



JOHNS HOPKINS
CAREY BUSINESS SCHOOL

Bundle Price and Assortment Optimization

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Amazon

Pure Bundles



Up to 200 Mbps Download Speeds	125+ Channels View Channels	\$89.⁹⁹/mo for the first 12 months \$99.99/mo for months 13-24 with 2-Year Agreement ⓘ Check Availability Pricing & Other Info View Details
STANDARD+ INCLUDES: \$100 Visa® Prepaid Card • Free Getting Started Kit and shipping • Price includes TV Latino at \$10/mo. (subject to change) • 20 Hours of DVR Service ☐ Select to Compare		
Up to 400 Mbps Download Speeds	185+ Channels View Channels	\$89.⁹⁹/mo for the first 12 months \$109.99/mo for months 13-24 with 2-Year Agreement ▼ ⓘ Check Availability Pricing & Other Info View Details
SELECT+ INCLUDES: \$100 Visa® Prepaid Card • Free Getting Started Kit and shipping • 20 Hours of DVR Service ☐ Select to Compare		
Up to 800 Mbps Download Speeds	189+ Channels View Channels	\$119.⁹⁹/mo for the first 12 months \$139.99/mo for months 13-24 with 2-Year Agreement ▼ ⓘ Check Availability Pricing & Other Info
SIGNATURE+ INCLUDES: \$100 Visa® Prepaid Card • Free Getting Started Kit and shipping • NETFLIX, EPIX • 150 Hours of DVR Service		

Mixed Bundles



Consumer Driven Bundles



Buy 2, save 50% on 1

Limited-time offer

Buy 2, save 50% on 1. Offered by Amazon.com. (restrictions apply)

How to claim

1. Add 2 items from the products below to your Cart using the Add to Cart button or select See Options for specific product variations.
2. When you're done shopping, select Go to Cart.
3. The offer will automatically be applied at checkout, if eligible. [Terms](#)

0 items from this promotion in your cart | Subtotal: \$0.00

Search qualifying items

Search

Sort by: Featured



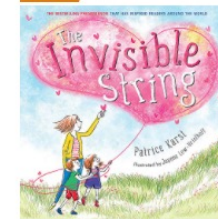
The Name Jar
Yangsook Choi

★★★★★ (2,818)

\$7.99

✓prime FREE delivery for Prime members

Add to Cart



The Invisible String
Patrice Karst

★★★★★ (13,737)

\$8.08 ~~\$16.00~~

✓prime FREE delivery for Prime members

Add to Cart



Little Blue Truck board book
Alice Schertle

★★★★★ (3,000)

\$8.08 ~~\$16.00~~

✓prime FREE delivery for Prime members

Add to Cart



Please Love Me at My Worst
Michaela Angemeer

★★★★★ (27)

\$12.99 ~~\$14.99~~

✓prime FREE delivery for Prime members

Add to Cart



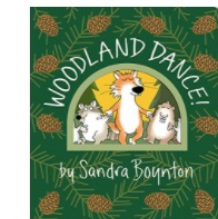
Narwhal's School of Awesomeness (A Narwhal and Jelly Book #6)
Ben Clanton

★★★★★ (162)

\$10.99 ~~\$12.99~~

✓prime FREE delivery for Prime members

Add to Cart



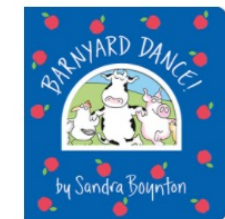
Woodland Dance! (Boynton on Board)
Sandra Boynton

★★★★★ (94)

\$7.95

✓prime FREE delivery for Prime members

Add to Cart



Barnyard Dance! (Boynton on Board)
Sandra Boynton

★★★★★ (5,126)

\$6.95 ~~\$12.99~~

✓prime FREE delivery for Prime members

Add to Cart



Healing After Loss: Daily Meditations for Working Through Grief
Martha Whitmore Hickman

★★★★★ (4,510)

\$13.99 ~~\$14.99~~

✓prime FREE delivery for Prime members

Add to Cart



Why bundles?

- » It is a form of nonlinear pricing and indirect price discrimination mechanism.
- » Bundles of products that have negatively correlated demand increase the value of bundle promotions to the firms.

» Bundling strategies

	Customer A	Customer B	Price	Profit
Product 1	\$8	\$7	\$7	\$14
Product 2	\$2.5	\$3	\$2.5	\$5
Bundle 1+2	\$10.5	\$10	\$10	\$20

an assortment. Easier to design bundles at scale for online retailers.

Firm increase its profits from \$19 to \$20 by adapting bundles by exploiting the negative correlation in preferences.

Bundling Services



- » Customer Driven Bundle Promotion Optimization at Scale
 - Ali Fattahi, Yuexing Li, Ozge Sahin, 2023
- » Pricing Ancillary Service Subscription
 - Ruxian Wang, Maqbool Dada, Ozge Sahin, *Management Science* 2019
- » Can Free-Shipping Hurt Online Retailers? Evidence from Online Grocery Shopping,
 - Ricard Gil and Evsen Korkmaz, Ozge Sahin, *Quantitative Marketing and Economics*, 2020
- » Pricing Ancillary Services: When to Unbundle?
 - Yao Cui and Izak Duenyas, Ozge Sahin, *Manufacturing and Service Operations Management*, 2018



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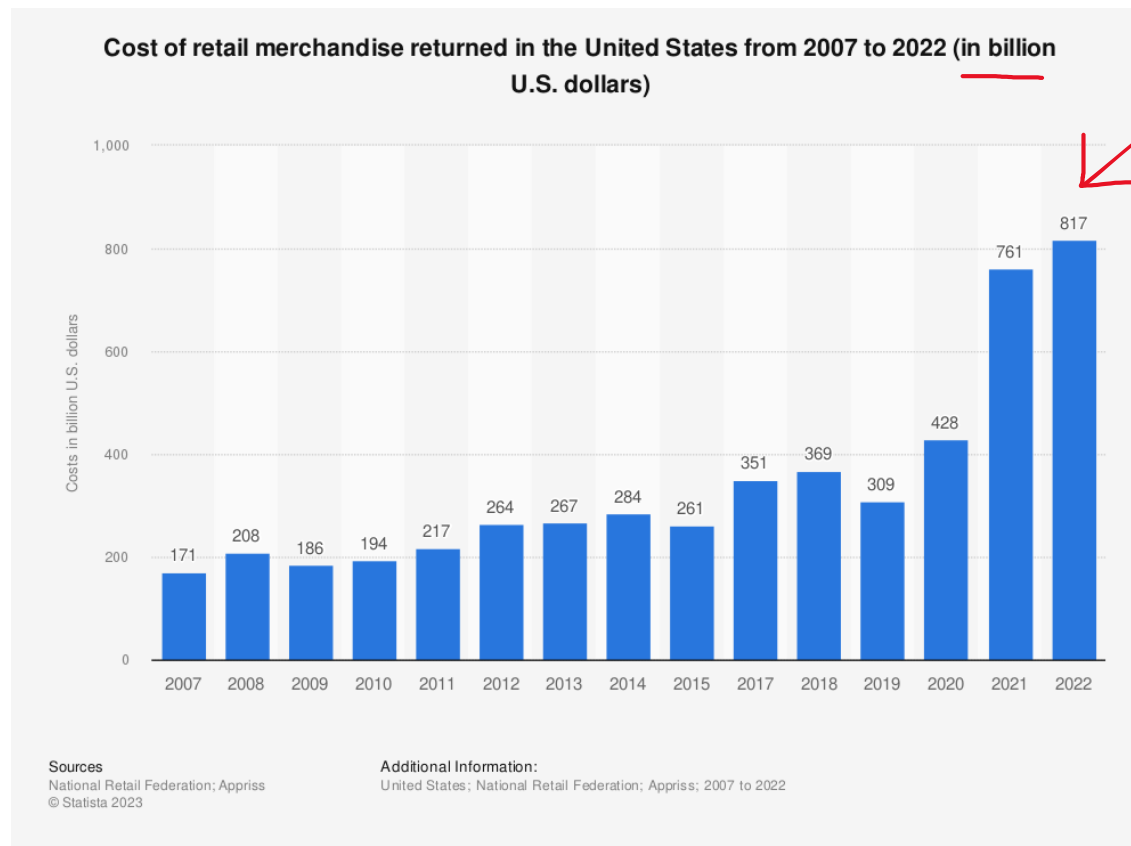
Impact of Bundles on Returns: A Price Transparency and Valuation Update Story

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Product Returns: Trillion-Dollar Problem for Retailers

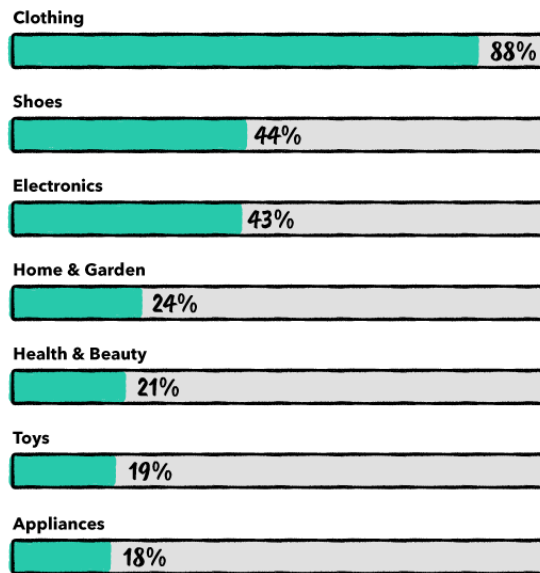


817 billion dollars

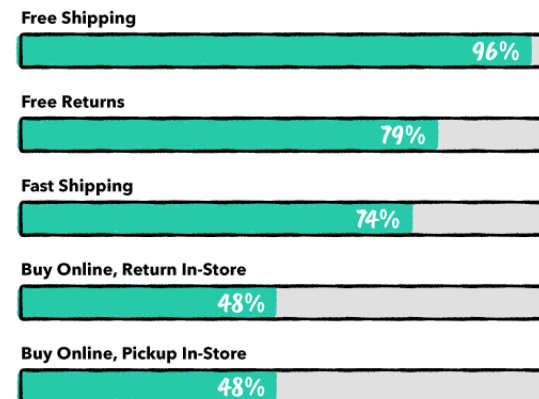
Product Returns: Trillion-Dollar Problem for Retailers



Which types of products
have you returned in the past?



When shopping online, which of the
following options are important to you?



Product Returns: Trillion-Dollar Problem for Retailers



- » 5% to 15% of in-store purchases and **15% to 40%** of online purchases end up returned;
- » Customers return the products due to
 - Fit and quality uncertainty
 - Duplicate purchases
 - Changing preferences
- » Markdown season – impulse purchases
 - Discounts induce sales AND returns
 - returns are more costly: limited time for reselling
- » How does discount strategy impact sales and returns?



Returned products in Walmart's warehouse

Related Literature



» Bundle Promotions

- *Pure and Mixed Bundling*: Adam and Yellen (1976), Schmalensee (1982,84), Salinger (1995), Honohan and Pan (2017), Venkatesh and Kamakura 2003, Banciu et al. 2010, Bhargava 2013, Ma and Simchi-Levi (2021)
- *Consumer-driven Bundling*: Hitt and Chen (2005), Fattahi, Li, Sahin (2023)
- *Pricing and Design* : Hanson and Martin (1990), Netessine and Savin (2006), Wu, Hitt, Chen and Anandalingam (2008), Li, Sun and Teo (2021), Li, Fattahi and Sahin (2022)

» Returns

- Davis et al. (1998), Su (2009), and Altug and Aydinliyim (2016), Bower and Maxham III (2012), Anderson et al. (2009)

» Price Transparency

- Morwitz et al. (1998), Brown et al. (2012)



How does Pricing Strategy affect Sales and Returns?

Single-item discount: “20% off”

Bundle discount: Buy 2 for \$16



Net Sales = Sales - Return

Single-item discount



Bundle discount



If one of the products is returned, consumer pays the full price for the kept product.

Customer Valuation at the Purchase Stage



Single-item discount

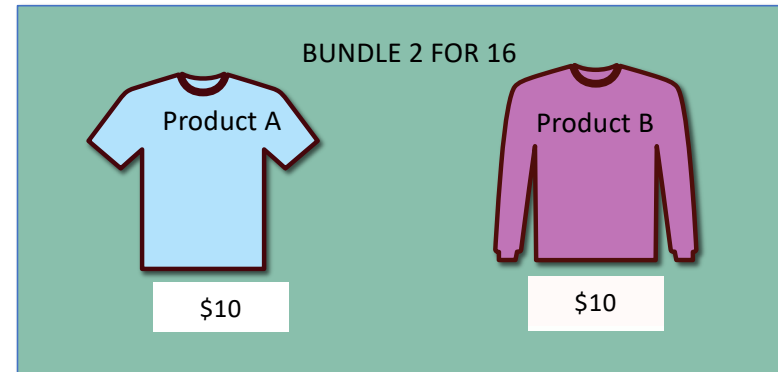


Valuation:

\$8

\$8

Bundle discount



\$8

\$8

Decision:

purchase both under both discount strategies

Customer Valuation at the Purchase Stage



Single-item discount



Valuation:

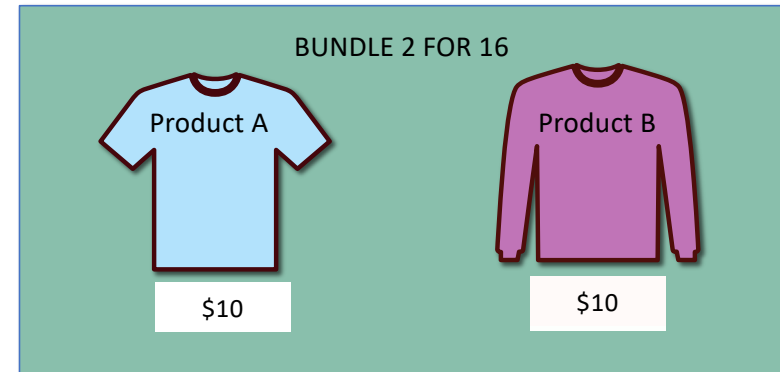
\$9

\$7

Decision:

purchase product A only

Bundle discount



\$9

\$7

purchase both

Valuation Update at the Return Stage



Single-item discount



Valuation: \$8 \$8

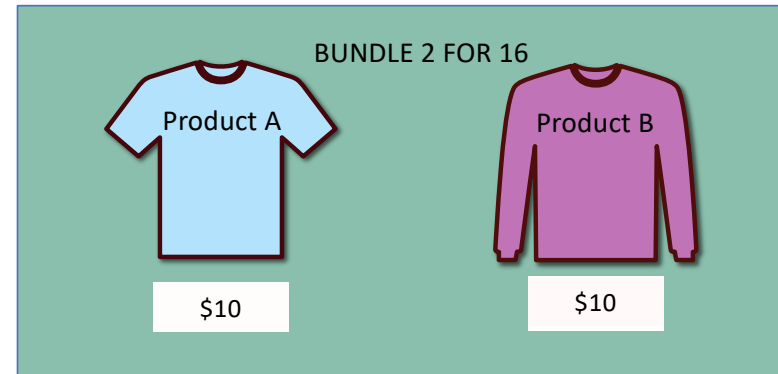
Valuation update : +1 Keep 0 Keep

 +1 Keep -1 Return

 +1 Keep -2 Return

Return Product B

Bundle discount



\$8 \$8

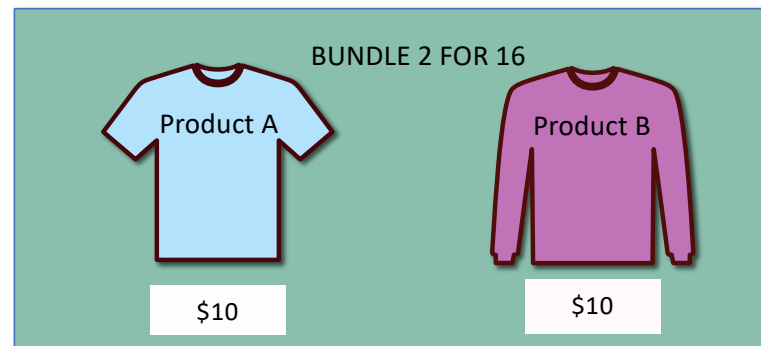
+1 Keep 0 Keep

+1 Keep -1 Keep

+1 Return -2 Return

Return the entire basket!

Consumer Inattention



Purchase stage: Purchase both for \$16

Return stage : Keep both: pay \$16

Keep A or B: pay \$10 per item

Return both: pay 0

Do customers consider the “cost” of return at the purchase stage?

Research Questions



- »» How do bundle discounts impact product sales and returns in comparison to regular discounts?
- »» What are the key factors that drive different purchase and return behavior under different pricing strategies?
- »» What are the implications for retailers?

Partner Retailer



Luxury denim retailer, established in Istanbul, Turkey



Five main categories:

Pants

Fashion Pants

Polos

Shirts

T-shirts

Generous return policy: customers dissatisfied with their purchases can return the items for a full refund within 30 days of purchase, with no shipping or restocking fees incurred.

Partner Retailer



- » The brand sells, directly or indirectly, in 35 countries and is distributed through over 5,500 points of sale, 440 branded stores.
- » 30 weeks of sales data of all brick-and-mortar stores in Turkey.
- » Markdown season started at week 25 of our observation period.
- » During the 6 weeks of markdown, regular-discounts and bundle discounts on qualifying purchases were offered.
- » We define the return rate as ratio of **number of returned units to total number of units sold per product**.



Bundle Discounts and Return Rates

Markdown Season: ~80% discounted,



Bundle Discounts

	2FOR59	2FOR79	2FOR99	2FOR149	2FOR179	2FOR199	2FOR249
Pants							x
Shirts				x	x		
T-Shirts	x	x	x				
Polos				x	x		
Fashion Pants						x	
Discount depth	10.11%	9.83%	7.89%	12.96%	10.80%	14.84%	9.25%

Comparison on Returns

Returns	Single-item Discount		Bundle Discount	
	mean	std. dev.	mean	std. dev.
Product return rate	0.0903	0.0408	0.0734	0.0284
Whole basket return rate	0.0132	0.0046	0.0202	0.0039

Summary Statistics



Purchases	Pre-Markdown Season		Markdown Season	
	mean	std. dev.	mean	std. dev.
Count of items per basket	1.23	0.54	1.44	0.74
Weekly sales quantity per product	199.87	158.72	235.14	278.82
Prices				
Pants	172.34	11.54	154.37	31.91
Fashion pants	133.75	26.74	110.26	16.97
Polos	85.89	12.44	79.57	10.88
Shirts	119.78	23.65	101.44	18.58
T-shirts	44.68	11.19	42.09	9.65



Impact of Discount Type on Sales and Returns

Category	Parameters	log(Sales)	log(Return Percentage)
Pants	SingleDiscount	0.0292*** (0.002)	-0.0069*** (0.002)
	BundleDiscount × 2FOR249	0.0550*** (0.005)	-0.0145*** (0.005)
Shirts	SingleDiscount	0.0091*** (0.002)	0.0115 (0.060)
	BundleDiscount × 2FOR149	0.0100* (0.005)	-0.0153 (0.022)
	BundleDiscount × 2FOR179	0.0060* (0.003)	0.0026 (0.011)
T-shirts	SingleDiscount	0.0130* (0.006)	-0.0200 (0.011)
	BundleDiscount × 2FOR59	0.0113 (0.009)	0.0419 (0.020)
	BundleDiscount × 2FOR79	0.0178* (0.009)	0.052* (0.025)
	BundleDiscount × 2FOR99	0.0049 (0.007)	0.0795*** (0.020)
Polos	SingleDiscount	0.0672*** (0.019)	0.032 (0.028)
	BundleDiscount × 2FOR149	0.0731*** (0.011)	0.1071*** (0.024)
	BundleDiscount × 2FOR179	0.0642*** (0.016)	0.1273** (0.043)
Fashion Pants	SingleDiscount	0.0533*** 0.018	0.021 (0.022)
	BundleDiscount × 2FOR199	0.0769*** -0.019	0.028 (0.029)

$$y_{jt} = \beta_1 + \beta_2 \text{SingleDiscount}_{jt} + \beta_3 \text{BundleDiscount}_{jt} \times \text{BundleType}_j + \text{Item}_j + \text{Week}_t + \zeta_{jt}$$

- y_{jt} : log (sales quantity), log(return percentage)
- $\text{SingleDiscount}_{jt}$, $\text{BundleDiscount}_{jt}$: discount depth in percentage

Bundle discount:

- Increases initial sales
- Mixed effects in returns

Why?

How to choose discount strategy to improve net sales?

Consumer choice model



- » **Forward looking customers:** customers are forward-looking and consider their future valuation updates and return options in their purchase decisions.
- » Customers buy at most 2 –item baskets (covers 88% of the orders in the data).
- » Customers may not be attentive to the price and return conditions.



Return Stage Model

Basket size: $b^* = \{0, 1, 2\}$

Return options (r): keep **both**, keep **1**, keep **2**, keep **none**

Value of each option:

$$V(r = \text{keep})_i = v_{i,1st} + v_{i,2nd} + v_{ib^*} + z_{i,1st} + z_{i,2nd} + z_{ib^*} - \alpha_i P_{b^*},$$

$$V(r = \text{keep } 1st)_i = v_{i,1st} + z_{i,1st} - \alpha_i P_{b^*,1st},$$

$$V(r = \text{keep } 2nd)_i = v_{i,2nd} + z_{i,2nd} - \alpha_i P_{b^*,2nd},$$

$$V(r = \text{keep none})_i = 0.$$

Bundle discount: $P_{b^*,1st}, P_{b^*,2nd} = \text{original price}$

Single-item discount: $P_{b^*,1st}, P_{b^*,2nd} = \text{discounted price}$



Return Stage Decision

Customer i 's utility if return option r is chosen:

$$u_{ir} = V(r)_i + \xi_{ir}$$

The conditional probability of choosing option r^* :

$$p(y_i = r^* | b^*, v_{ij}, z_{ij}, j \in b^*, v_{ib^*}, z_{ib^*}, \alpha_i) = \frac{\exp(V(r^*)_i)}{1 + \sum_r \exp(V(r)_i)}$$



Purchase Stage Model

Customers are **forward-looking**, making decisions based on expected value of the basket post-purchase. Customer i 's **utility of choosing basket b** :

$$u_{ib} = \mathbb{E}[V(Basket)]_{ib} + \epsilon_{ib},$$

The conditional probability of choosing basket b^* :

$$p(x_i = b^* | v_{ij}, z_{ij}, v_{ib}, z_{ib}, j \in J, b \in B, \alpha_i, \delta_i) = \frac{\exp(\mathbb{E}[V(Basket)]_{ib^*})}{1 + \sum_b \exp(\mathbb{E}[V(Basket)]_{ib})}.$$



Expected Value of a Two-Item Basket

$$\begin{aligned}\mathbb{E}[V(\text{Basket})]_{ib} = & \mathbb{E}[V'(\text{keep})_{ib} \mid \text{keep}] \mathbb{P}(\text{keep})_{ib} + \\ & \mathbb{E}[V'(\text{keep 1st})_{ib} \mid \text{keep 1st}] \mathbb{P}(\text{keep 1st})_{ib} + \\ & \mathbb{E}[V'(\text{keep 2nd})_{ib} \mid \text{keep 2nd}] \mathbb{P}(\text{keep 2nd})_{ib} + \\ & \mathbb{E}[V'(\text{keep none})_{ib} \mid \text{keep none}] \mathbb{P}(\text{keep none})_{ib}\end{aligned}$$

$$V'(\text{keep})_{ib} = v_{ib,1st} + v_{ib,2nd} + v_{ib} + z_{ib,1st} + z_{ib,2nd} + z_{ib} - \alpha_i P_b$$

$$V'(\text{keep 1st})_{ib} = v_{ib,1st} + z_{ib,1st} - \alpha_i P'_{b,1st} = v_{ib,1st} + z_{ib,1st} - \alpha_i \Delta_i P_{j,1st}$$

Customer inattention:

Attentive: $P'_{b,1st} = P_{j,1st}$, $\rightarrow$ the original price

Inattentive: $P'_{b,1st} = (1 - d_j)P_{j,1st}$, $\rightarrow$ the discounted price

Using δ to measure customers' attention to price details:

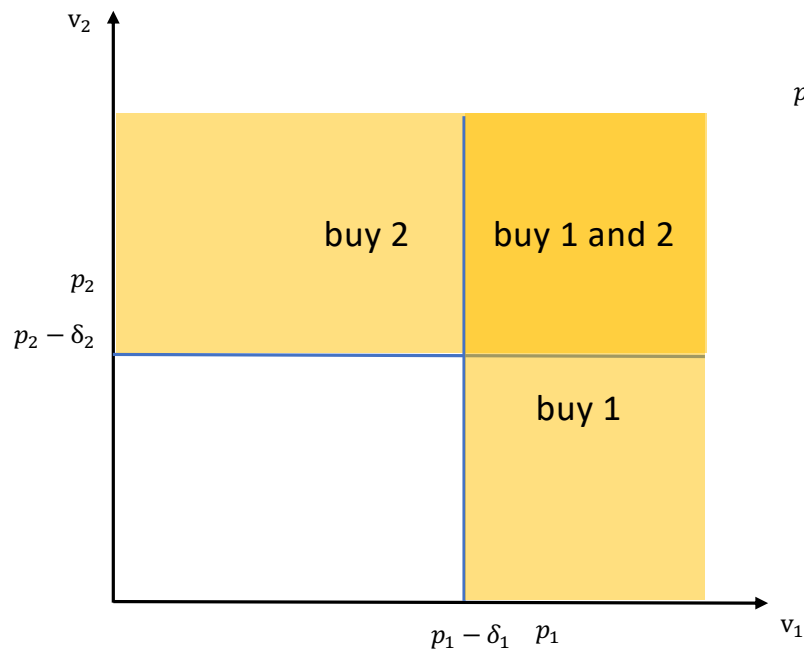
$$P'_{b,1st} = \Delta_i P_{j,1st} = (1 - (1 - \delta_i)d_j)P_{j,1st}$$

$\delta \in [0, 1]$: $\delta = 0$: inattentive; $\delta = 1$: attentive

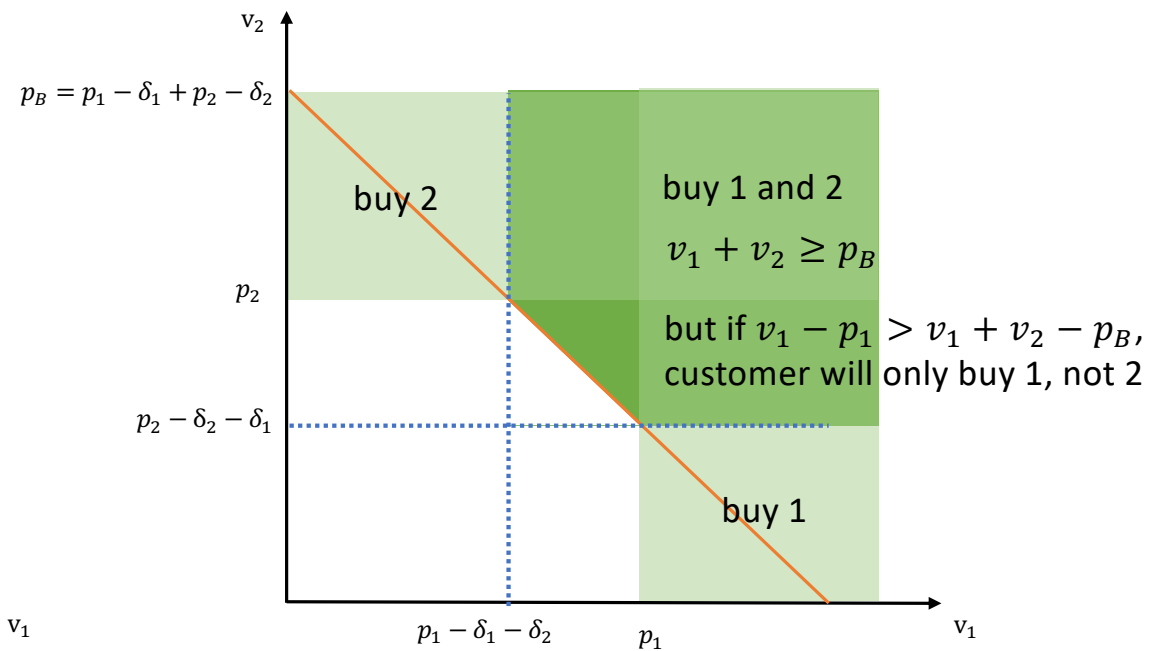
Single Item Discount vs. Bundle Discount



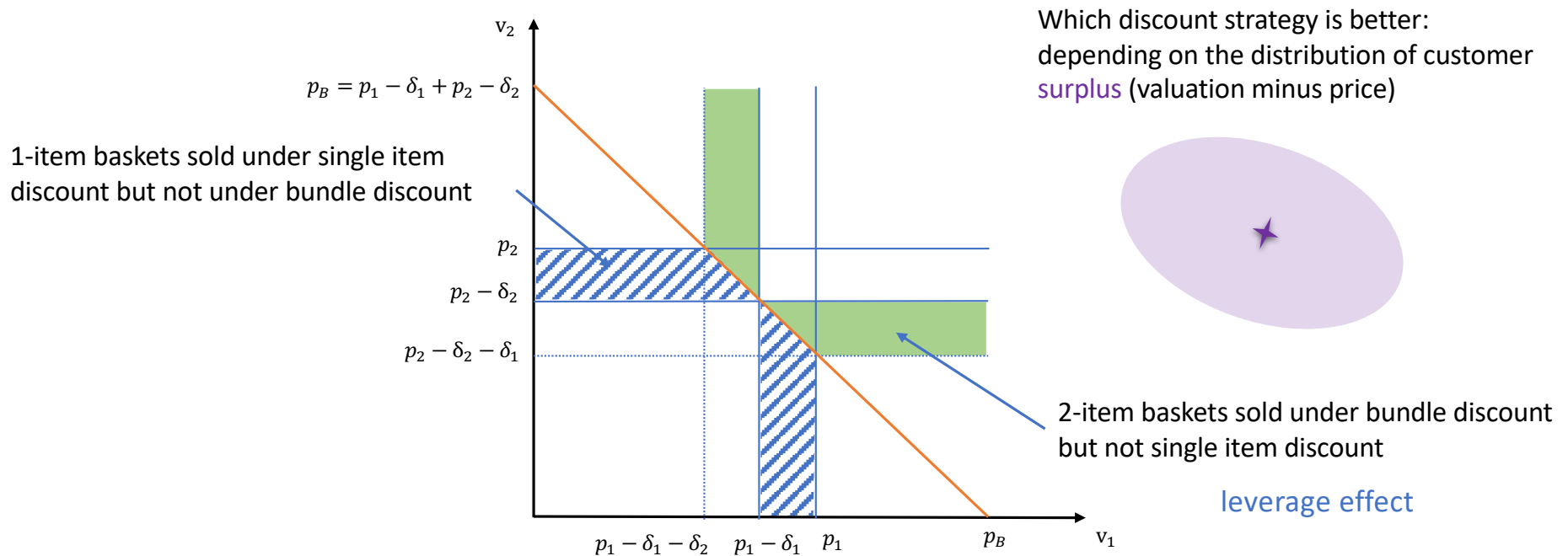
single item discount



bundle discount



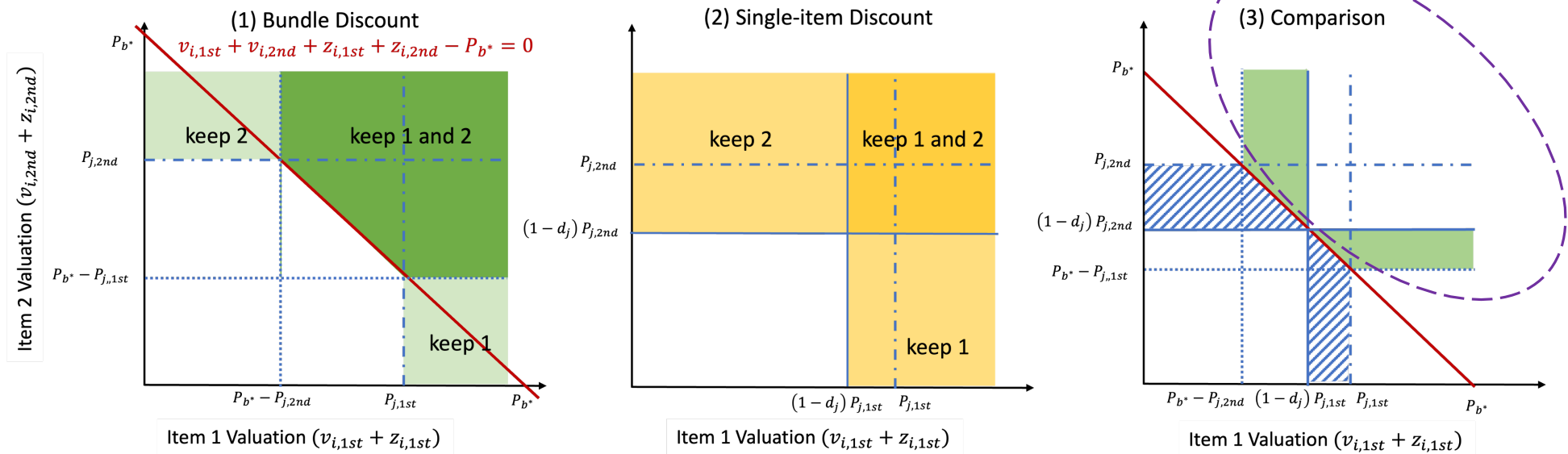
Which Discount Strategy Is Better?



Which Discount Strategy Is Better if we consider *net sales*?

Return Stage Decisions

Bundle discount reduces returns if valuations post update concentrate in this region.



Conditional on purchase of a bundle, bundle promotion results in fewer returns if

- Valuation updates are negatively correlated or
- at least one of the items is high value.

Model Framework



Understand a customer's purchase decision and return decision

- » Forward-looking: consider return options when making purchase decision
- » Flexibility in post-purchase valuation updates
- » Allow inattentiveness to pricing under bundle discount

Purchase Stage	Return Stage
Valuation v inattentiveness to pricing details δ	Valuation v + valuation update z exact prices realized

$\delta \in [0, 1]$ for purchases under bundle discounts

e.g., A and B are purchased as a bundle,

- $\delta = 0$: fully inattentive – upon the return of A, B will be charged at the discounted price
- $\delta = 1$: fully attentive – upon the return of A, B will be charged at the full price

Estimation Results



	mean	std. dev.				
Price sensitivity (α)	0.07	0.02				
Attentiveness (δ)	0.39	0.04				
	Purchase stage (v)		Return stage (z)			
Valuations	mean	std. dev.	mean	std. dev.	Avg price ($\bar{p}$)	Mean myopic surplus ($\mu_v - \mu_\alpha \bar{p}$)
Pants	22.08	4.62	4.05	2.37	154.37	11.27
Fashion pants	19.28	5.63	1.51	1.21	110.26	11.56
Polos	4.78	1.68	-0.74	0.31	79.57	-0.79
Shirts	5.54	1.56	-0.23	0.25	101.44	-1.56
T-shirts	2.13	1.41	-0.25	0.14	42.09	-0.82
Substitutes	0.28	0.34	-1.41	0.30		
Complements	1.53	0.30	3.24	0.20		

On the inattentive side

High surplus

Low surplus

Confirmation Bias ?

Current Bundle Discounts



Which product categories shall we offer bundle discounts on?

Current bundles (✓)

	Pants	Fashion Pants	Polos	Shirts	T-shirts
Pants	✓				
Fashion Pants		✓			
Polos			✓		
Shirts			✓	✓	
T-shirts					✓

high-high

high-high

low-low

low-low

low-low

Leverage effect not fully utilized.



Counterfactual Analysis: Proposed Bundles

Which product categories shall we offer bundle discounts on?

- Maximizing post-purchase leverage effect

Current bundles (✓) Proposed bundles (✓)

	Pants	Fashion Pants	Polos	Shirts	T-shirts
Pants	✓✓	✓	✓	✓	✓
Fashion Pants	✓	✓✓	✓	✓	✓
Polos	✓	✓	✓		
Shirts	✓	✓	✓	✓	
T-shirts	✓	✓			✓

- Compare proposed bundle with current bundle: single-item discount as the baseline;
- Compare customer attentiveness levels: fully inattentive as the baseline.

Counterfactual Analysis: Sales and Net Sales Quantities



Compared to single-item discount: $(\text{bundle discount} - \text{single-item discount}) / \text{single-item discount} \times 100\%$

Under the estimated customer attentiveness parameters:

	Initial Sales	Net Sales	Net Revenue	Return Rates
Current bundle (change in %)	-1.19	-0.69	-0.07	5.33
Proposed bundle (change in %)	15.50	15.61	12.58	-1.60

Based on 10,000 customers' purchase and return decisions; averaged from 10 trials.



Counterfactual Analysis: Level of Attentiveness

Compared to fully inattentive: $(\text{estimated or fully attentive} - \text{fully inattentive}) / \text{fully inattentive} \times 100\%$

Strategy		Estimated (change in % compared to fully inattentive)	Fully Attentive
Initial Sales (Count)	Current bundle	-0.43	-0.81
	Proposed bundle	-1.38	-2.63
Net Sales (Count)	Current bundle	-0.40	-0.56
	Proposed bundle	-0.04	-0.05
Net Revenue (TL)	Current bundle	-0.28	-0.43
	Proposed bundle	0.34	0.37
Return Rates (%)	Current bundle	-0.25	-2.08
	Proposed bundle	-10.75	-20.88

Based on 10,000 customers' purchase and return decisions; averaged from 10 trials.

Assuming no restocking cost:

With fully attentive customers, return rates reduce by 20.88%, net revenue increases by 0.37%, at a cost of 0.05% decrease in net sales.

With a 2TL flat restocking cost:

Fully attentive customers: an extra 1.04% increase in profit.



Markets with High Post-purchase Uncertainties

- » Suppose purchase stage valuation is not dominant
 - Let mean of v = discounted price
- » Customers are more uncertain about the value of the products they purchased (e.g., online shopping)
 - Let mean of z vary from -50% to 50% of mean of v

Categories	Mean of z
A	+50%
B	+25%
C	-25%
D	-50%

What is the preferred strategy?

- Bundle A
- Bundle AB
- Bundle ABC
- Bundle ABCD

Compare sales quantity using single-item discount as a baseline

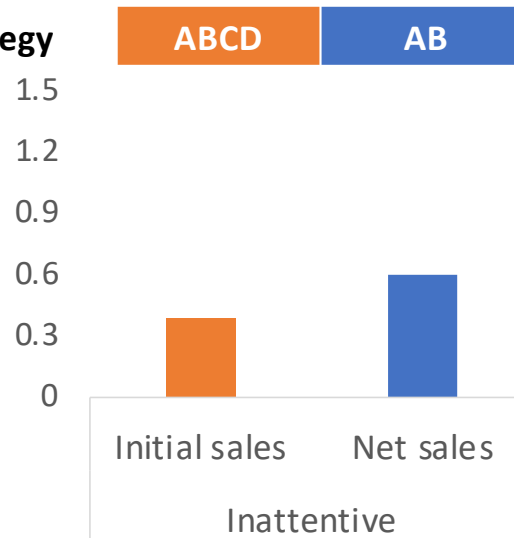
Best Discount Strategy depends on Returns and Attentiveness



Sales quantity: % change compared to single-item discount

Categories	Mean of z
A	+50%
B	+25%
C	-25%
D	-50%

Best strategy



What is the preferred strategy?

- Bundle A
- Bundle AB
- Bundle ABC
- Bundle ABCD

- Considering returns changes the optimal choice of discount strategy;
- More initial sales with inattentive customers, but more net sales with attentive customers;
- The most versatile bundle ABCD gives the highest net sales with attentive customers.

Summary of Results



- » Pricing strategies affect consumer behavior at both purchase and return stages.
- » Bundle discounts leverage positive product valuations in both purchase and post-purchase stages:
 - Heterogeneity of valuations
 - Correlation of post purchase updates
- » In the data, products offered with a bundle discount have on average **21% lower** returns.
 - Explained by high + low value product bundles, consumer inattention and confirmation bias
- » Accounting for returns may change a retailer's optimal strategy.
- » Considering product returns has impact on design of bundle assortment and retailer's bottom line
 - up to **12.53% increase in revenue** compared to markdown policies disregarding product return.



THANK YOU!
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Ecommerce...



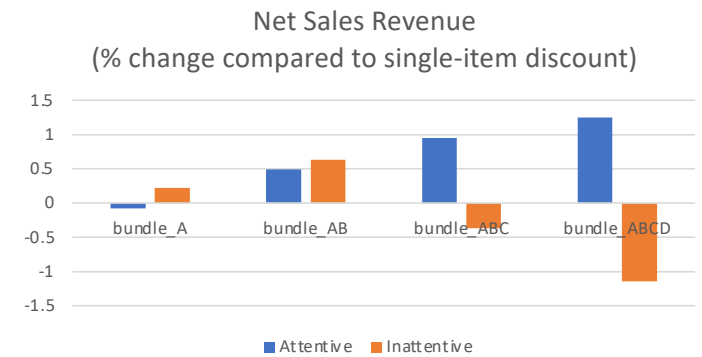
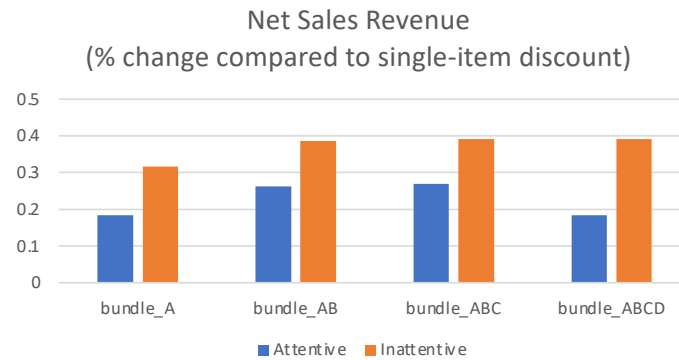
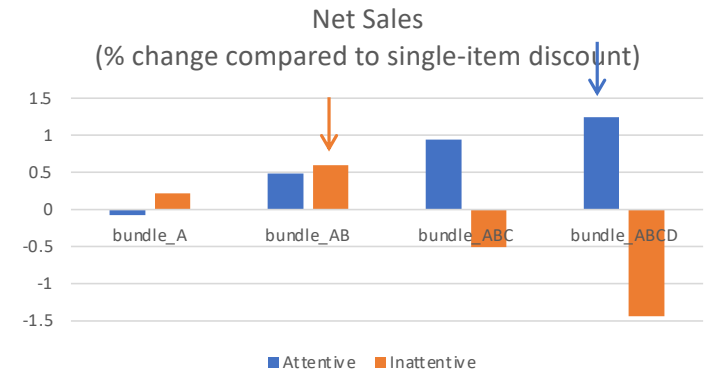
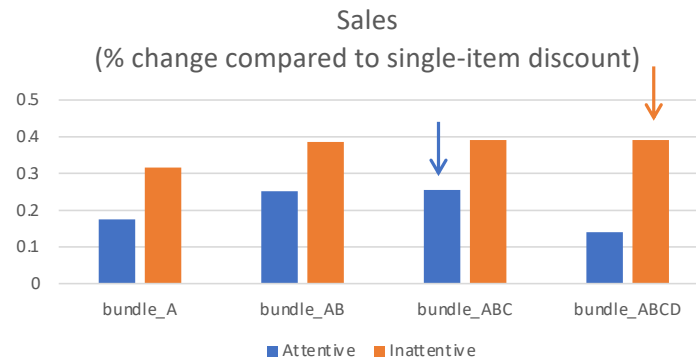
- » Suppose that purchase stage surplus is not high
 - Let mean purchase stage valuation be v = discounted price
- » Customers are more uncertain about the value of the products they purchased (e.g., online shopping)
 - Let mean of post purchase update z vary from -50% to 50% of v

What is the preferred bundle strategy?

Categories	Scenario 1	Scenario 2	Scenario 3
A	+50%	+50%	-0%
B	+25%	+25%	-10%
C	-25%	+10%	-25%
D	-50%	+0%	-50%



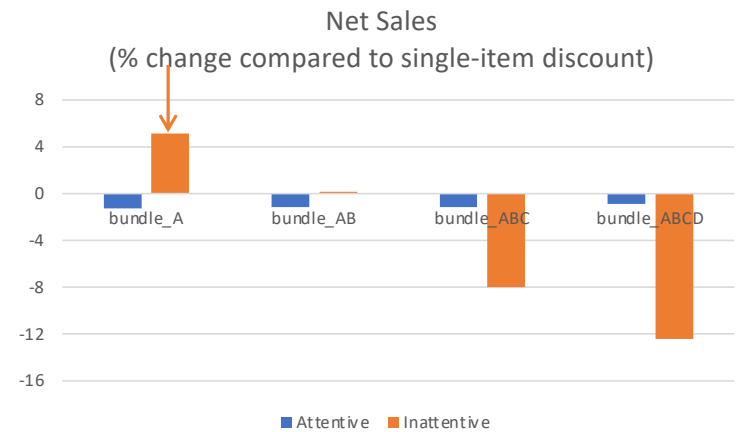
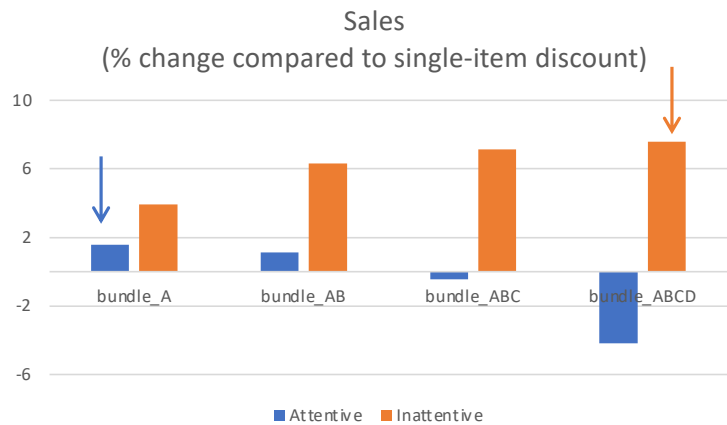
Categories	Mean of z
A	+50%
B	+25%
C	-25%
D	-50%



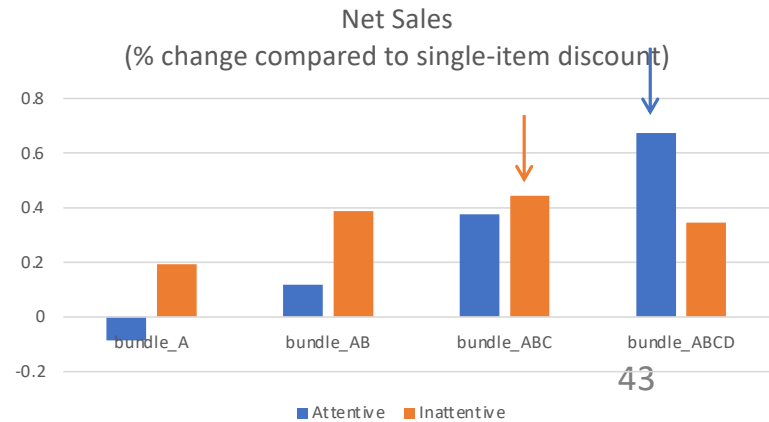
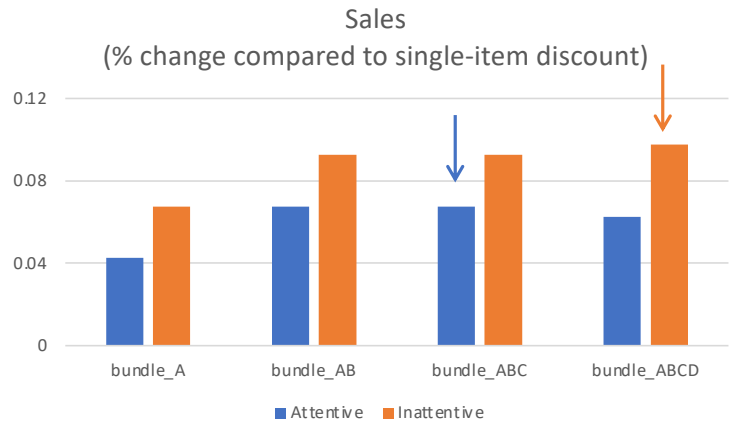


For attentive customers, single-item discount preferred

Categories	Mean of z
A	-0%
B	-10%
C	-25%
D	-50%

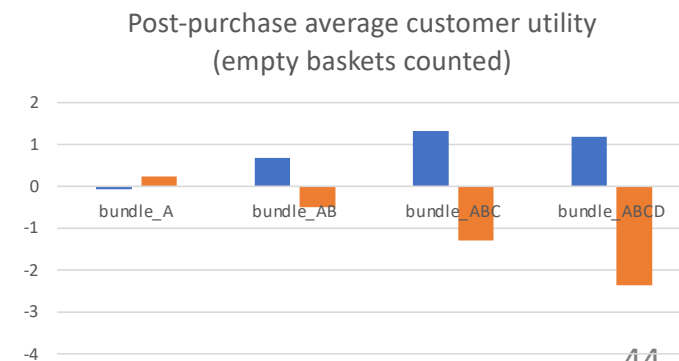
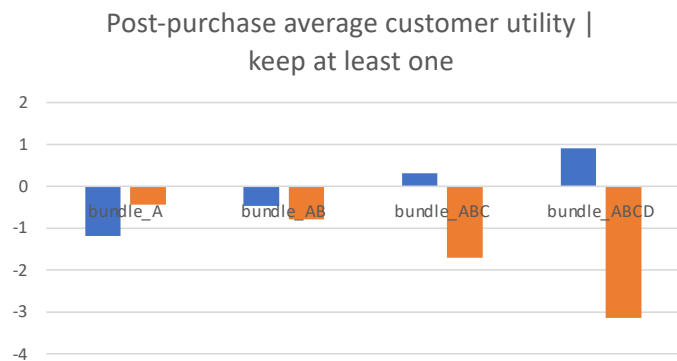
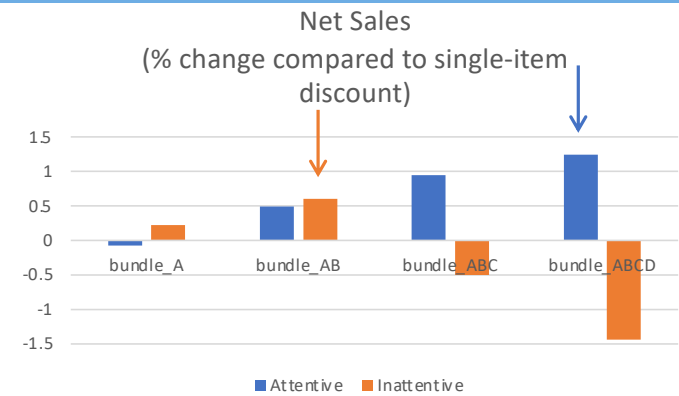
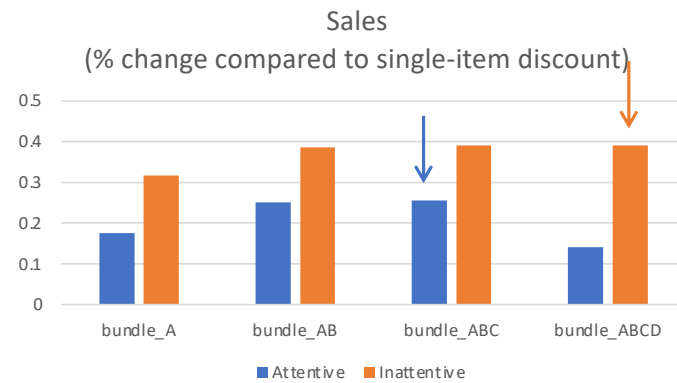


Categories	Mean of z
A	+50%
B	+25%
C	+10%
D	+0%



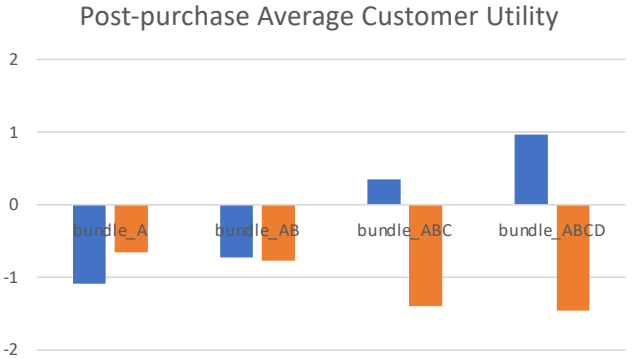
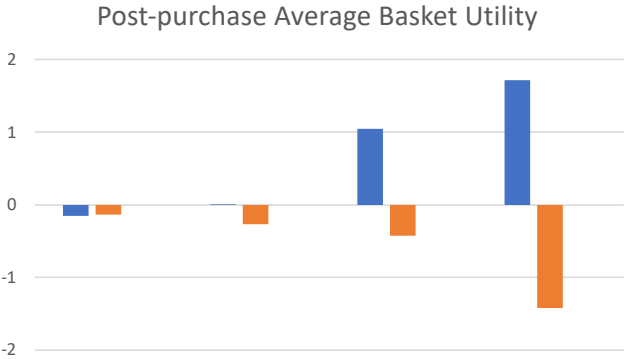
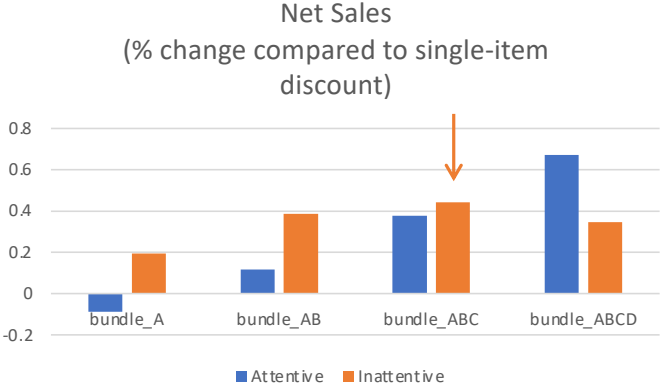
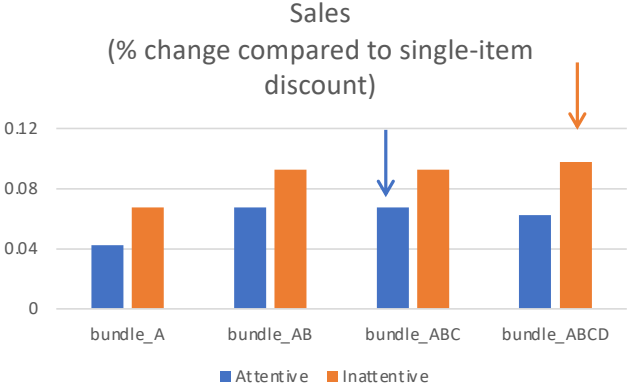


Categories	Mean of z
A	+50%
B	+25%
C	-25%
D	-50%



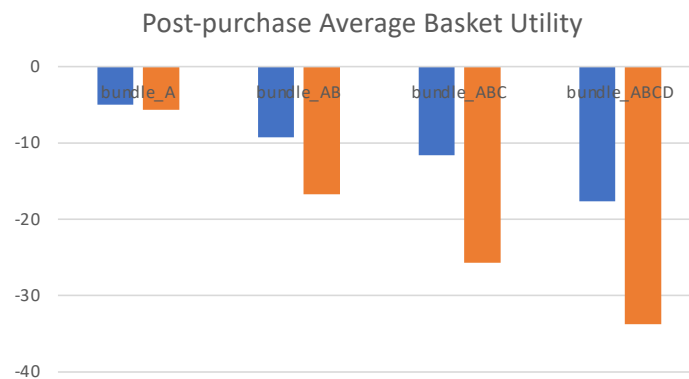
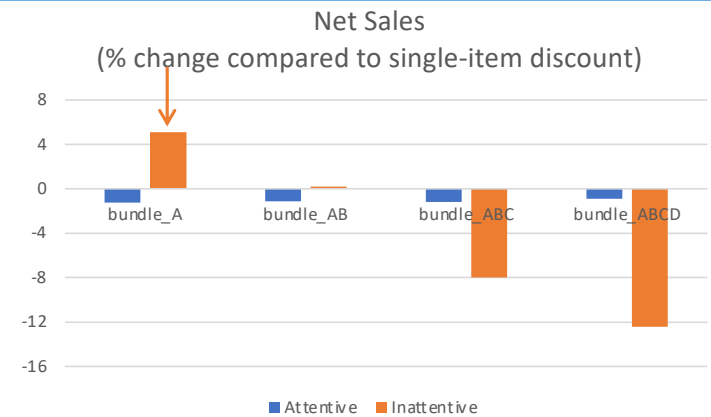
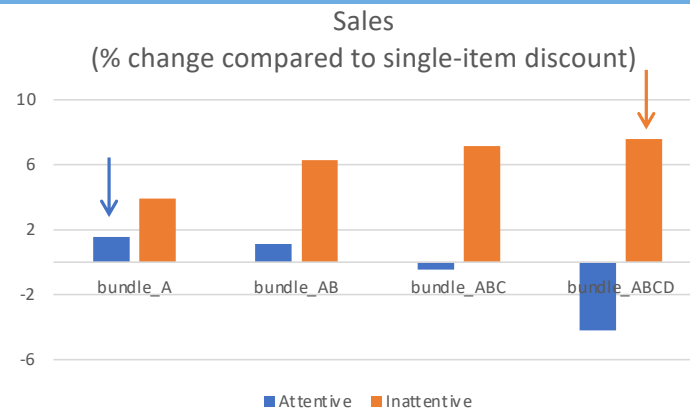


Categories	Mean of z
A	+50%
B	+25%
C	+10%
D	+0%





Categories	Mean of z
A	-0%
B	-10%
C	-25%
D	-50%



For attentive customers, single-item discount preferred

