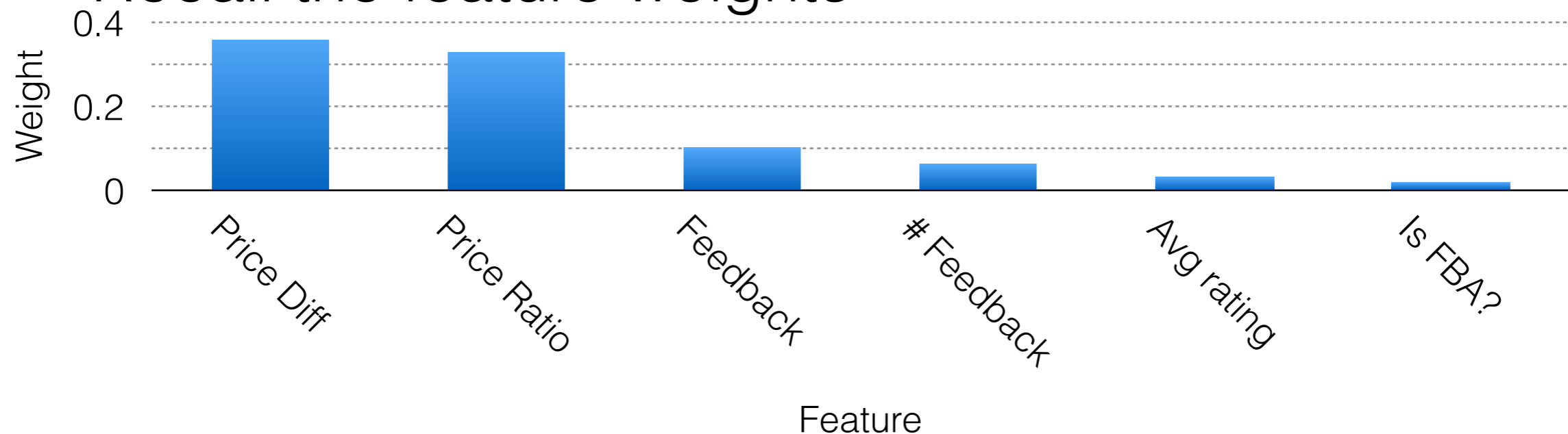- Feedbacks received for algo/non-algo sellers

Feedback loops

Feedback loops

- Algo sellers sell less types of products but receive much more feedbacks than non-algo sellers
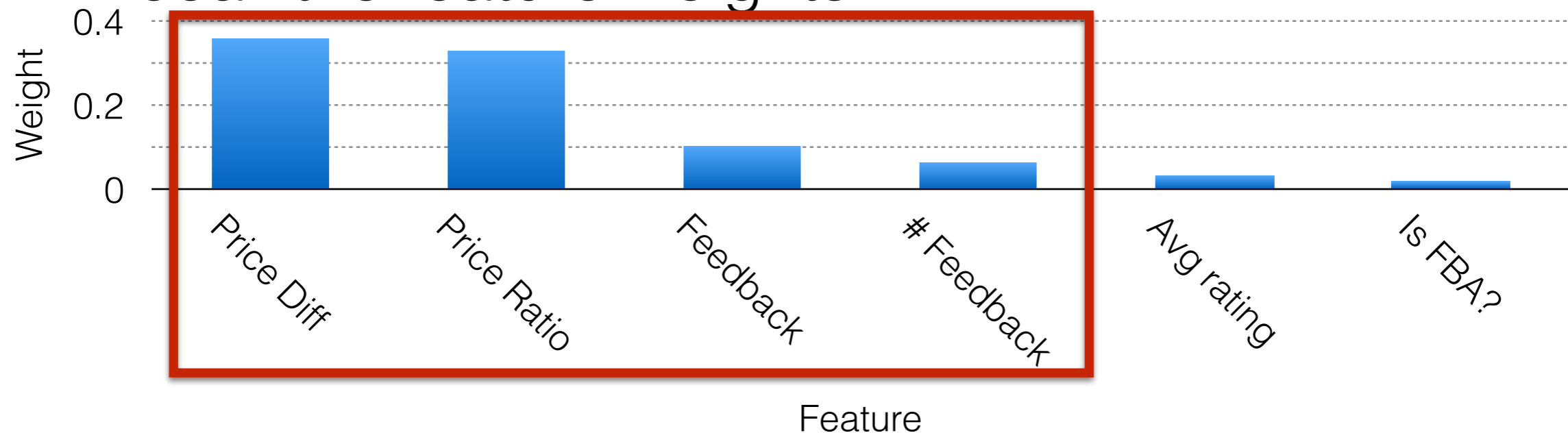
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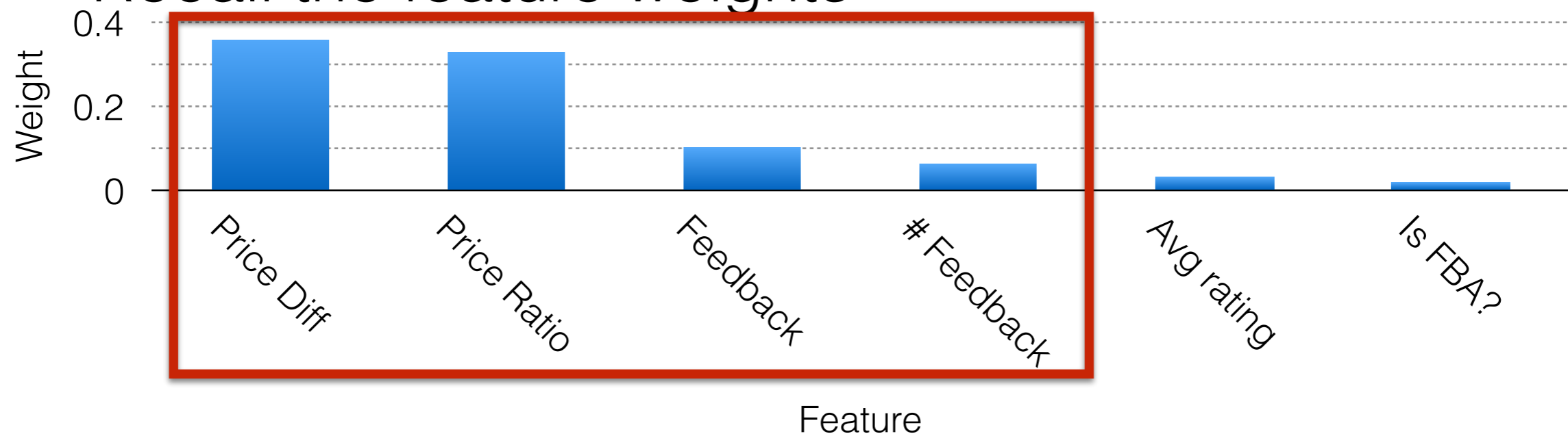- Feedback loops: Feedback

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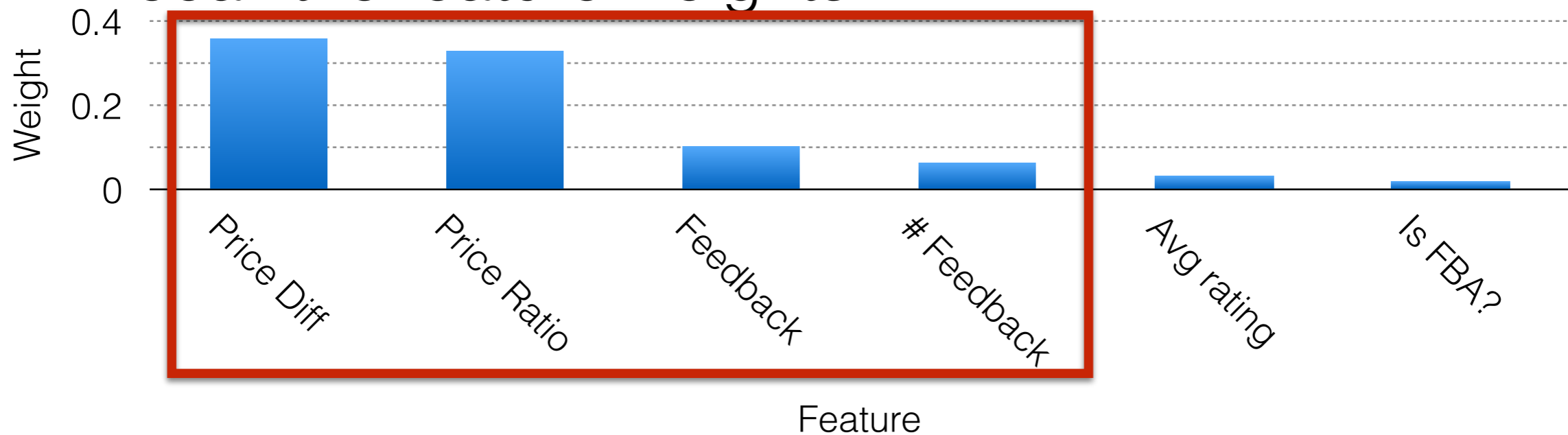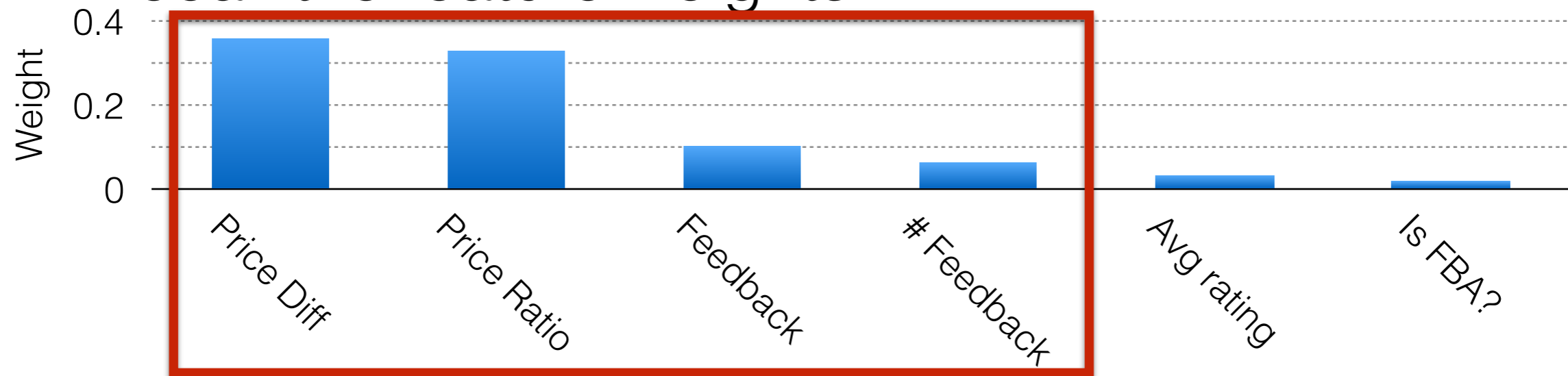
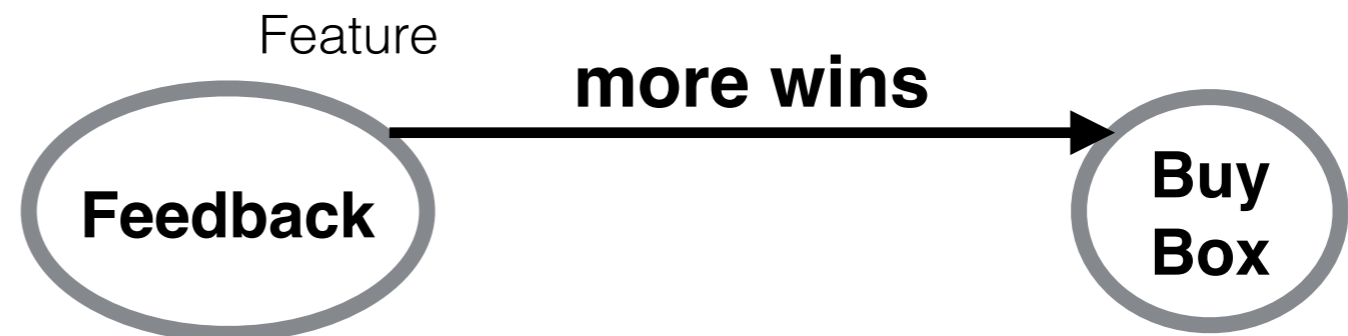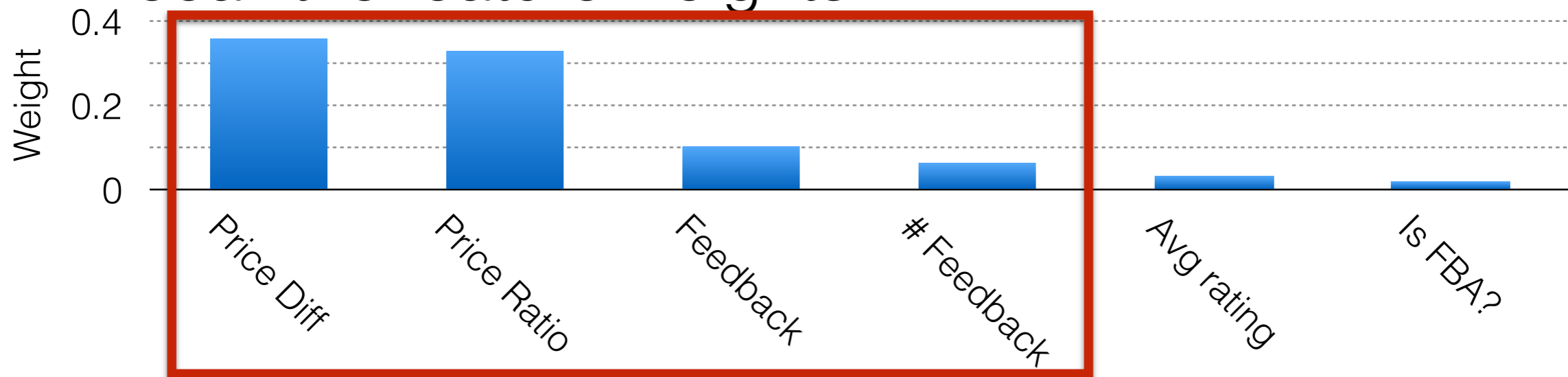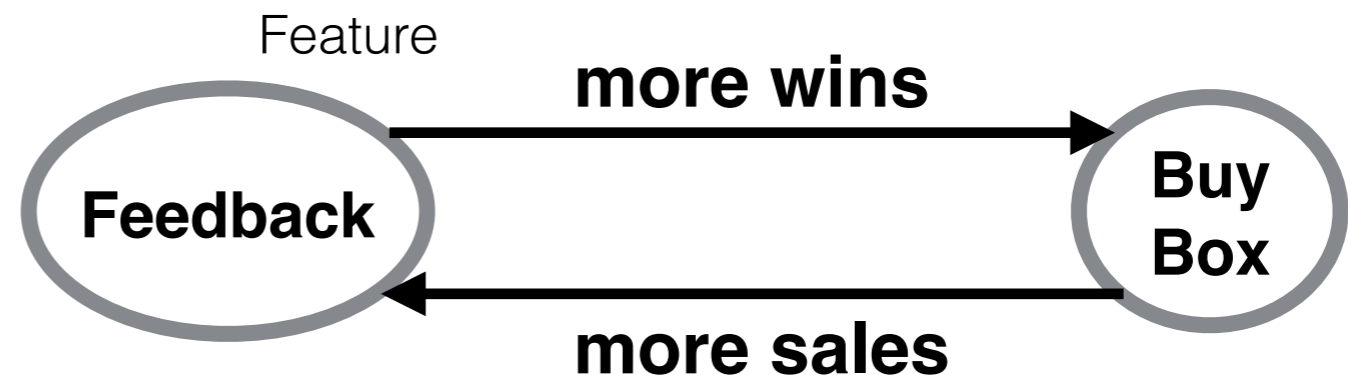- Recall the feature weights

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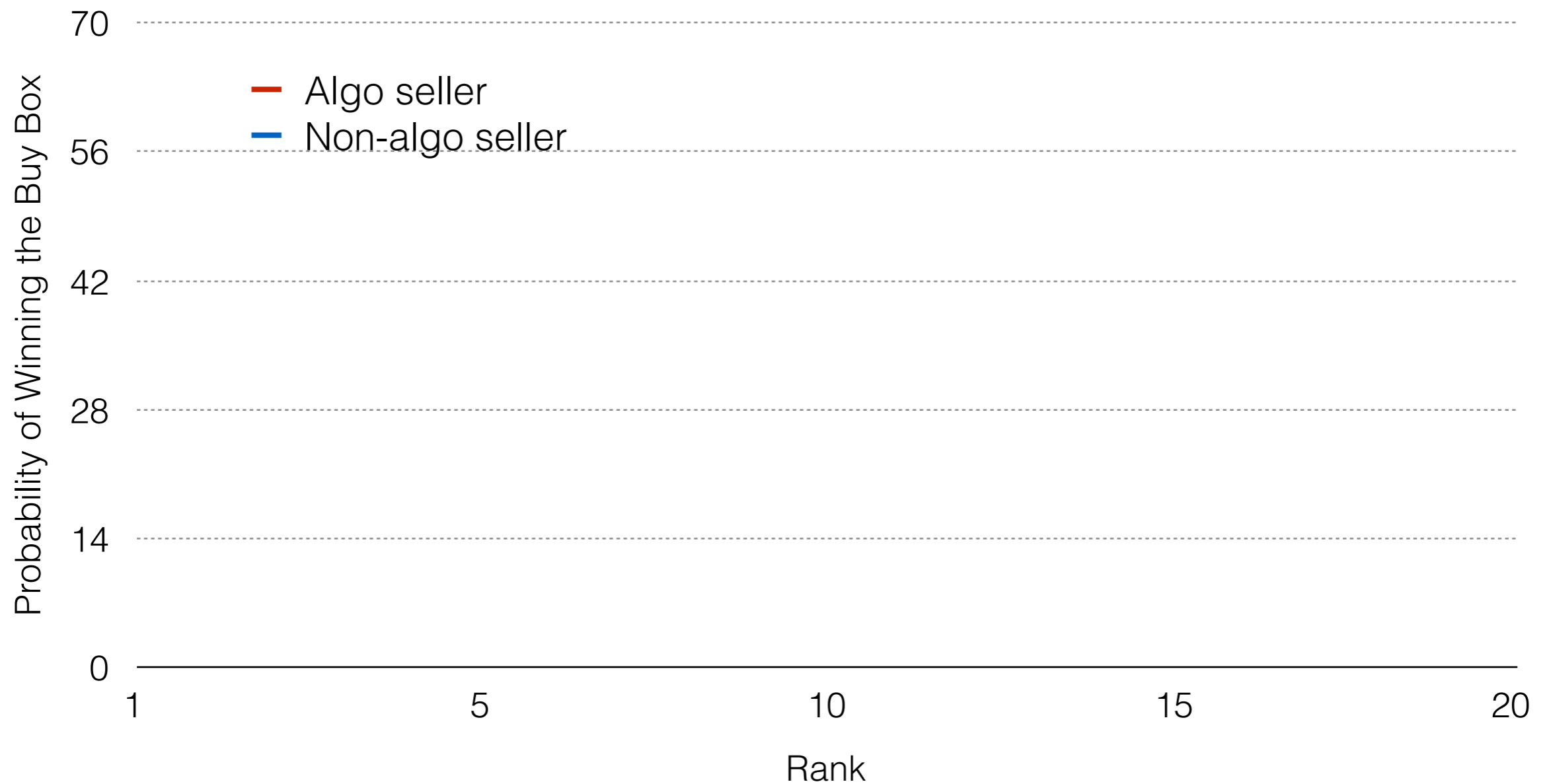
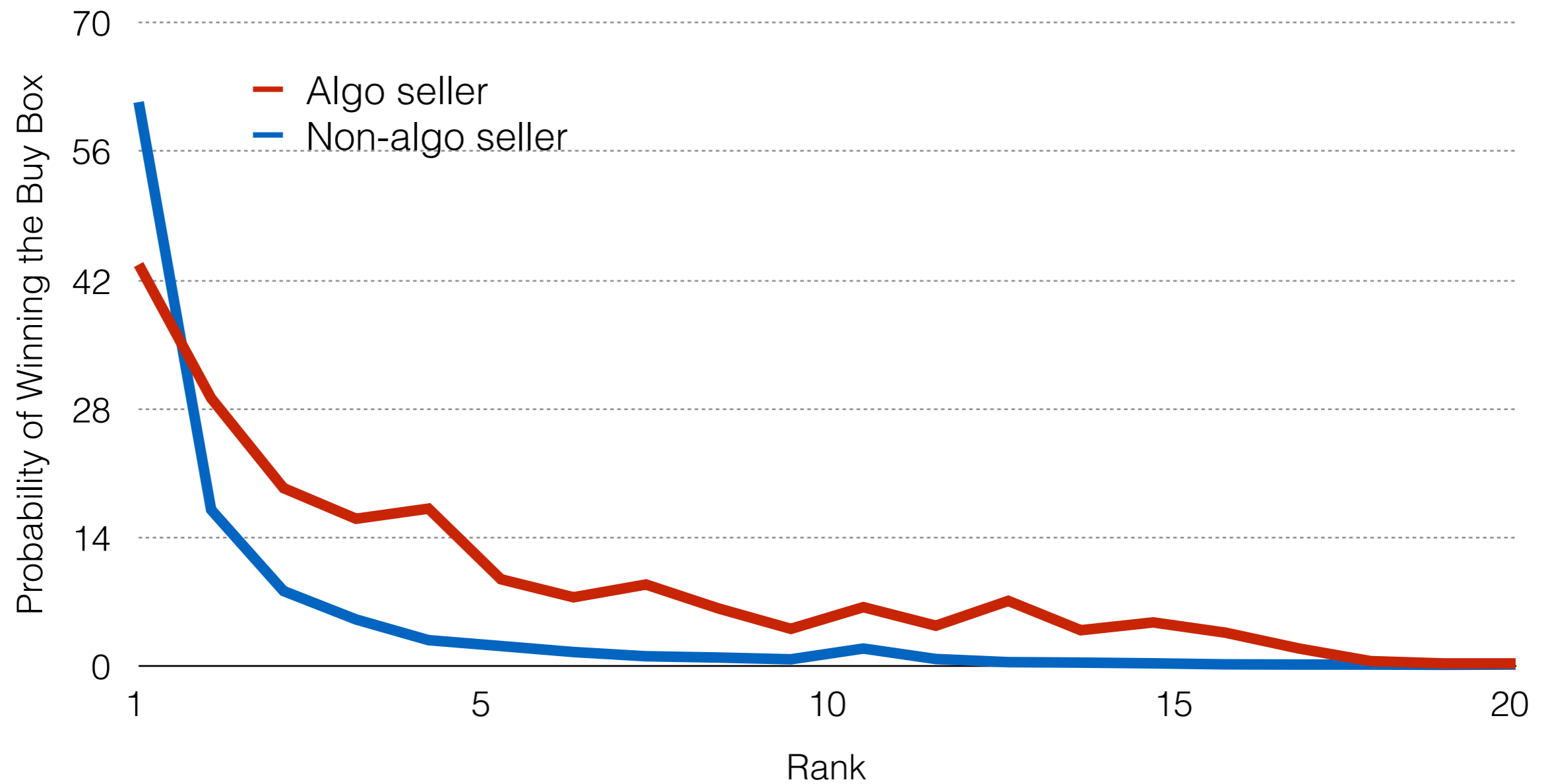- Recall the feature weights

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Behaviors of algo-sellers

- Probability of winning the Buy Box for algo/non-algo sellers

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Summary

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- We tracked the price and sellers of best selling products on Amazon for 5 months

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- We developed a methodology to detect algo sellers

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- We tracked the price and sellers of best selling products on Amazon for 5 months

- We developed a methodology to detect algo sellers

- We uncovered their strategies for winning the Buy Box, and potentially creating the feedback loops

Thanks!

- Questions?