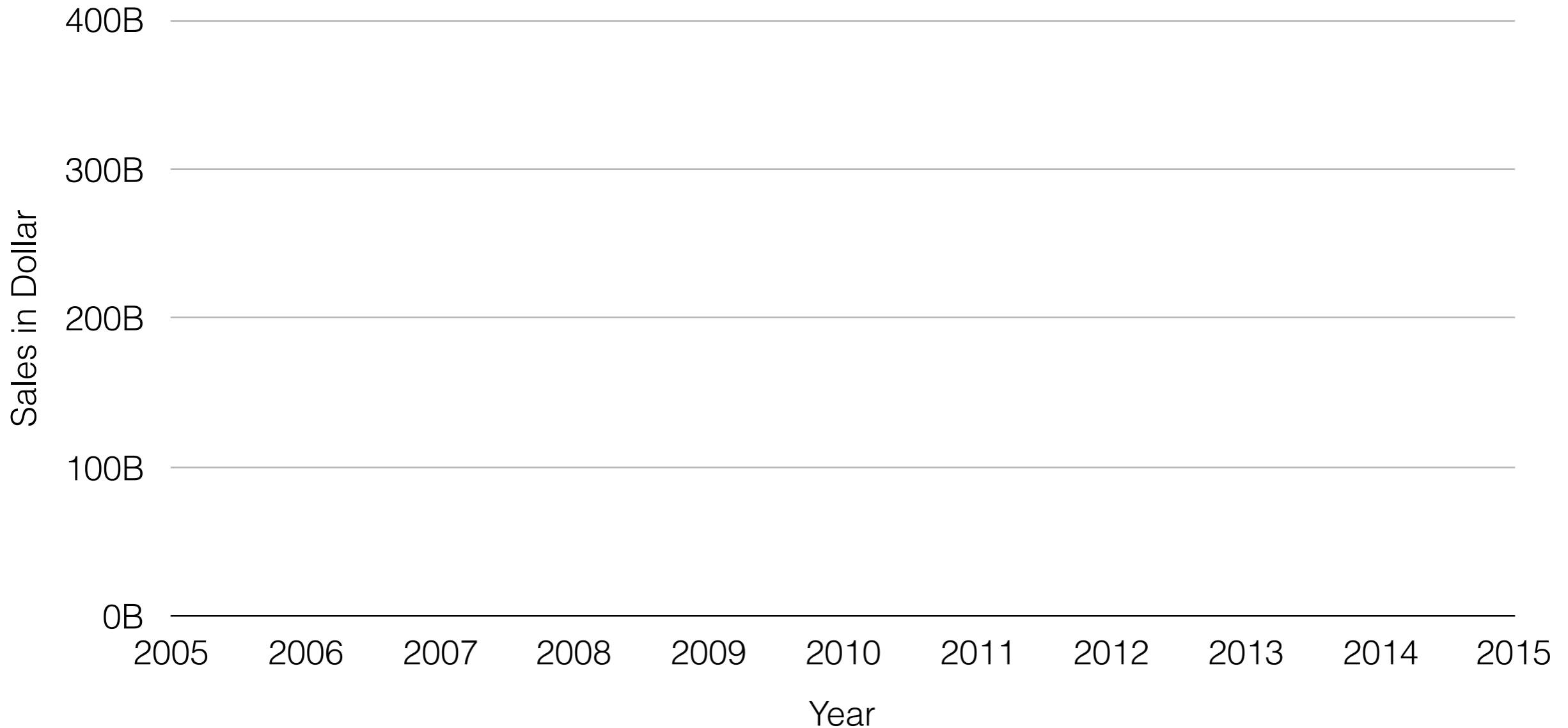


An Empirical Analysis of Algorithmic Pricing on Amazon Marketplace

Le Chen, Alan Mislove, Christo Wilson
Northeastern University

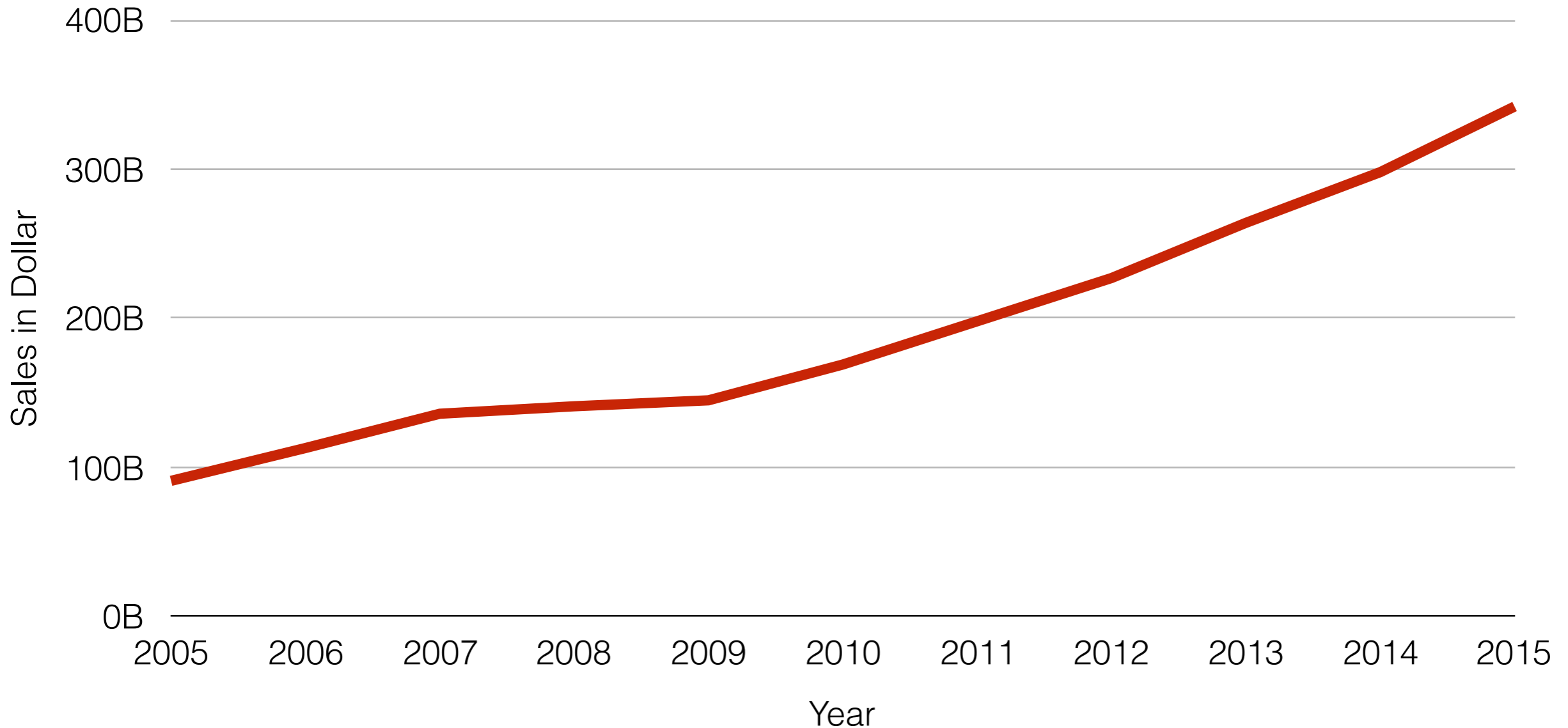
The rise of e-commerce

E-commerce Sales over time (US Commerce Department)



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Algorithmic pricing

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- Dynamic pricing algorithms or Revenue/Yield Management

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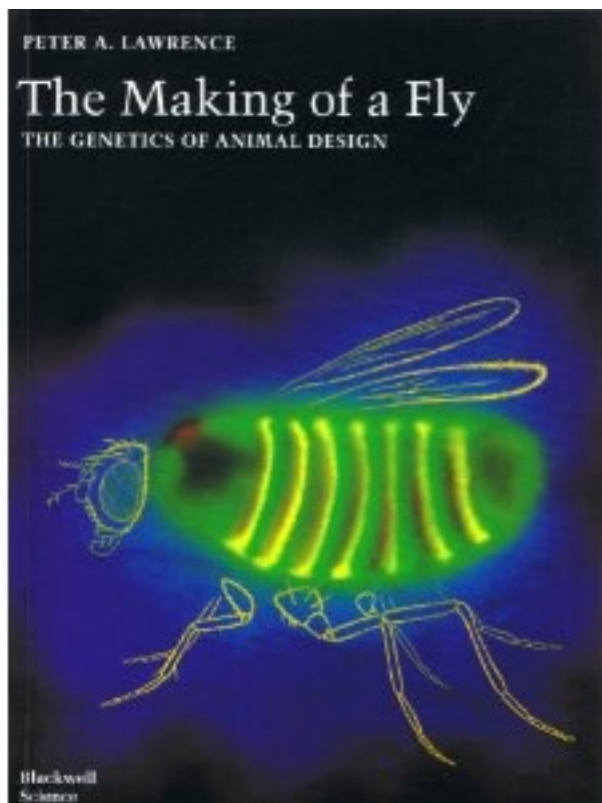
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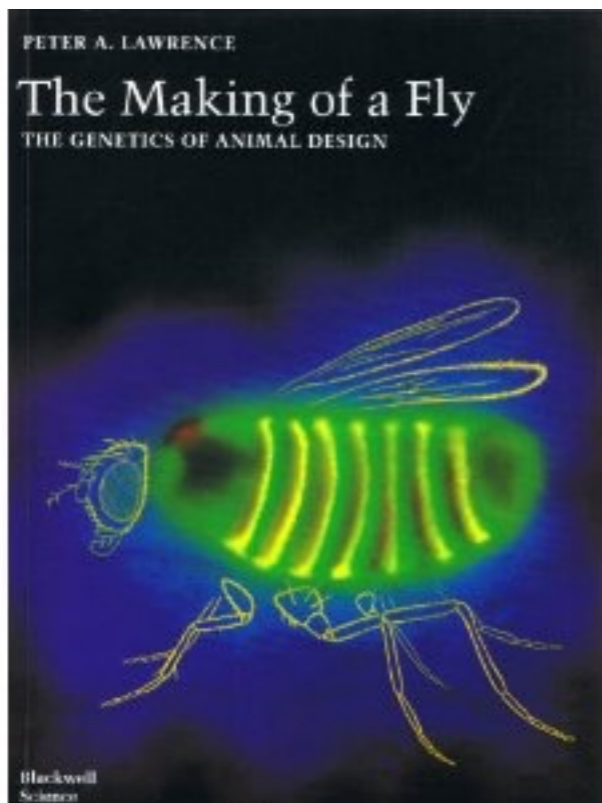
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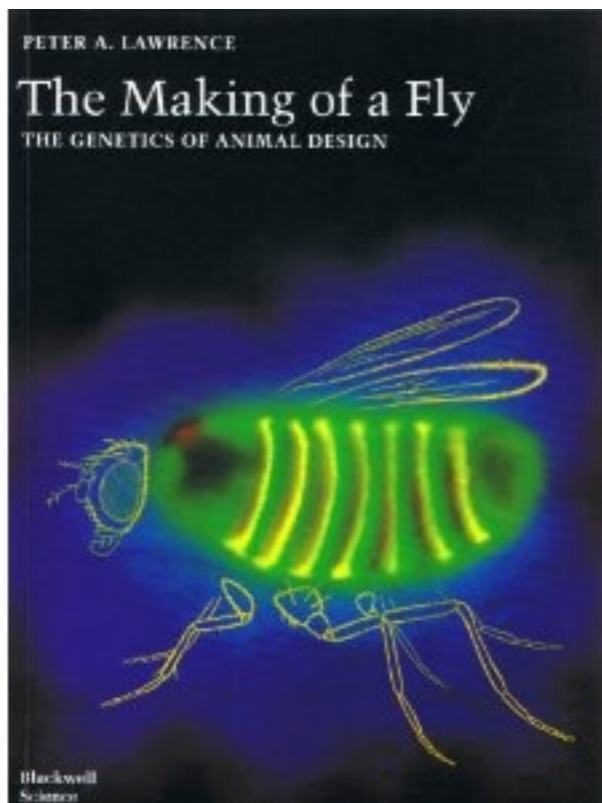
New 1-2 of 2 offers

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

\$2,198,177.95 **New**
+ \$3.99 shipping

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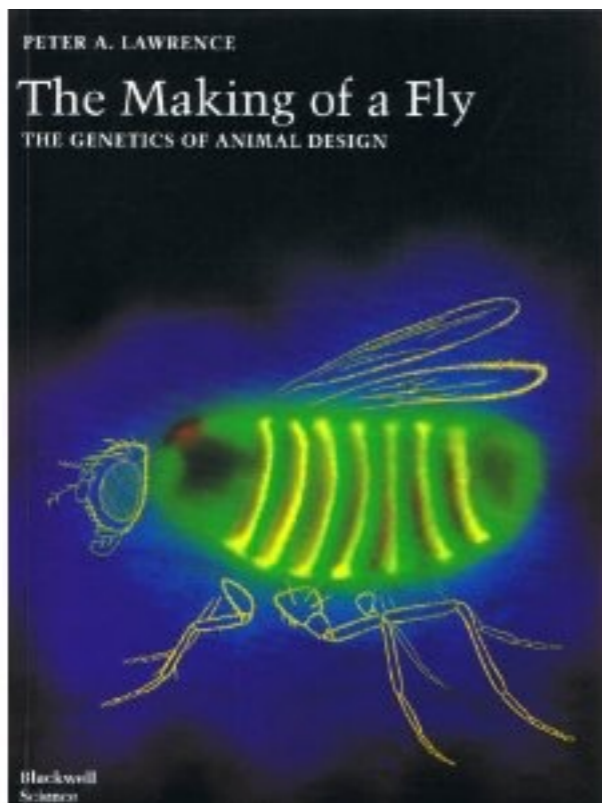


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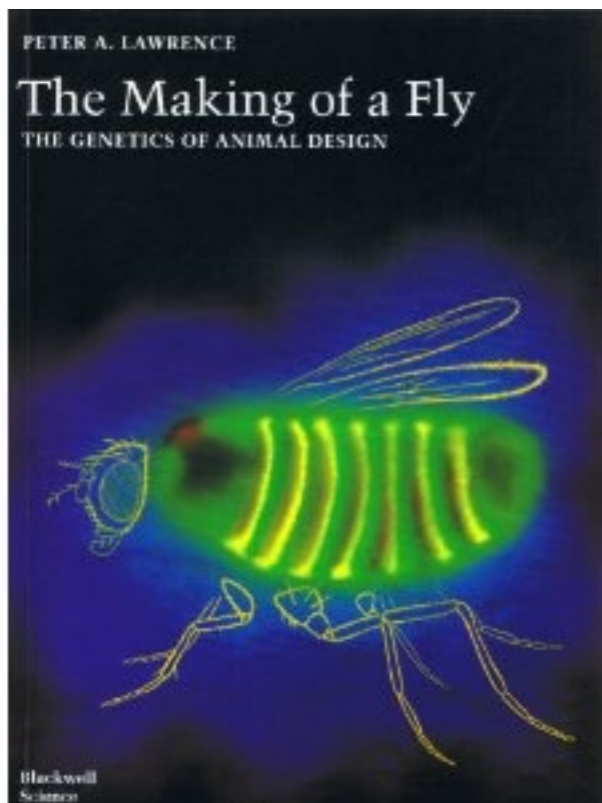
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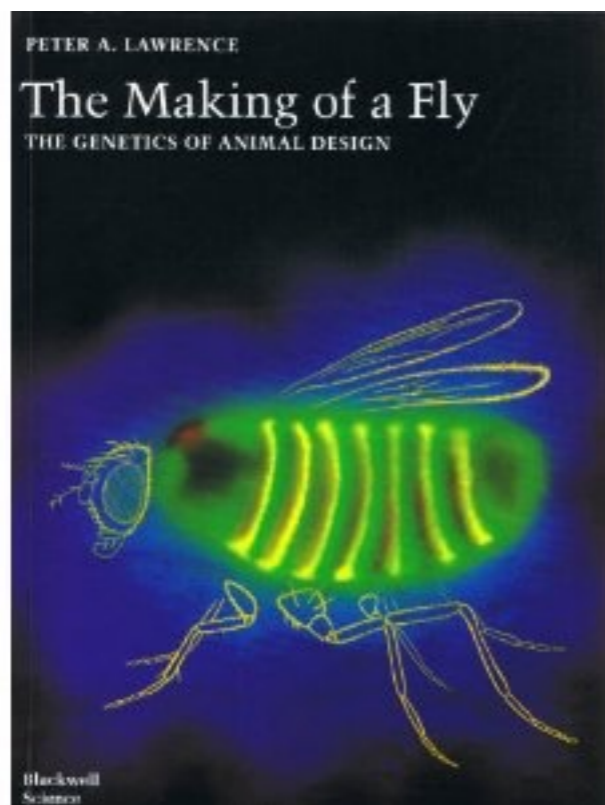
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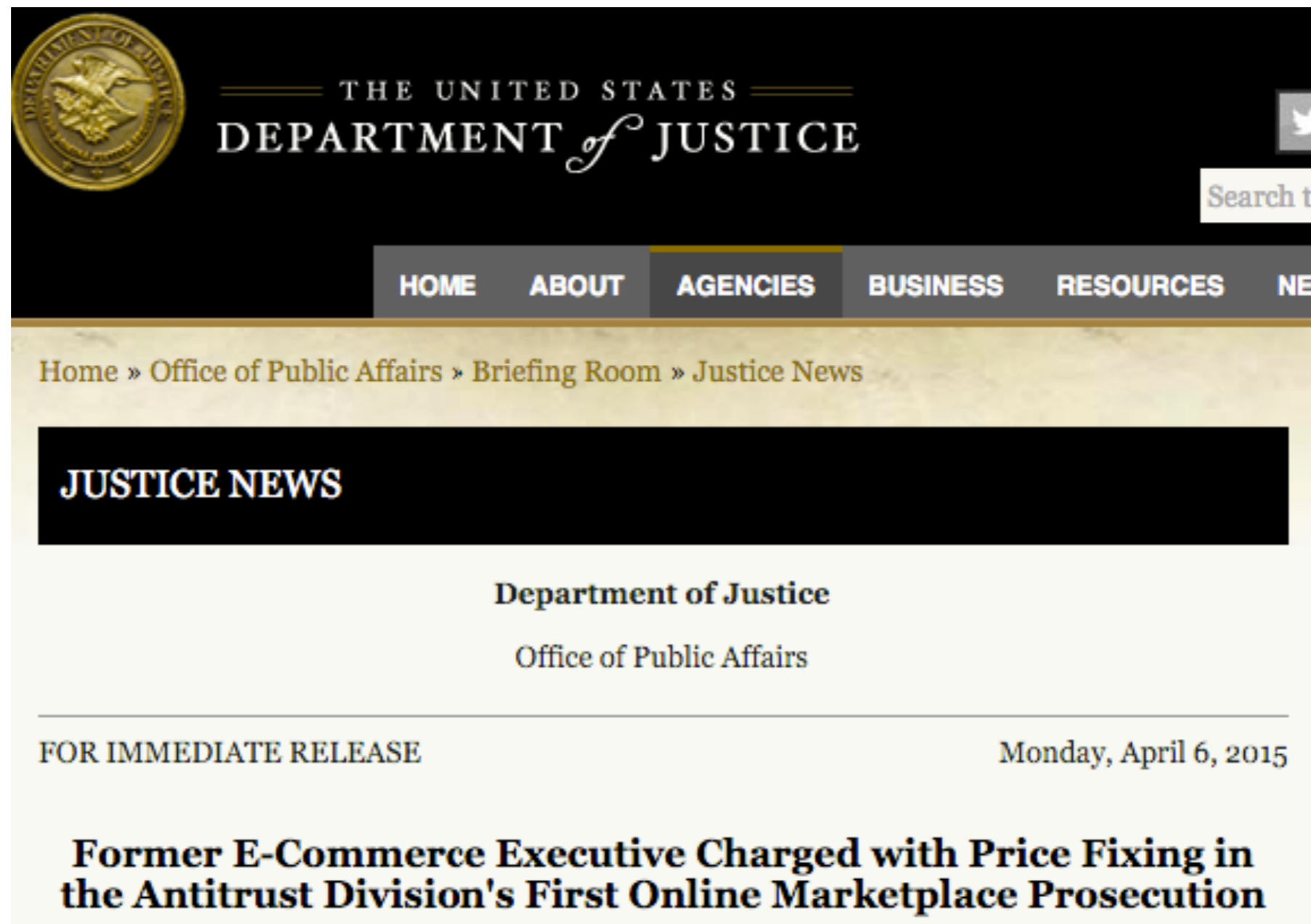
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Problems in algorithmic pricing

- Collusive strategies

Problems in algorithmic pricing

- Collusive strategies



The image is a screenshot of the Department of Justice website. At the top left is the Department of Justice seal. To its right, the text reads "THE UNITED STATES DEPARTMENT of JUSTICE". A search bar is visible on the right side. Below the header is a navigation menu with links for HOME, ABOUT, AGENCIES, BUSINESS, RESOURCES, and NEWS. The breadcrumb trail indicates the current page is "Home » Office of Public Affairs » Briefing Room » Justice News". A large black box with the text "JUSTICE NEWS" is prominently displayed. Below this, the text "Department of Justice" and "Office of Public Affairs" is centered. A horizontal line separates the header from the main content. On the left side of the line, it says "FOR IMMEDIATE RELEASE". On the right side, it says "Monday, April 6, 2015". The main headline reads "Former E-Commerce Executive Charged with Price Fixing in the Antitrust Division's First Online Marketplace Prosecution".

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Data collection

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 - 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:

Yes, I want **FREE Two-Day Shipping** with [Amazon Prime](#)




[Turn on 1-Click ordering for this browser](#)

28 used & new from **\$49.49**


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](#)

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- Seller pages

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\$51.00 & FREE Shipping	New	<ul style="list-style-type: none">• Arrives between April 14-20.• Ships from CA, United States.• Domestic shipping rates and return policy.	jepstore1 Just Launched (Seller Profile)
\$51.99 & FREE Shipping	New	<ul style="list-style-type: none">• Arrives between April 12-18.• Ships from TN, United States.• Domestic shipping rates and return policy.	jardine house ★★★★★ 100% positive over the past 12 months. (25 total ratings)
\$55.21 ✓Prime & FREE Shipping on eligible orders. Details	New	<div style="border: 1px solid black; padding: 2px;">FULFILLMENT BY AMAZON ▾</div> <ul style="list-style-type: none">• Want it delivered Tuesday, April 5? Order it in the next 3 hours and 10 minutes, and choose One-Day Shipping at checkout. See details• Domestic shipping rates and return policy.	Buy 15 ★★★★★ 100% positive over the past 12 months. (122,053 total ratings)
\$55.21 ✓Prime & FREE Shipping on eligible orders. Details	New	<div style="border: 1px solid black; padding: 2px;">FULFILLMENT BY AMAZON ▾</div> <ul style="list-style-type: none">• Want it delivered Tuesday, April 5? Order it in the next 0 hours and 59 minutes, and choose One-Day Shipping at checkout. See details• Domestic shipping rates and return policy.	Roseran ★★★★★ 98% positive over the past 12 months. (199 total ratings)

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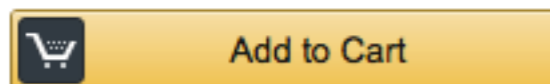
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Data collection

- Buy Box

- Seller pages

The screenshot displays an Amazon product page with the Buy Box on the left and a list of sellers on the right. A red arrow points from the Buy Box area to the top seller listing.

Buy Box:

- List Price: \$79.99
- Price: **\$55.21** & FREE Shipping. [Details](#)
- You Save: \$24.78 (31%)
- Qty: 1
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Seller Listings:

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82% of sales go to the Buy Box...

Data collection

- Buy Box

- Seller pages

The screenshot displays an Amazon product page with the following elements:

- Buy Box:** Located on the left, it shows the list price (\$79.99), current price (\$55.21), and shipping details. It includes a quantity selector (set to 1), a checkbox for Amazon Prime shipping, and a prominent yellow "Add to Cart" button.
- Seller Information Table:** A table on the right lists three sellers with their respective prices, shipping conditions, delivery details, and seller profiles.

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Additional text on the page includes: "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", and "28 used & new from \$49.49". A red arrow points from the "Add to Cart" button to the "Buy 15" seller information.

82% of sales go to the Buy Box...

Win the Buy Box!

Data collection

Data collection

- Cover Buy Box and seller pages

Data collection

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

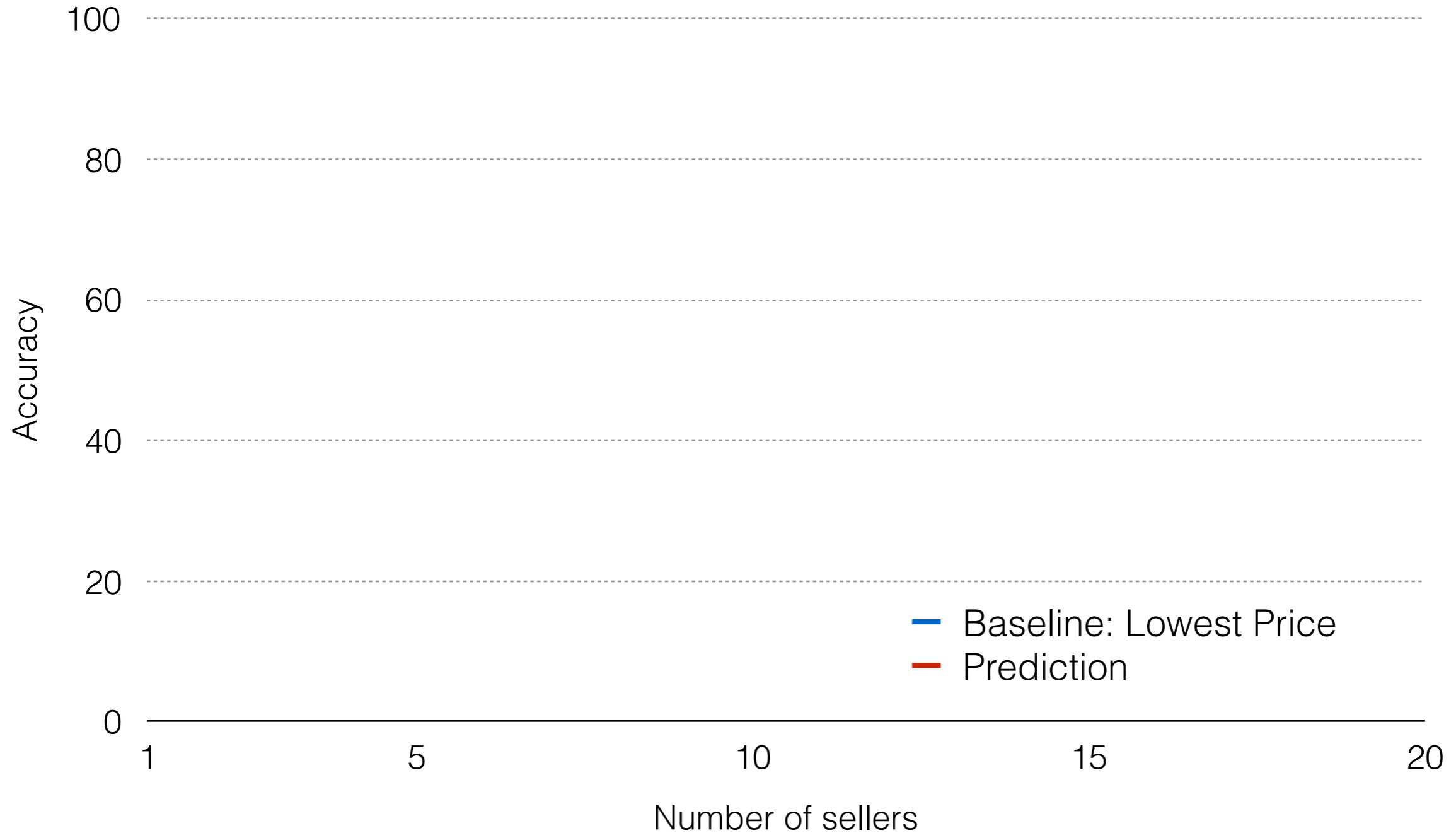
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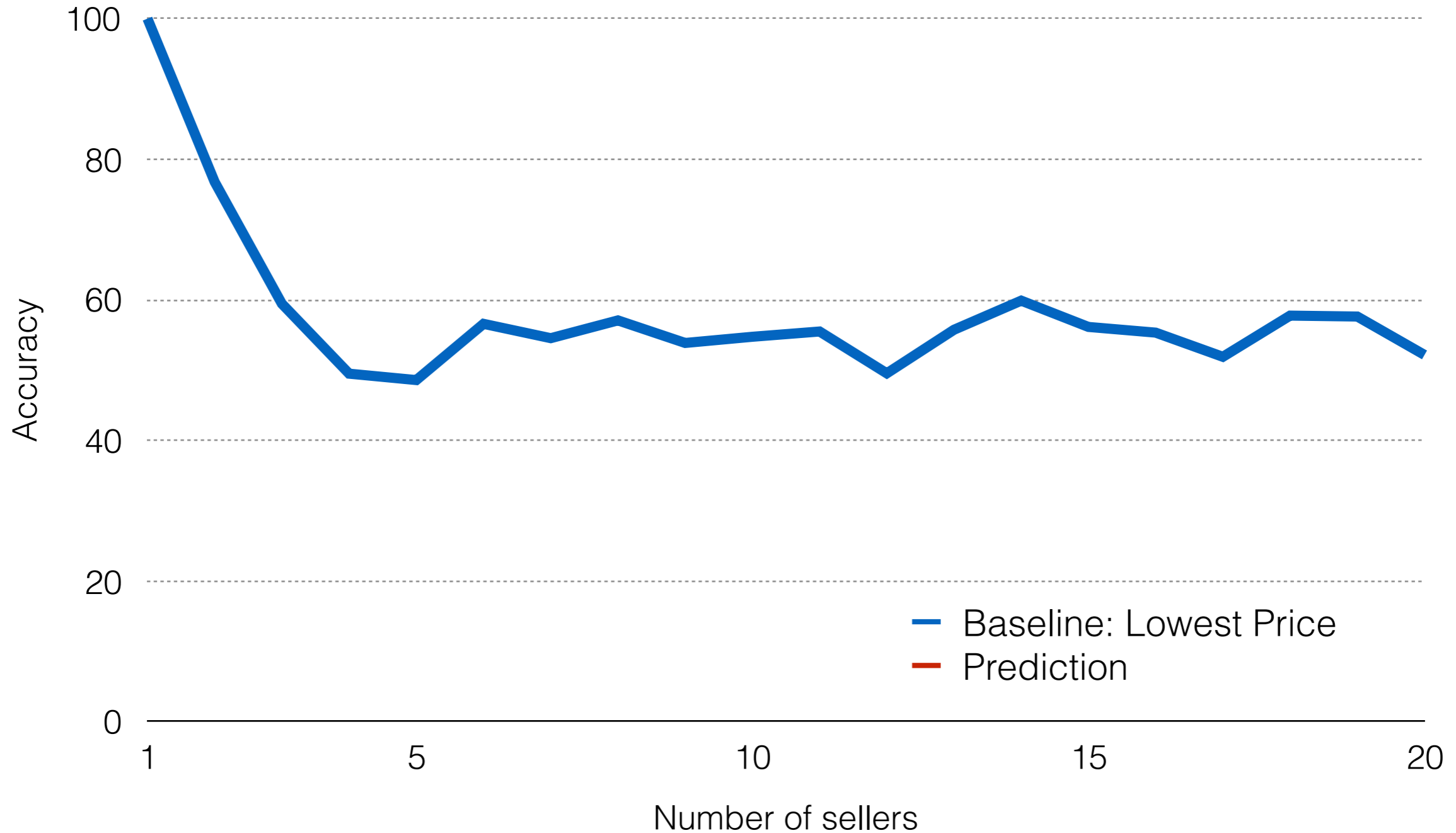
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- Features Amazon considers for each seller
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- Random forest

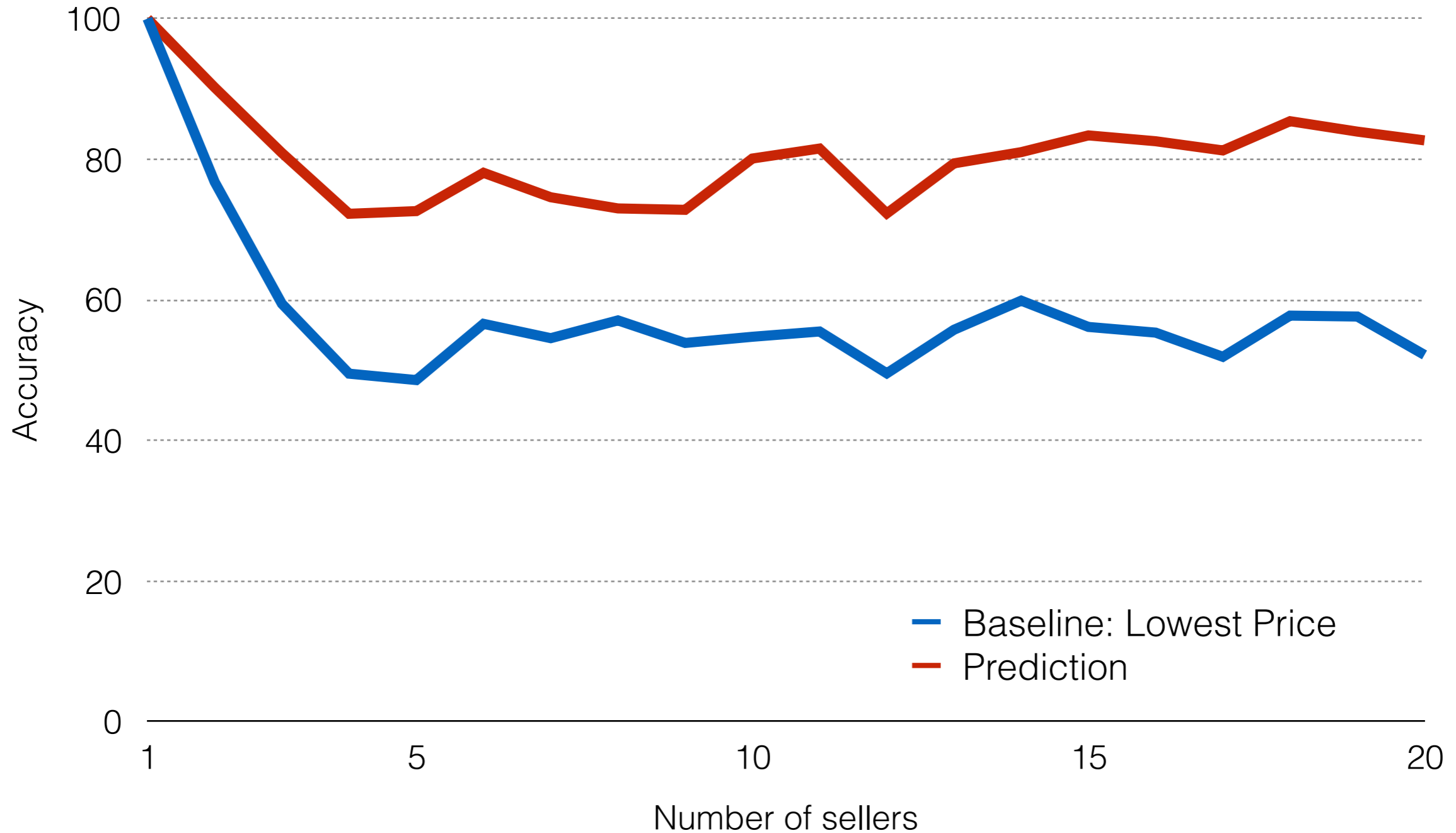
Buy Box winner prediction



Buy Box winner prediction

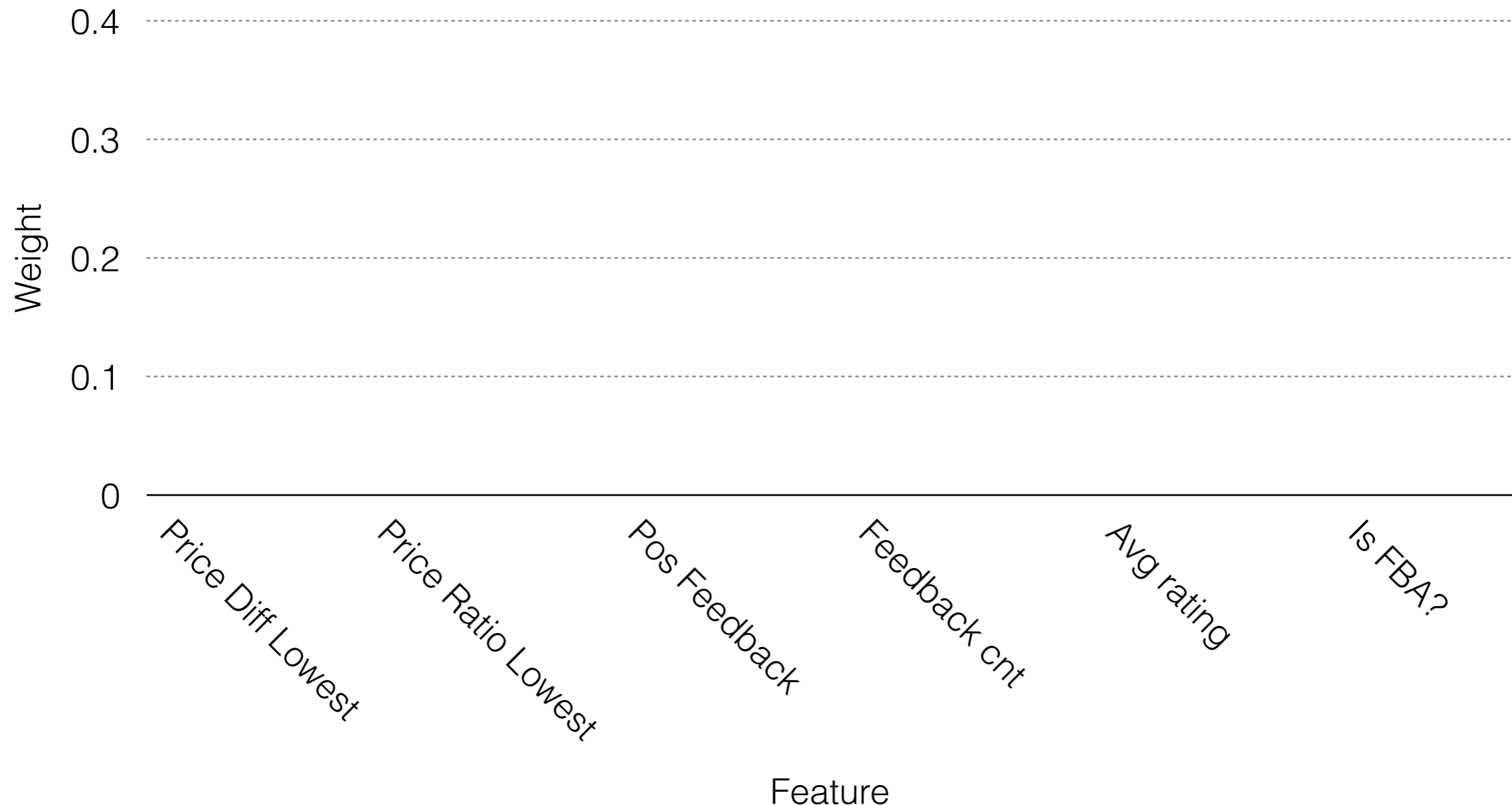


Buy Box winner prediction



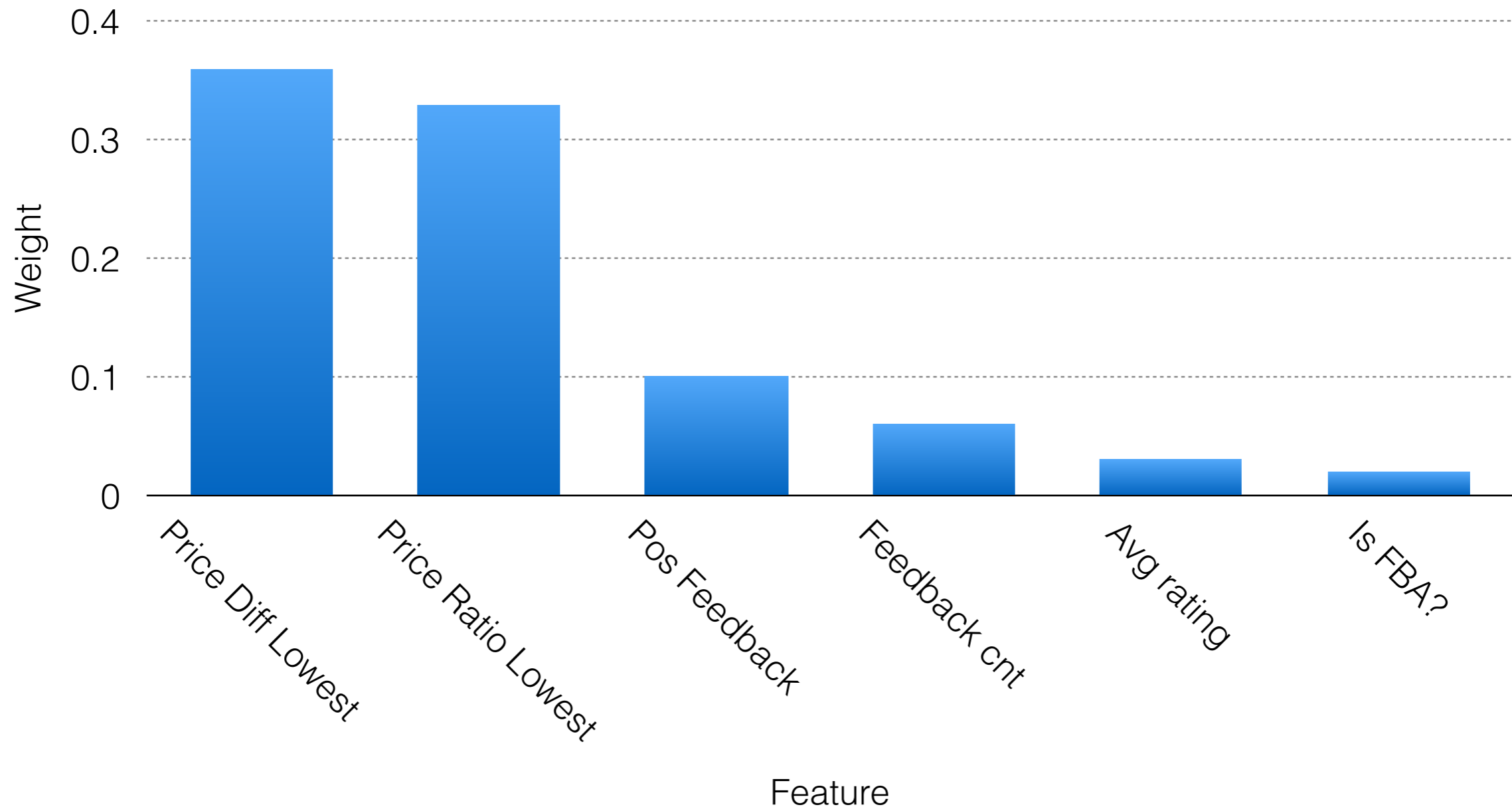
Buy Box winner prediction

- Feature weights



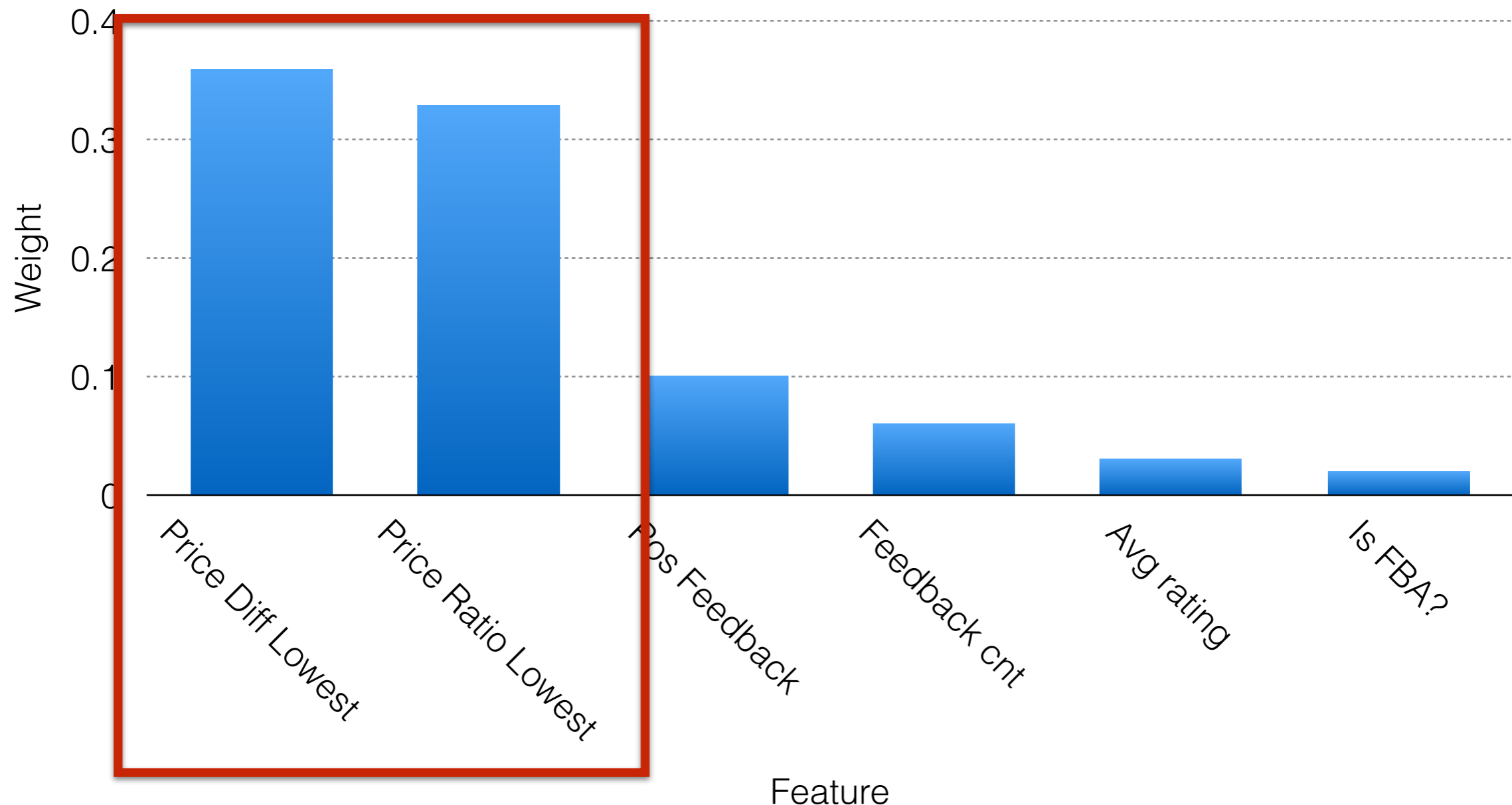
Buy Box winner prediction

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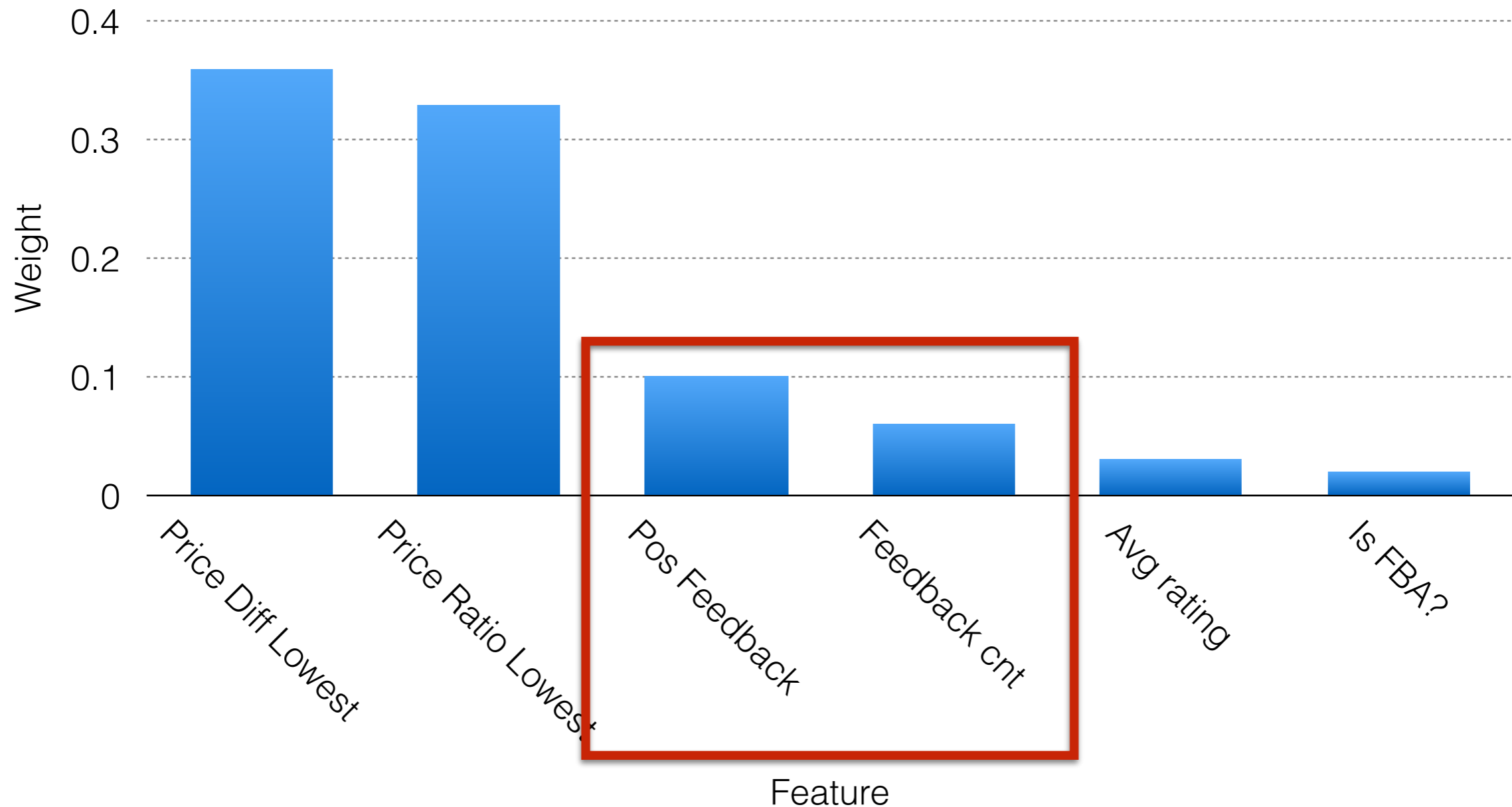
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- Can we develop a methodology to detect sellers who are adopting algorithmic pricing?
 - Limited information, such as, price, rank, etc.
 - Non-trivial because there is no ground truth.
Therefore, we locate sellers behaving like “bots”
- What are the different behaviors between the algo sellers and non-algo sellers?

Algorithmic pricing detection

Algorithmic pricing detection

- How can algo sellers stay competitive?

Algorithmic pricing detection

- How can algo sellers stay competitive?
 - Matching to a “competitive” price

Algorithmic pricing detection

- How can algo sellers stay competitive?
 - Matching to a “competitive” price
- Target price time series

Algorithmic pricing detection

- How can algo sellers stay competitive?
 - Matching to a “competitive” price
- Target price time series
 - Lowest price

Algorithmic pricing detection

- How can algo sellers stay competitive?
 - Matching to a “competitive” price
- Target price time series
 - Lowest price
 - Second lowest price

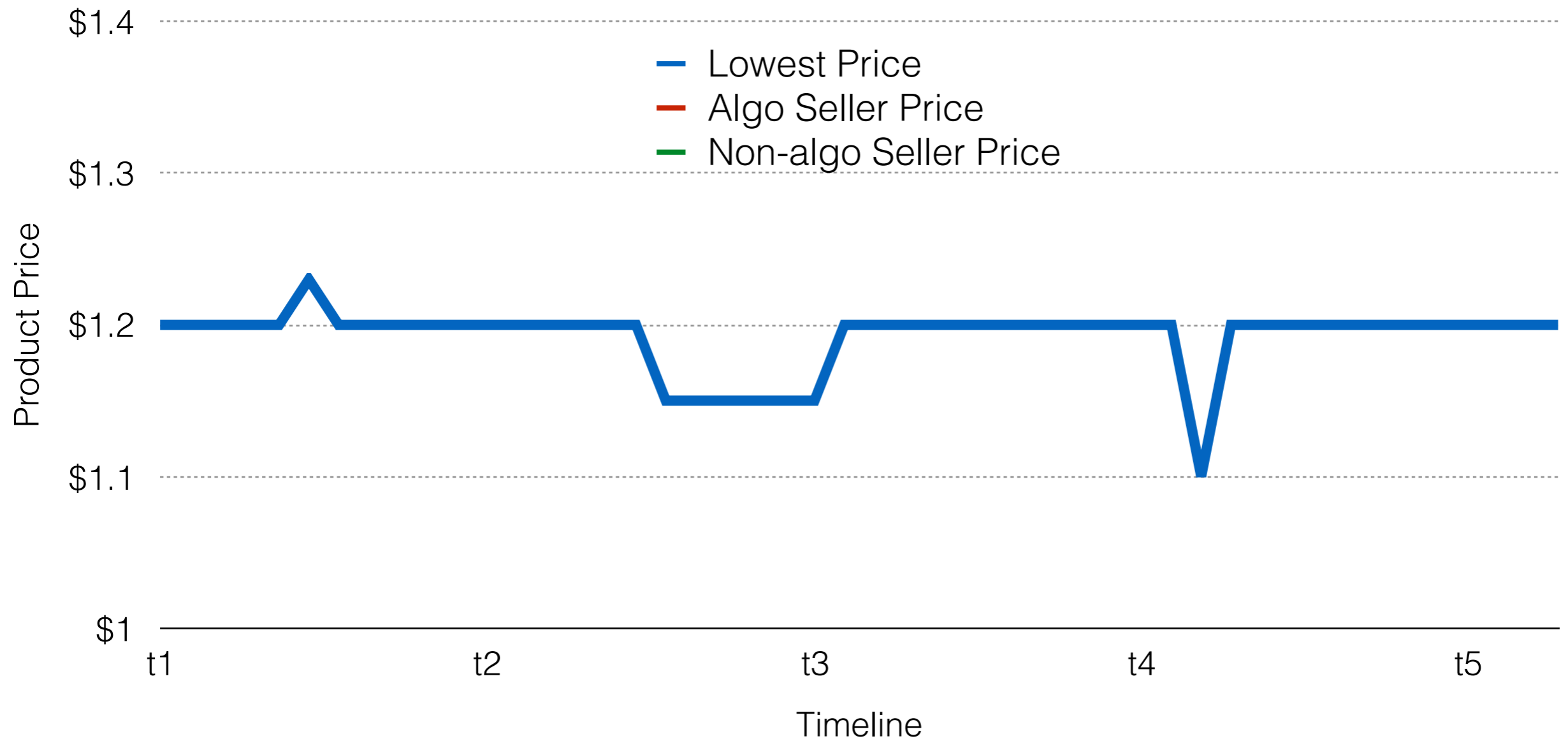
Algorithmic pricing detection

- How can algo sellers stay competitive?
 - Matching to a “competitive” price
- Target price time series
 - Lowest price
 - Second lowest price
 - Amazon price

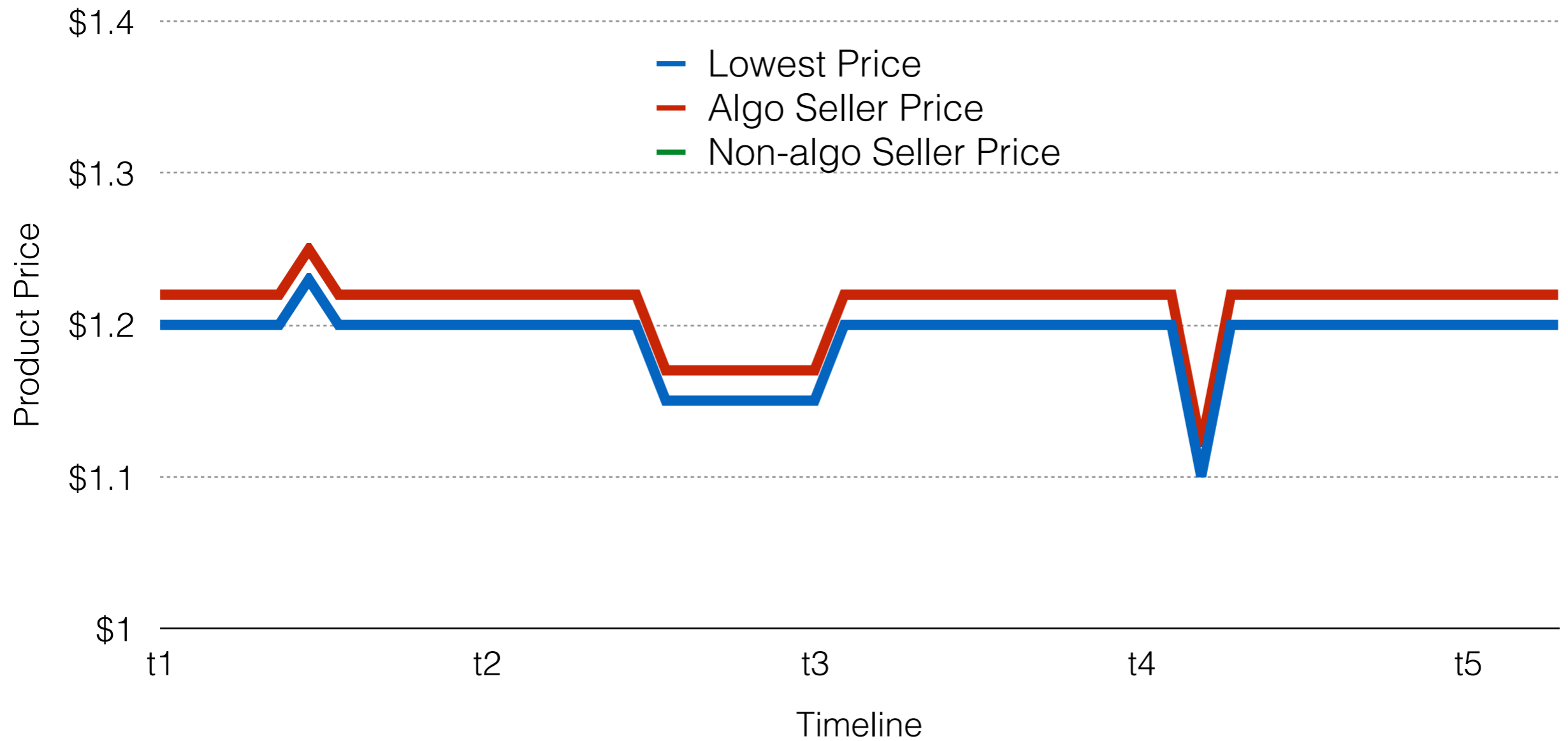
Algorithmic pricing detection



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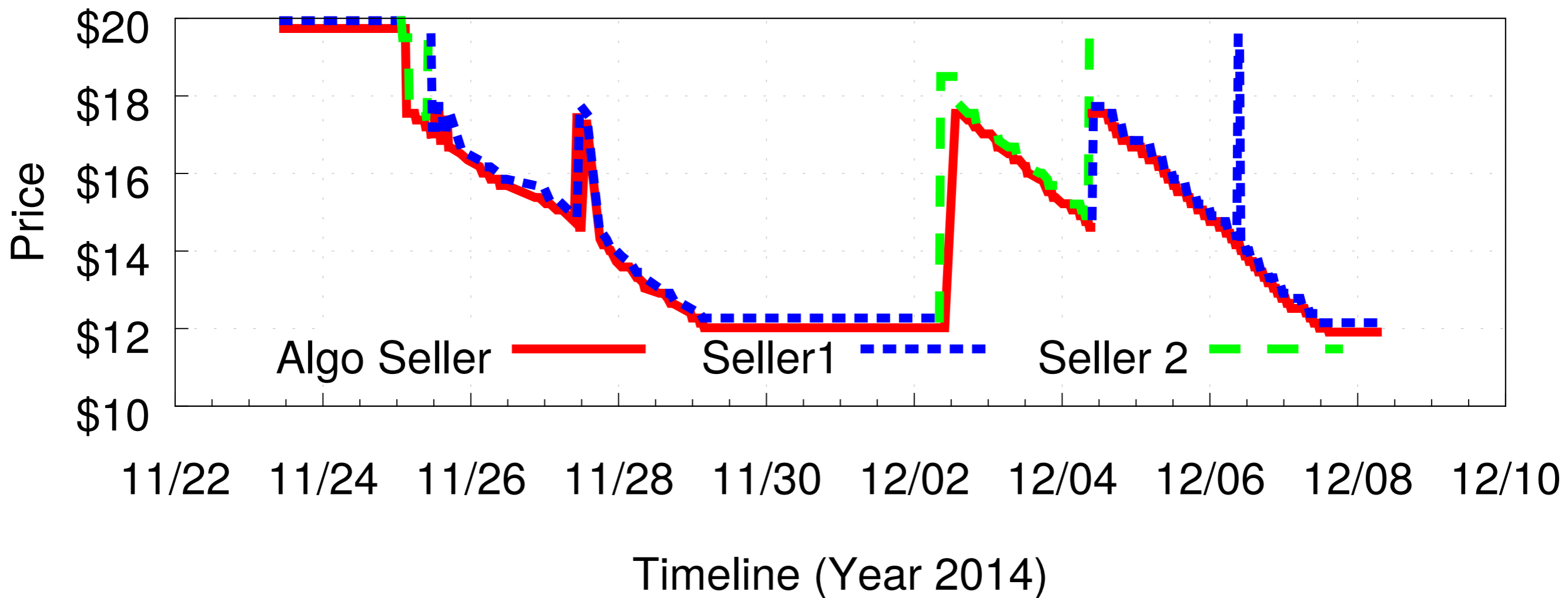
- Detection criteria
 - Spearman's rank correlation between seller and target price
 - Product must have more than 1 seller
 - Correlation coefficient ≥ 0.7
 - p-value ≤ 0.05
 - Number of price changes ≥ 20

Algorithmic pricing detection

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 - 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
- Discovered 543 sellers covering 513 products
 - 2.4% of total sellers
 - 31% of the bestselling products

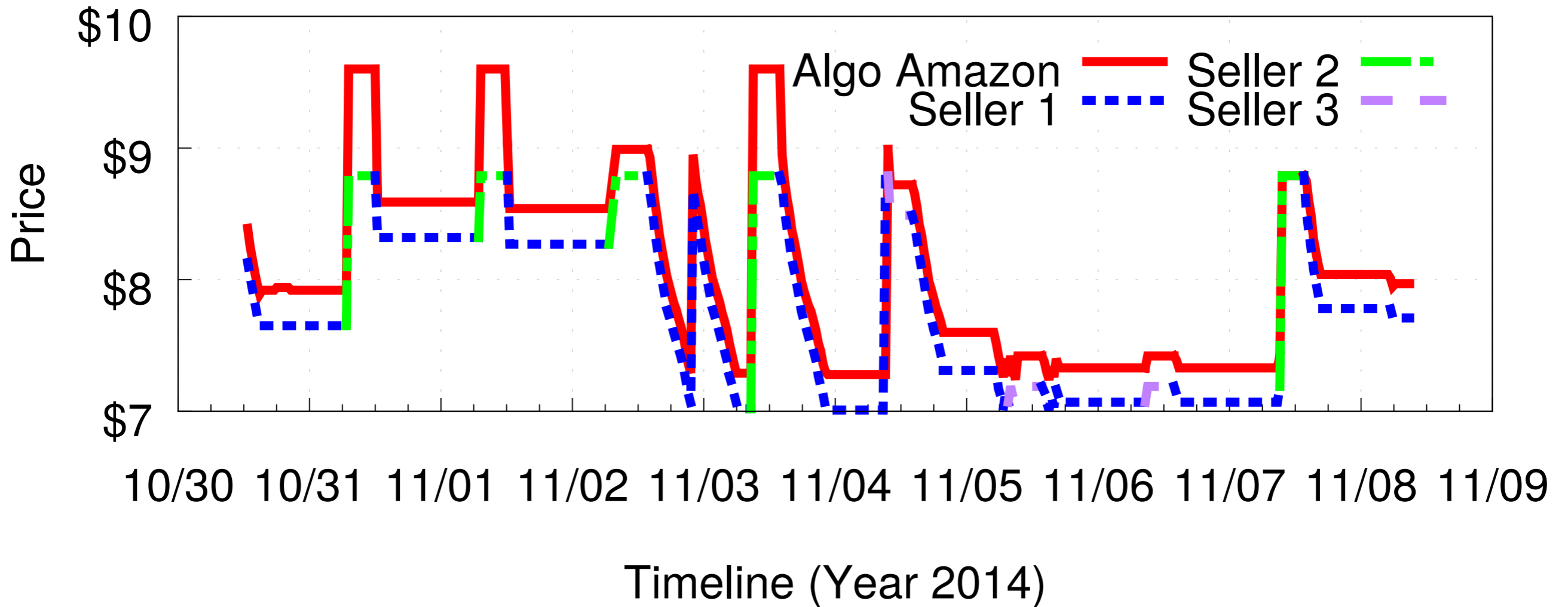
Algorithmic pricing detection

Algorithmic pricing detection



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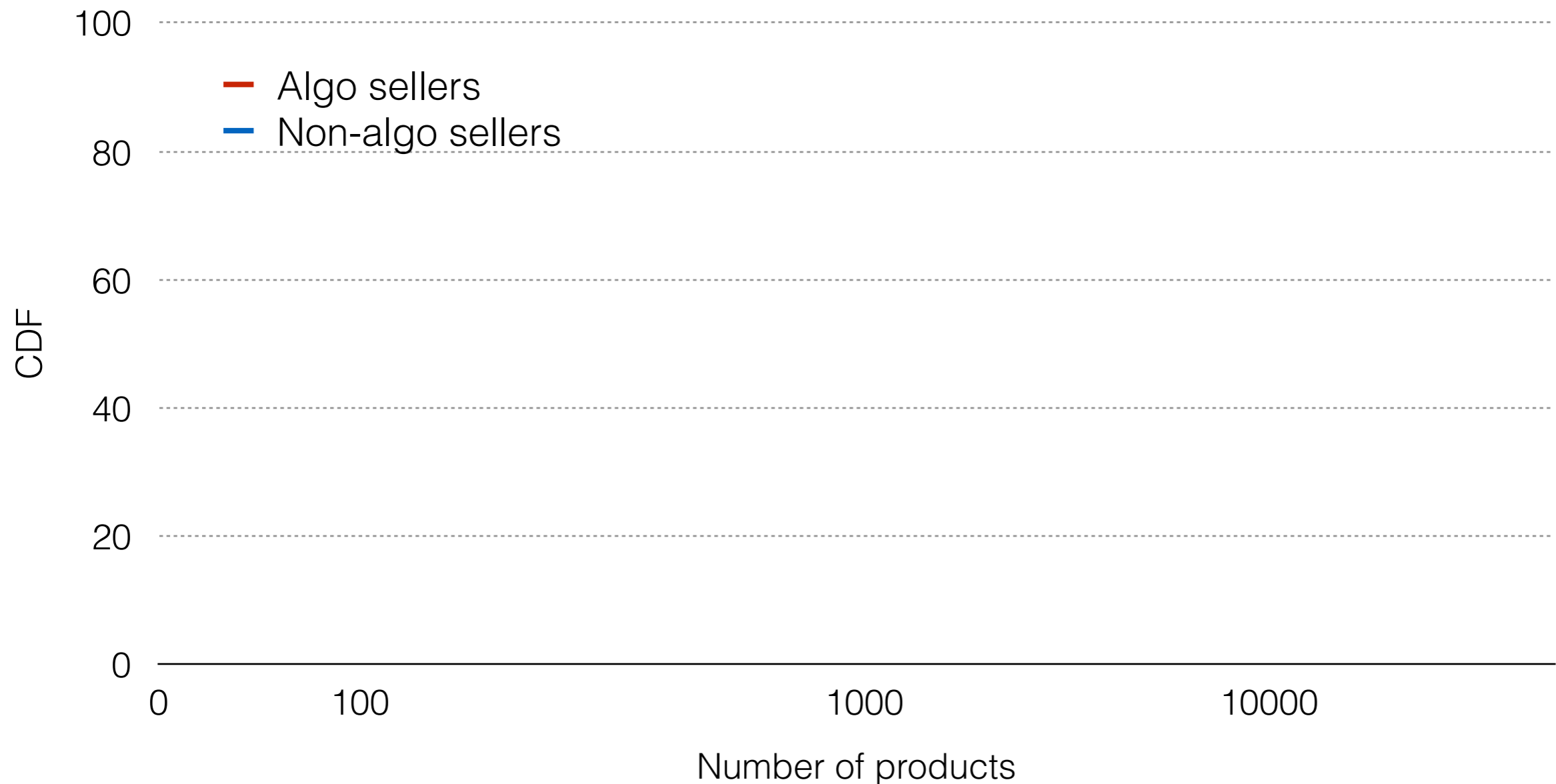
Behaviors of algo-sellers

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

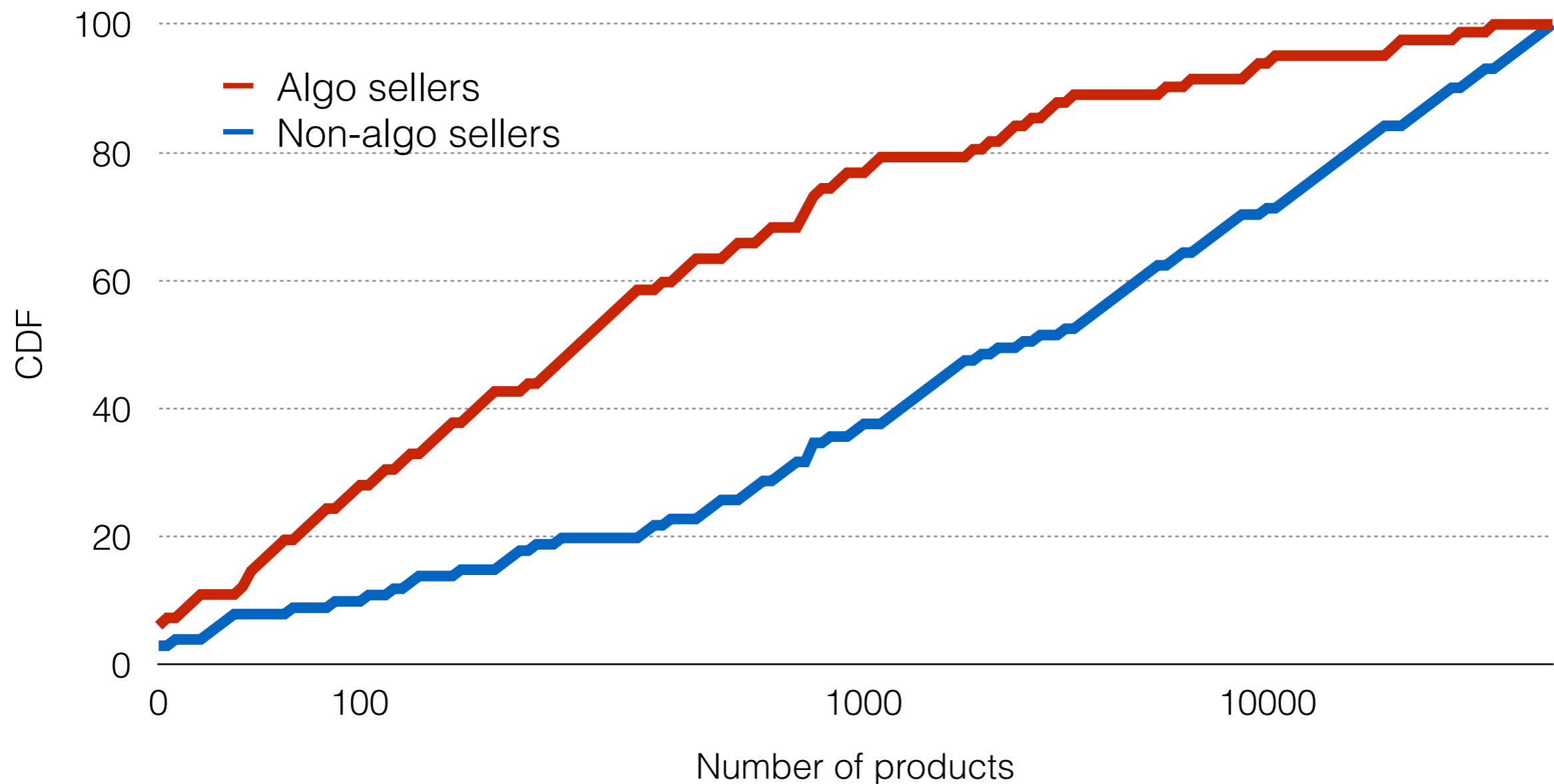
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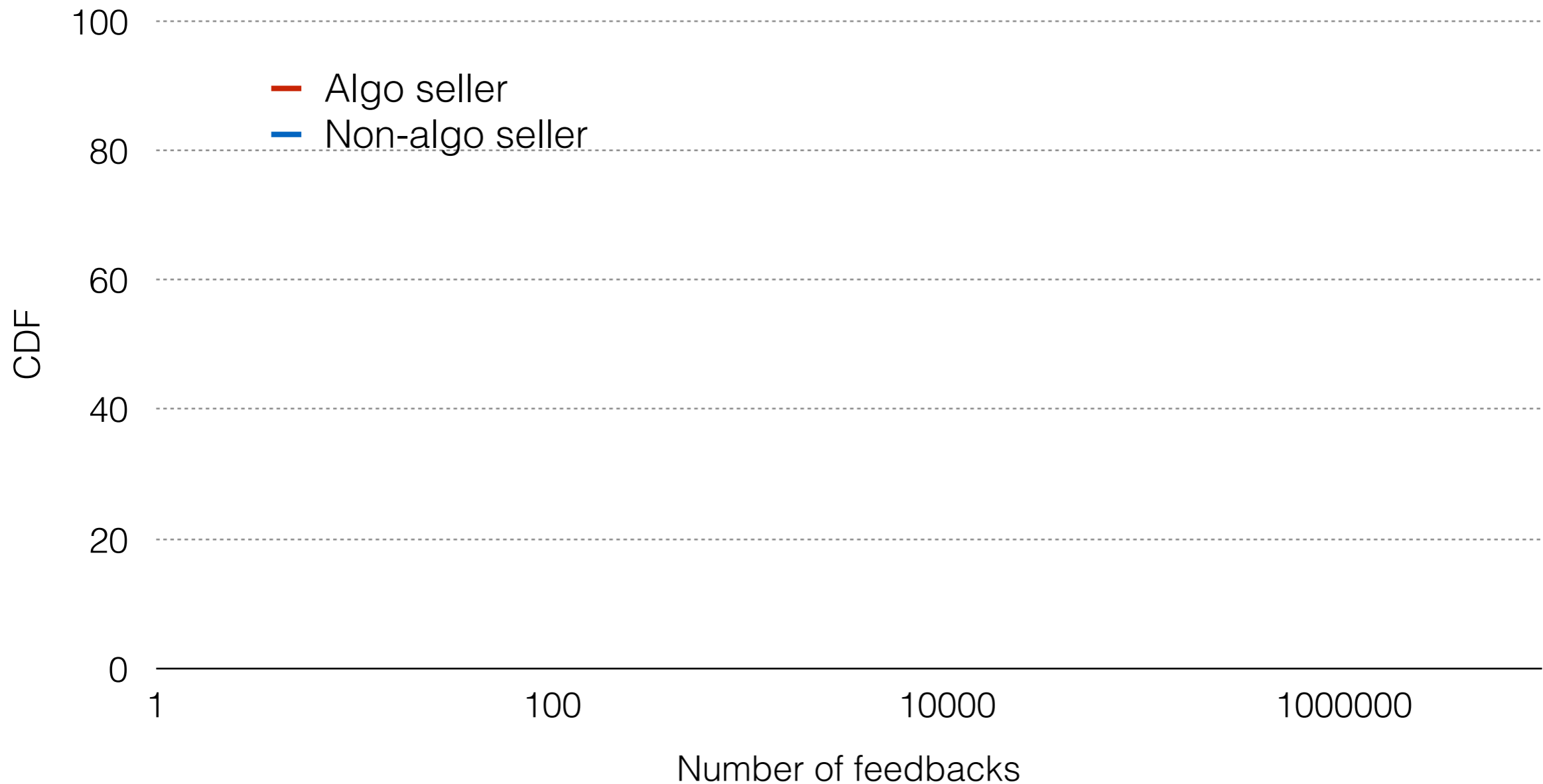
Behaviors of algo-sellers

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- Feedbacks received for algo/non-algo sellers

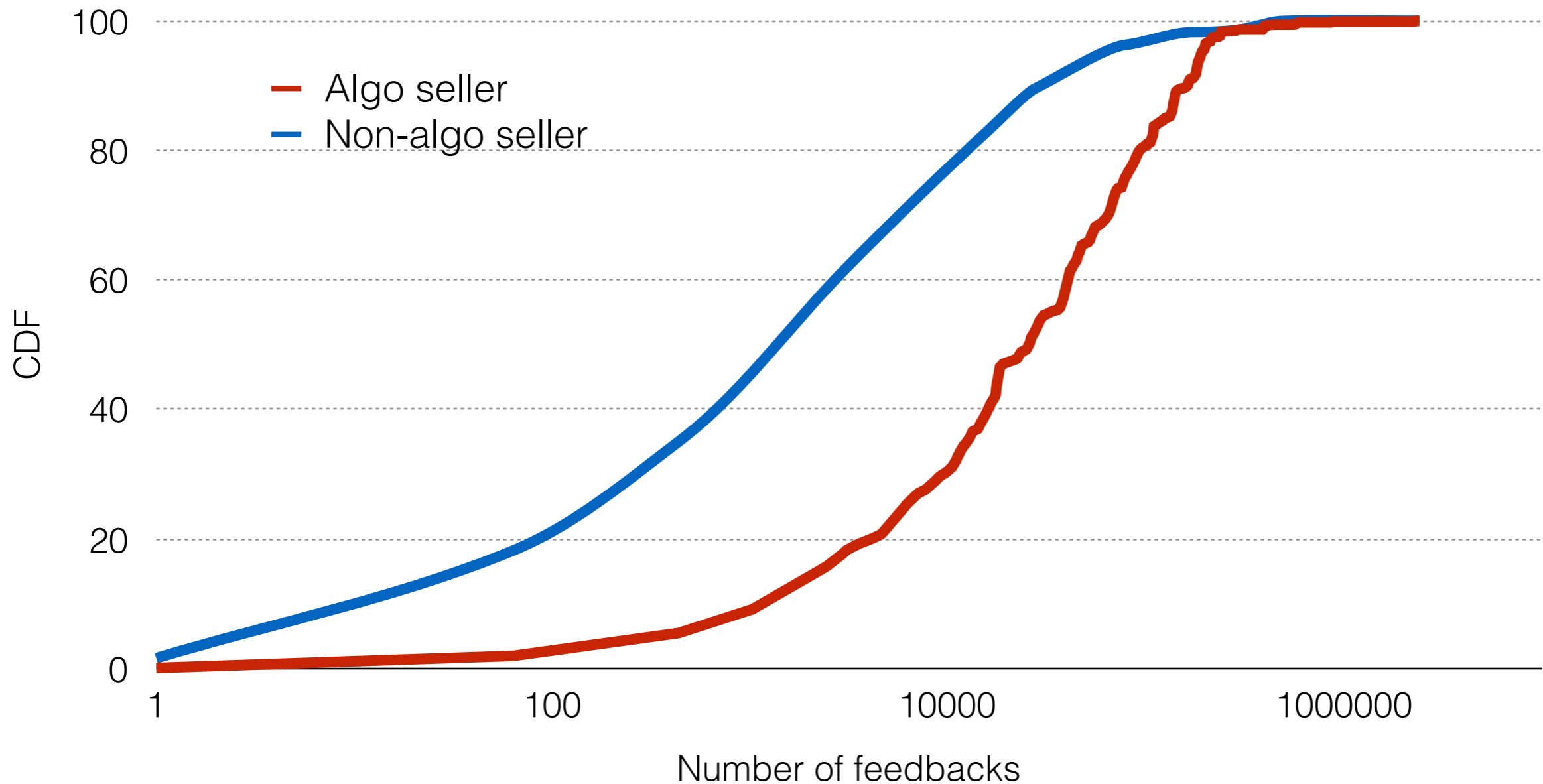
Behaviors of algo-sellers

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Behaviors of algo-sellers

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Feedback loops

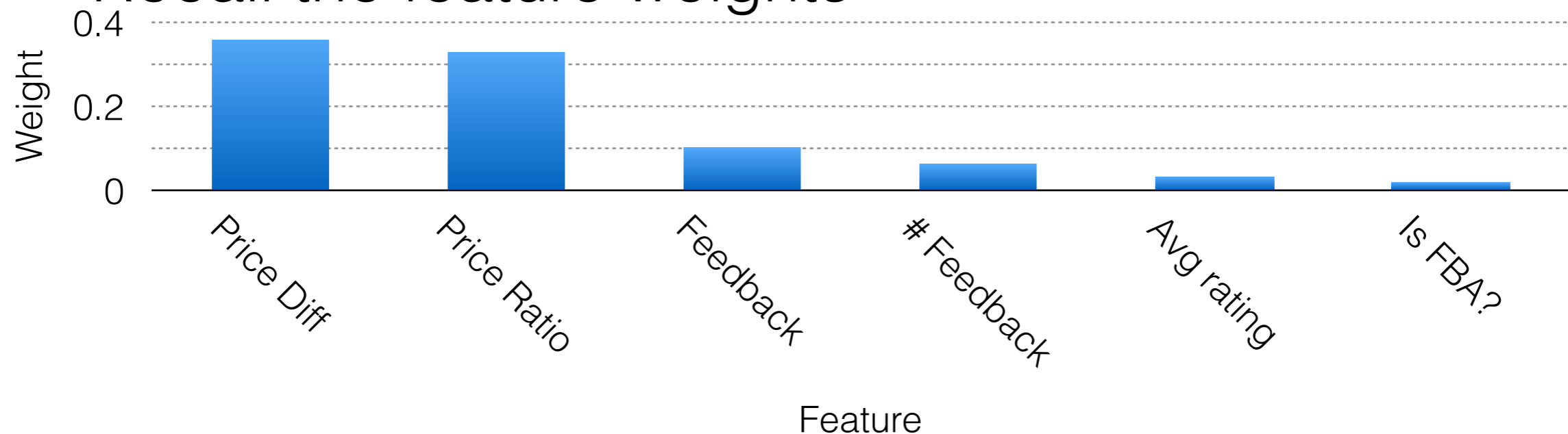
Feedback loops

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

Feedback loops

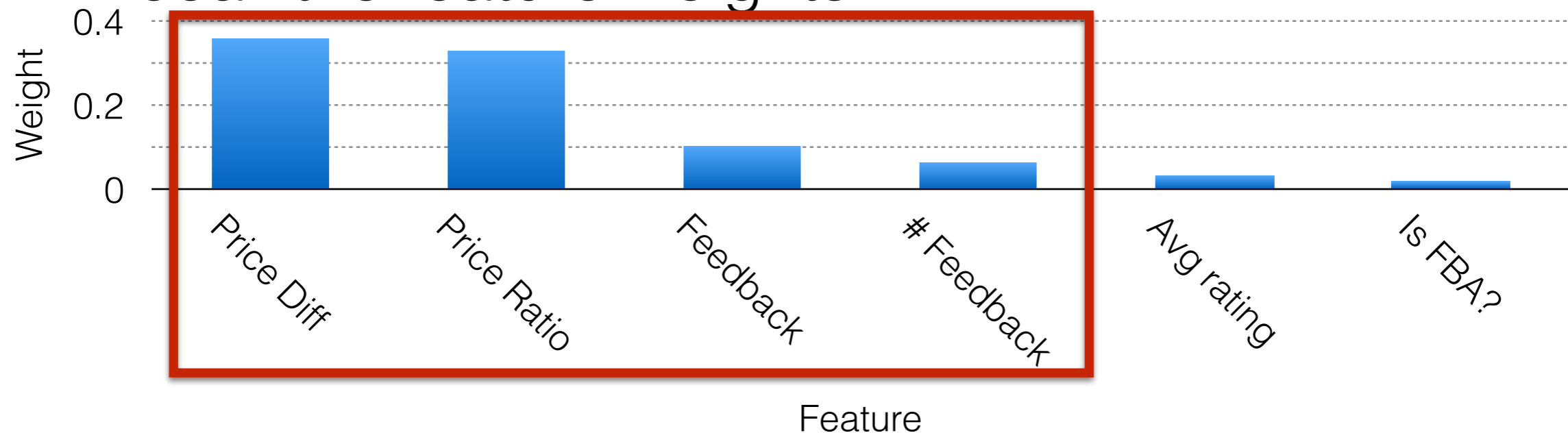
- Algo sellers sell less types of products but receive much more feedbacks than non-algo sellers

- Recall the feature weights



Feedback loops

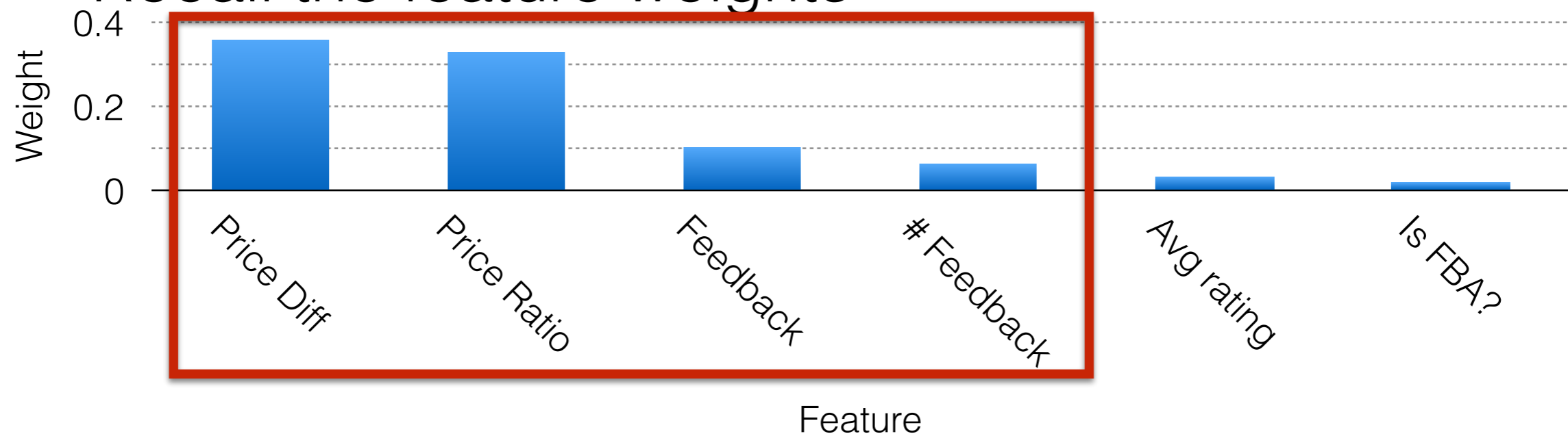
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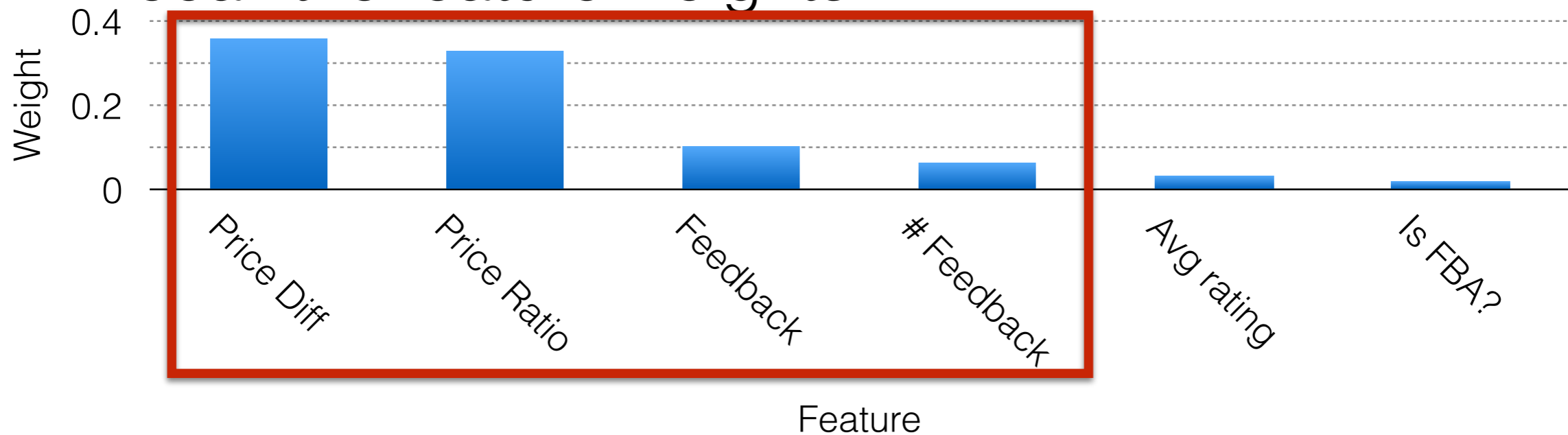


- Feedback loops:

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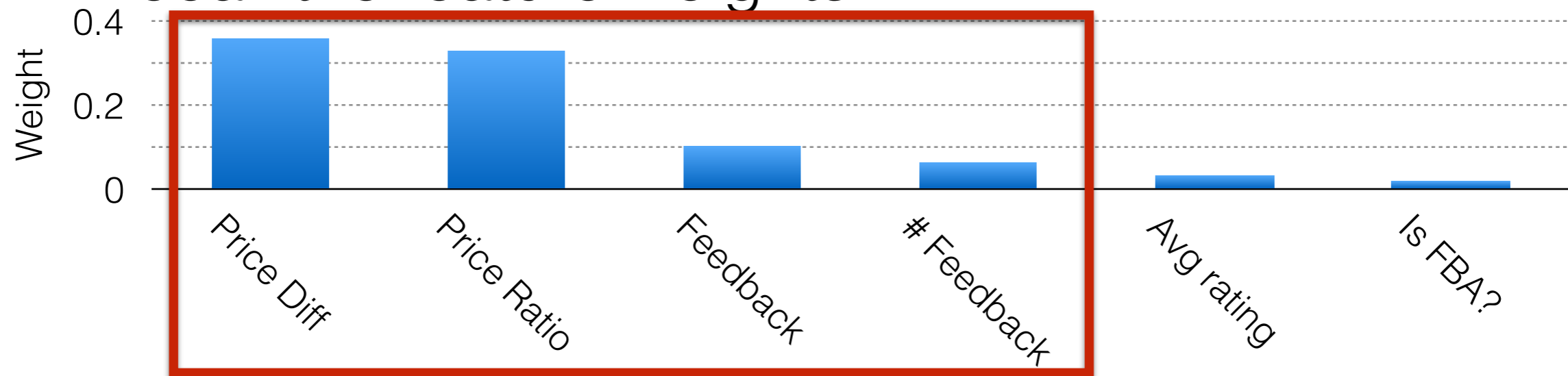
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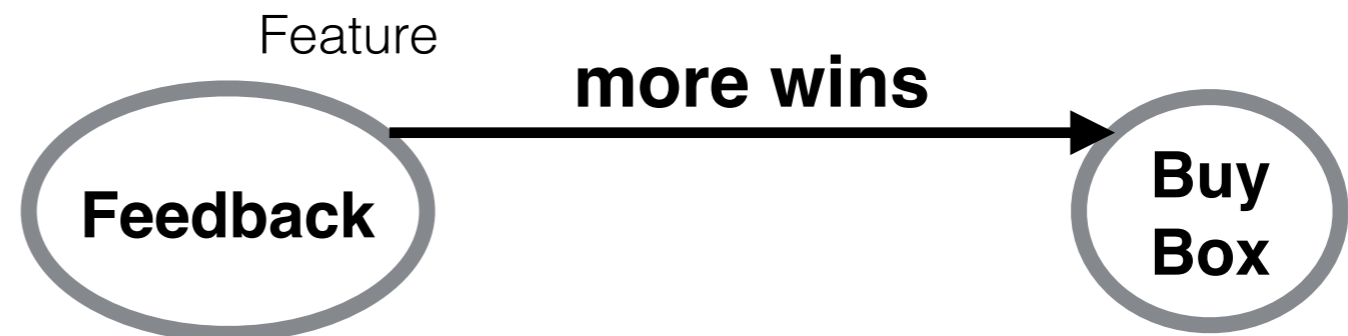
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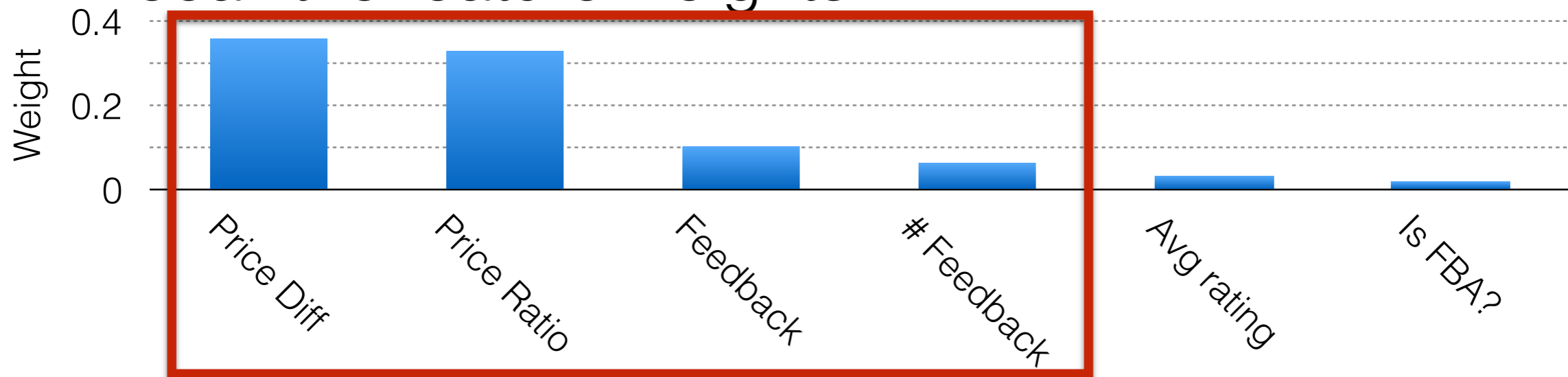
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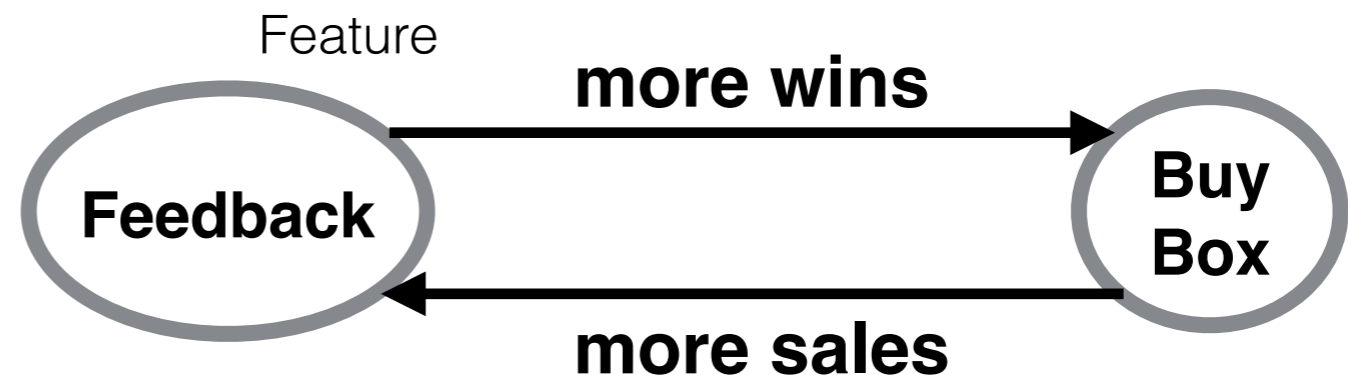
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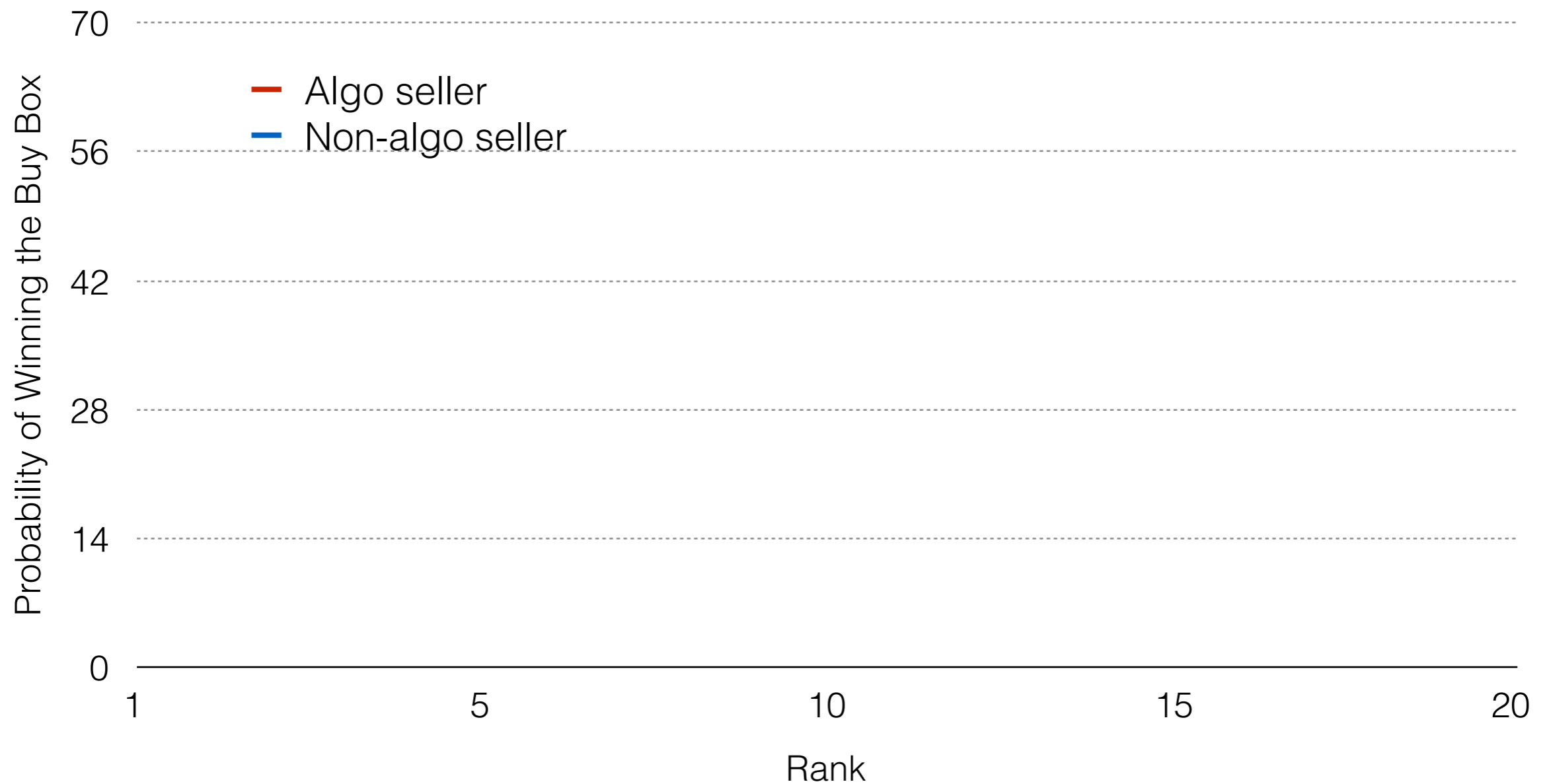


- Feedback loops:



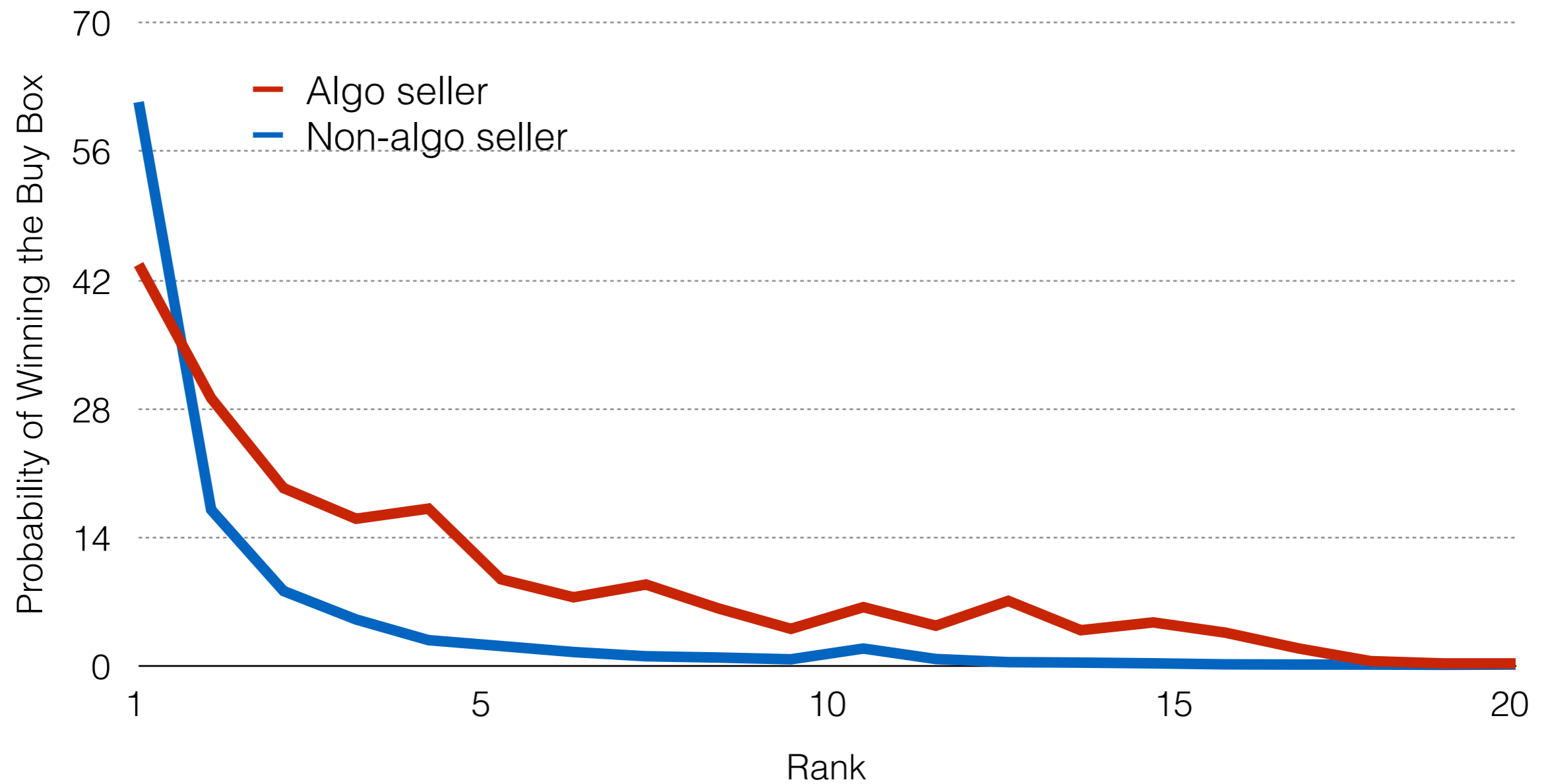
Behaviors of algo-sellers

- 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
- 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?