Information Distortion In Label Design in the Over-the-Counter Drug Market

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Motivation

Over-the-Counter Drug Market:

- Consumers shop unassisted for drugs to alleviate their symptoms:
  - → no prescription required
  - → readily available on shelf
- Matching symptoms to drugs requires specific knowledge

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What are consequences for consumers?

Same brand, **biologically identical** but **different** symptom **label**

- Alleviate Migraine

- Alleviate Headache

Large price difference

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What are consequences for consumers?

- Perceived efficacy $\neq$ Medical efficacy
- Result: artificial price differentiation

This project

Questions:

- How current label design impacts consumer decision-making?
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  Identify unobserved perceived efficacy and its role in DM

- How to provide information that leads to welfare-beneficial choices?
  Estimate beliefs response to information provision and their role in equilibrium

Project structure

1. **Randomized control trial:**

   → Identify unobserved perceived efficacy:

   - Baseline → Control Group
   - Updated → Three Information Treatment Arms

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   → Role of perceived efficacy in decision making → Demand Model

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   → Role of perceived efficacy in decision making → Demand Model

   → Equilibrium response to new information structure → Updated Demand + Supply Model

Key findings

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Key findings

- **Control group of RCT:**
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- **Demand**
  - → Both perceived efficacy and preferences matter in decision making
  - → Cheap information provision increases substitution between biologically identical products
- **Equilibrium**
  - → Dominant price response is decrease in price
  - → 2nd-degree price discrimination based on willingness to pay for migraine label
  - → Best treatment saves on average $1.09 (12% price) per transaction

Outline

Institutional details

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- 2 groups of medical conditions (distinct by FDA guidelines):
  - → Migraine
  - → Headache

Stylized facts (NielsenIQ scanner, panel data, 2017)

1. Brands often market identical products under various labels, pricing them differently

   ▸ histogram: migraine "markup"

2. Consumers overpay

   ▸ fraction of "wrong" purchases

RCT

- 1,300 participants equally sized: Control group + three treatment arms
- Representative sample of U.S. OTC medication shoppers
- Three question blocks (15 minutes survey)
  1. Demographic information
  2. Need to alleviate migraine/headache distribution
  3. Out of three, identify two drugs that are more similar to each other in efficacy

     Triplet embedding delivers perceived efficacy
- Treatment arms:
  - → Label Modification:
    - Same active components ▸ example
    - Same expected efficacy based on other consumers' experience ▸ example
  - → Brochures on match between active components and symptoms ▸ example

RCT: results

- Average probability of misperception about relative efficacy: 0.42
- Misperception correlates with cost of information acquisition ▸ regression
- Information treatments decrease misperception

Outline

1. **Institutional Details**
2. **Randomized Control Trial:**
   - → Baseline beliefs about efficacy
   - → Updated beliefs
3. **Structural Analysis**

Data

- RCT
- NielsenIQ scanner, panel data, 2017
- Medical expenditures panel survey

Demand setup

- **Individual–product–symptom utility:**
  - → **Product characteristics:**
    - Preferences: front-of-package drug characteristics
    - Symptom-specific beliefs about drug efficacy
  - → **Sociodemographic characteristics:**
    - Age, income, household size, gender
    - Probability of entering the market to mitigate: {migraine, headache}

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- **Mixed logit** ▸ formula:
  - → Random coefficients: price and size

Structural model results

- Demand estimation:
  - → Perceived efficacy matters
  - → Information transparency: increase in cross-price elasticity

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- Supply estimation:
  - → Competition: prices decrease ▸ boxplot
  - → Clear "preferences group": increase in price gap within molecula ▸ boxplot
  - → Clear "preferences group": product with migraine label always more expensive ▸ boxplot

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- Demand estimation:
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- New equilibrium:
  - → Save on average 1.09$ ▸ distribution
  - → Welfare goes up by 1.2$

Conclusion

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- Companies utilize these biased beliefs to charge higher markups
- Consumers respond to better information provision
- Increased transparency improves welfare by reducing biases and intensifying competition

Thank You!

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Snapshot: triplet embedding question

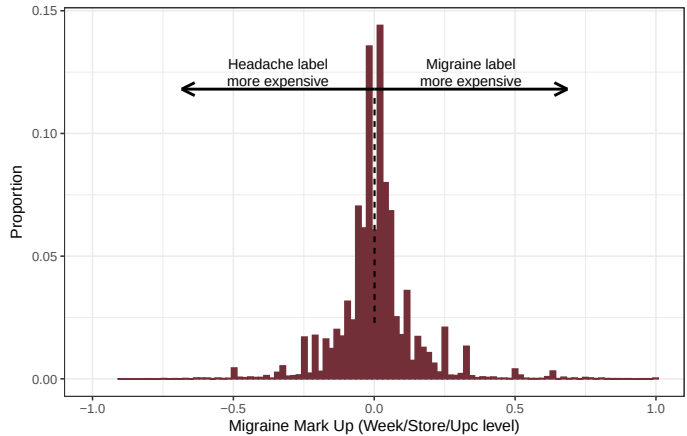
In this section, imagine you have a headache and are given a choice from one of three painkillers, all sold at the same price. The choice of painkillers will change from one question to the next. Your task in each question is to identify the two drugs that are most similar to each other in terms of their effectiveness for headache relief.
Effectiveness in this context refers to how well the drug reduces your headache and provides relief.

Please select the two headache relief drugs out of the following three options that you believe are most similar to each other in terms of their effectiveness for reducing headaches.

Institutional details

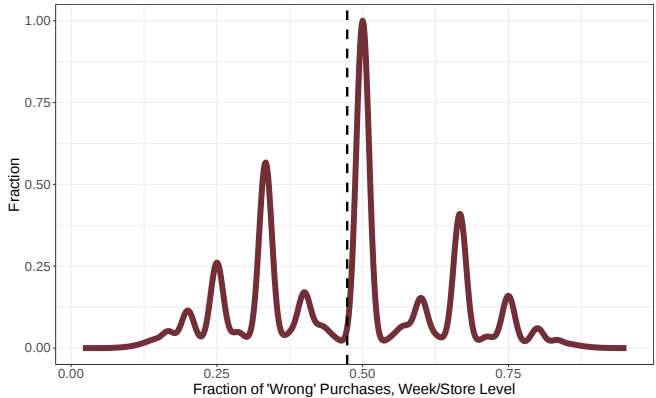
- 2 groups of medical conditions (distinct by FDA guidelines):
  - → Migraine:
    - "Migraine formula": Acetaminophen + Aspirin + Caffeine
    - Ibuprofen
  - → Headache:
    - "Migraine formula": Acetaminophen + Aspirin + Caffeine
    - Ibuprofen
    - Naproxen sodium; Acetaminophen; Aspirin...
- Consumers form beliefs about condition they have
- Consumers make decisions based on:
  - → Observed characteristics
  - → Expected efficacy

No dominant price label



Distribution of migraine label markup: $100 * \frac{p_m - p_h}{p_h}$, store-week level, 100 pills Absolute value mean: 5% ▸ all ▸

40% consumers purchase more expensive drug when analog available



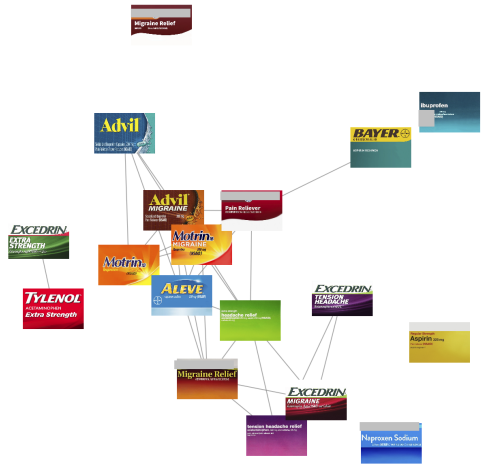
Distribution of “wrong" consumption: store-week level, all categories

Triplet embedding: relative similarity in perceived efficacy

- Goal: estimate relative expected efficacy of each product
- Input: binary function — drug A has more similar expected efficacy to drug B than C
- Output: relative position of each product

▸ Why triplet embedding ▸ Formula

Network Graph



Correlation between costs of information acquisition and “wrong” choices

$$\begin{aligned}\mathbf{Pr}(\text{“wrong choice”})_i = &\beta_0 + \beta_1 \cdot \text{female}_i + \beta_2 \cdot \text{age}_i + \beta_3 \cdot \text{age}_i^2 + \beta_4 \cdot \log(\text{income})_i + \\ &\beta_5 \cdot \text{high school education} + \sum_k \gamma_k \cdot X_i^k + \epsilon_i\end{aligned}$$

“Wrong” choices increase with high costs of information acquisition

Dependent Variable:	$\mathbf{Pr}$(“wrong choice”)		
Model:	(1)	(2)	(3)
age	-0.0181**	-0.0243***	-0.0206***
	(0.0077)	(0.0084)	(0.0076)
age^2	0.0002**	0.0002***	0.0002**
	(0.0000)	(0.0000)	(0.0000)
high school education and higher	-0.0969*	-0.1313**	-0.0724
	(0.0557)	(0.0648)	(0.0527)
Group allocation	Yes	Yes	Yes
region	Yes	Yes	Yes
industry		Yes	
frequency purchase			Yes
Observations	224	210	224

mean: 42% wrong choices

Heteroskedasticity-robust standard-errors in parentheses

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

High school education decreases the probability of wrong choices by 9.7% (mean = 42%). back

Why triplet embedding

- Second choice data:

  “A is the closest substitute to B” + qualitative measure

- Conjoint analysis

  No assumptions about independence or additivity of factors in decision-making

  (Luce Tukey, 1964; Ho, Landy, Maloney, 2008; Knoblauch Maloney, 2012...)

Triplet embedding: relative similarity in perceived efficacy

- Goal: estimate distance between each pair of products $\delta_{i,j}$ - relative effectiveness
- From answers - (i,j,k): i and j are more similar in terms of effectiveness than j
- Minimize loss in information:

$$\min_{X} \sum_{(i,j,k)} \max\left\{0, 1 + \sqrt{\delta_{i,j}} - \sqrt{\delta_{i,k}}\right\}$$

▸ Why triplet embedding ▸

Label modification: notion about active components

Label modification: notion about effectiveness

Migraine Educational Material Treatment

Here are some common OTC medications used to treat migraine, plus their active ingredients:

Brand or Product Name	Active Ingredients (plus amounts per tablet or capsule)
Aleve®	Naproxen sodium 220 mg
Advil®	Ibuprofen 200 mg
Bayer	Enteric-coated aspirin 325 mg
Anacin®	Aspirin 400 mg, caffeine 32 mg
Excedrin® Migraine	Aspirin 250 mg, acetaminophen 250 mg, caffeine 65 mg*
Excedrin® Tension Headache	Acetaminophen 500 mg, caffeine 65 mg*

Demand model

- consumer (i): Socio-Demographic characteristics
- beliefs on which symptom to alleviate (s_i): $\{migraine, headache\}$
- market (t): retailer, DMA, month
- product (j):
  - $\rightarrow$ $p_{j,t}$ - price
  - $\rightarrow$ l_j - label: quick match between product and beliefs about the symptom/diseases
  - $\rightarrow$ a_j - active components
  - $\rightarrow$ $g_j \in$ {branded; generic}
  - $\rightarrow$ w_j - size of the package
  - $\rightarrow$ $\mathbf{E}\left[Efficacy_{i,j}|s_i\right]$ - quality measure: how good is drug in alleviating symptom (s_i)

Utility function: separate beliefs (expected efficacy) from preferences

$$
\begin{aligned}
u_{i,s,j,t} = & \underbrace{\delta_{j,t} + \gamma_i \cdot p_{j,t}}_{\text{non symptom specific mean utility}} \\
& + \underbrace{\sum_{k,r} p_{j,k} \cdot z_{i,r} \cdot \gamma^{obs}_{k,r} + \gamma_m \cdot p_j \cdot \mathbf{I}[s_i = m] + \gamma_h \cdot p_j \cdot \mathbf{I}[s_i = h]}_{\text{consumer characteristic specific price sensitivity}} \\
& + \underbrace{\beta^{eff.}_m \cdot \mathbf{E}\left[\textit{Efficacy}_{i,j} \mid m\right] \cdot \mathbf{I}[s_i = m] + \beta^{eff.}_h \cdot \mathbf{E}\left[\textit{Efficacy}_{i,j} \mid h\right] \cdot \mathbf{I}[s_i = h]}_{\text{symptom specific beliefs}} \\
& + \underbrace{\sum_{k,r} x_{j,k} \cdot z_{i,r} \cdot \beta^{obs}_{k,r} + \sum_k x_{j,k} \cdot \mathbf{I}[s_i = m] \cdot \beta^{obs}_{s,k} + \sum_k x_{j,k} \cdot \mathbf{I}[s_i = h] \cdot \beta^{obs}_{s,k} + \sum_k x_{j,k} \cdot v_{i,k} \cdot \beta^{unobs}_{k,r}}_{\text{preferences}} \\
& + \underbrace{\epsilon_{i,j,t}}_{\text{non symptom specific idiosyncratic shock}}
\end{aligned}
$$

Supply side set-up

- Nash-Bertrand competition at manufacturers level for packages ≥ 80
- Small packages $\rightarrow$ simplifying pricing
  (Cohen et al., Baumol et al., Laitinen et al...)

Contribution

- OTC drug market:
  - → *Bronnenberg et al. (2014), Shrank et al. (2009), Cox et al. (1983), Suillivan et al. (1994), Hushkamp et al. (2003), Carrera and Villas-Boas (2023), Atal et al. (2024)...*

  Role of distorted beliefs about drugs' efficacy in decision-making process

- Information distortion in decision making:
  - → Beliefs and consumer choice: *Allcott 2010...*
  - → Label design: *Barahona et al. (2023), Kiesel and Villas-Boas (2013), Zhu et al. (2015)...*
  - → Consumer obfuscation: *Spielberg (2006a), Ellison & Wolitzky (2009), Willson (2009), Ellison (2005), Ellison and Ellison (2009), Carrera et al. (2020), Handel (2013)...*

  Policies that decrease information distortion

Contribution

- Unobserved quality:

  → *Dranove et al. (2003); Jin and Leslie (2003); Greenstone et al. (2006); Dranove and Jin (2010); Roe et al. (2014); Houde (2018); Vatter (2021)...*

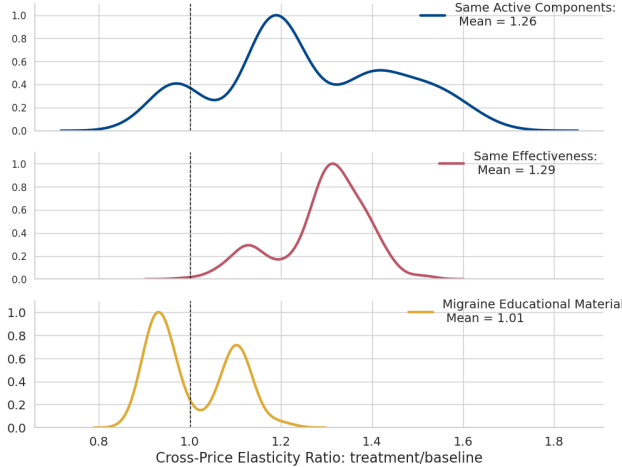
  Case of strategic quality biasing

- Utilization of machine learning to account for unobserved choice parameters:

  → *Conlon et al. (wp), Magnolfi et al. (forthcoming) ...*

  Identification of quality and change in counterfactuals

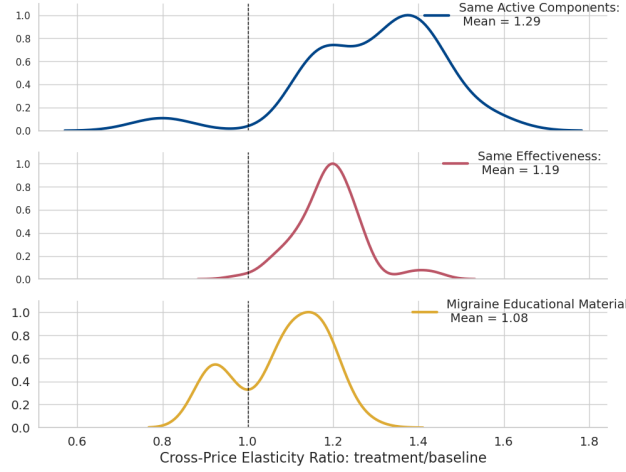
Cross-price elasticity: between biologically identical drugs



Front-label statements indicating equivalent efficacy increases substitution by 29%

back

Cross-price elasticity: from brand to generic

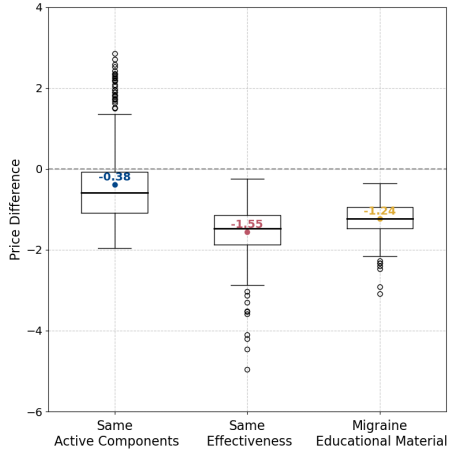


Front-label statements indicating equivalent efficacy increases substitution by 19%

back

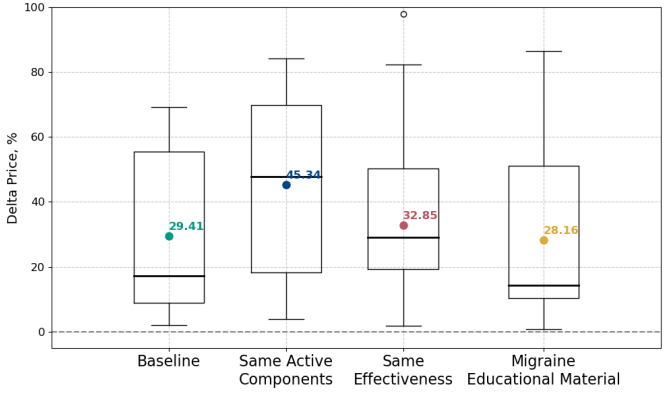
Supply side response: Prices go down

- $p_{treatment} - p_{baseline}$



Supply side response: Increase in price gap

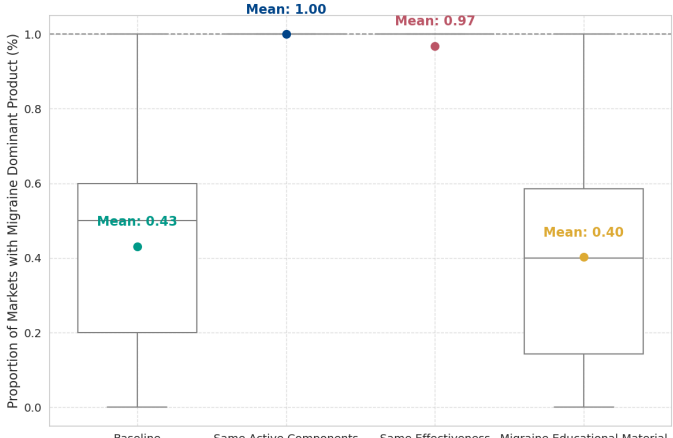
- Delta price = $\frac{p_{brand} - p_{generic}}{p_{generic}}$



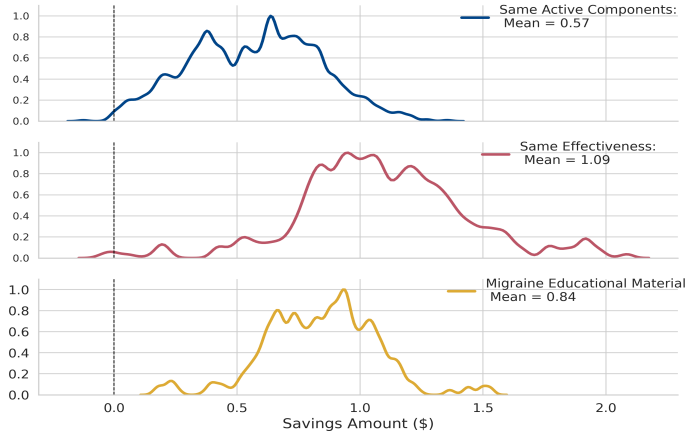
back

Supply side response: migraine always more expensive

- $\mathbf{Pr}_{brand,a.c.}(p_{migraine} > p_{headache})$



Savings in new equilibrium



In same effectiveness treatment save on average 1.09$ (16% average price)