Equilibrium Effects of Food Labeling Policies

Nano Barahona   Cristóbal Otero   Sebastián Otero

February 11, 2023

The war against obesity

- Obesity rates have **tripled** since 1975
- **Dietary factors** are a leading cause of obesity
- Governments are exploring policies to improve nutritional intake
- Increasingly popular policy is to implement **food labels**

Research questions

1. Do food labels improve nutritional intake and consumer welfare?

Research questions

1. Do food labels improve nutritional intake and consumer welfare?

2. How do supply-side responses affect the potential benefits of food labels?

Research questions

1. Do food labels improve nutritional intake and consumer welfare?

2. How do supply-side responses affect the potential benefits of food labels?
   - Affect **prices** through product differentiation and market power
   - Induce the use of **healthier ingredients** to avoid labels

   ⇒ *Equilibrium effects* of food labels are ambiguous

Research questions

1. Do food labels improve nutritional intake and consumer welfare?
2. How do supply-side responses affect the potential benefits of food labels?
3. How do food labels compare to alternative policy instruments?

The Chilean Food Act

- We study a national food labeling regulation passed in Chile in 2016:
  - Mandates food labels on all processed foods that:
    surpass threshold in **sugar**, **calorie**, **sodium**, and **saturated fat** concentration

policy details

Overview of results

1. Reduction in **sugar** and **calorie** intake of 9% and 7% due to the policy

Overview of results

1. Reduction in **sugar** and **calorie** intake of 9% and 7% due to the policy

2. Descriptive evidence from the cereal market
   - **Consumers**: Substitute from labeled to unlabeled products
     - Stronger effect for products **mistakenly believed** to be healthy
   - **Firms**: Change prices and reformulate their products

Overview of results

1. Reduction in **sugar** and **calorie** intake of 9% and 7% due to the policy

2. Descriptive evidence from the cereal market

3. Model of supply and demand for cereal
   - **Policy effects**: Increases in consumer welfare by 1.8% of total expenditure
   - **Decomposition**: Role of demand and supply
   - **Counterfactuals**: Compare food labels to sugar taxes

Related literature

1. Consumer choice in settings of imperfect information
   - Hastings and Weinstein (2008), Abaluck and Gruber (2011), Abaluck (2011), Woodward and Hall (2012), Allcott (2013), Handel and Kolstad (2015), Allcott and Knittel (2019)

   → Consumers beliefs are crucial for policy effectiveness

Related literature

1. Consumer choice in settings of imperfect information

2. Quality disclosure and certification

   - Dranove et al. (2003), Jin and Leslie (2003), Greenstone et al. (2006), Dranove and Jin (2010), Roe et al. (2014), Ito and Sallee (2018), Houde (2018)

   → Framework to study equilibrium effects of mandatory disclosure policies

Related literature

1. Consumer choice in settings of imperfect information

2. Quality disclosure and certification

3. Policies to improve consumers' nutritional intake
   - Food labels: Sacks et al. (2009), Kiesel and Villas-Boas (2013), Zhu et al. (2015), Taillie et al., (2020), Araya et al. (2020), Pachali et al. (2020), Alé-Chilet and Moshary (2020)
   - Information on Menus: Elbel et al. (2009), Wisdom et al. (2010), Bollinger et al. (2011), Finkelstein et al. (2011)
   - Advertising: Ippolito and Mathios (1990,1995), Dubois et al. (2017a)
   - Taxes: Dubois et al. (2017b), Allcott et al. (2019), Aguilar et al. (2020)

   → (i) Equilibrium framework, (ii) Role of beliefs (iii) Policy counterfactuals

This Talk

- Data
- Descriptive evidence
- Model
- Estimation
- Results

Data

1. Prices and quantities
   - Walmart-Chile scanner data (2015-2018)
   - Panel of 524,000 consumers that shop at Walmart regularly

2. Nutritional content
   - Hand-collected data - two snapshots: before (2016) and after (2018)
   - Coverage: 90% of revenue of packaged products and 94% in the cereal market

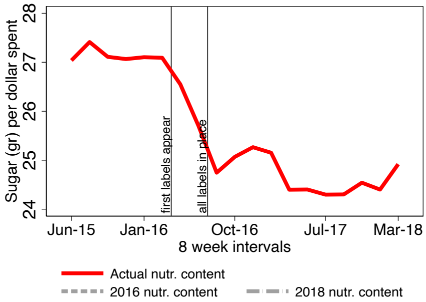
3. Beliefs about nutritional content
   - We conducted an online survey in Argentina to 1,500 customers

This Talk

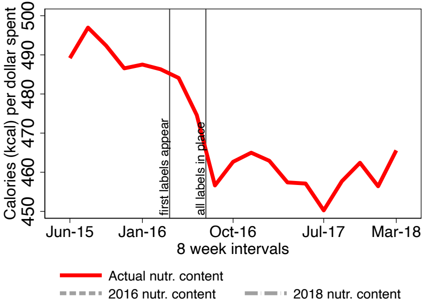
- Data
- Descriptive evidence
  - Overall changes in nutritional intake
  - Zoom in on the breakfast cereal market
- Model
- Estimation
- Results

Descriptive evidence: Overall changes in nutritional intake

- Sugar and calorie intake per dollar spent decreased 9% and 7% respectively
- **Channels**: 1. between-category subs., 2. within-category subs., 3. product reformulation



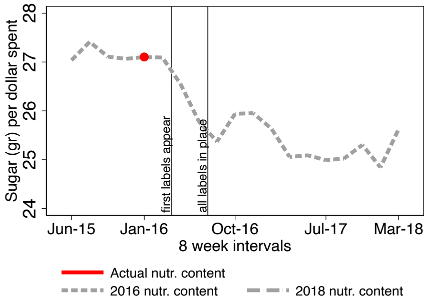
(a) Sugar intake



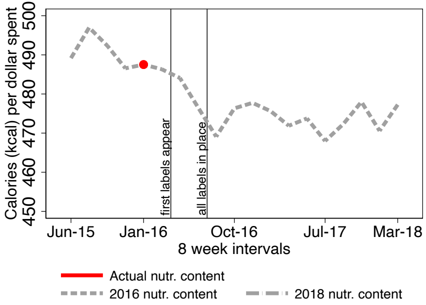
(b) Caloric intake

Descriptive evidence: Overall changes in nutritional intake

- Sugar and calorie intake per dollar spent decreased 9% and 7% respectively
- **Channels**: 1. between-category subs., 2. within-category subs., 3. product reformulation



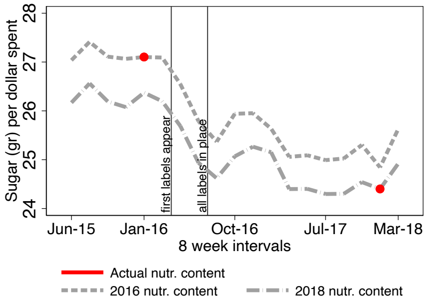
(a) Sugar intake



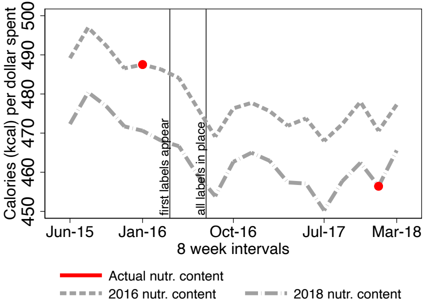
(b) Caloric intake

Descriptive evidence: Overall changes in nutritional intake

- Sugar and calorie intake per dollar spent decreased 9% and 7% respectively
- **Channels**: 1. between-category subs., 2. within-category subs., 3. product reformulation



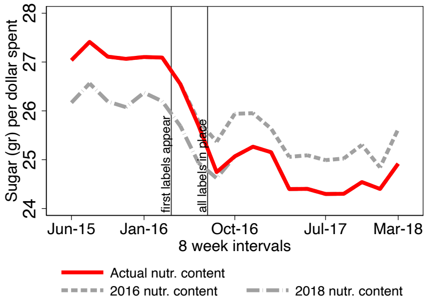
(a) Sugar intake



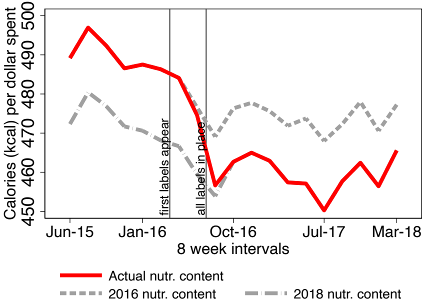
(b) Caloric intake

Descriptive evidence: Overall changes in nutritional intake

- Sugar and calorie intake per dollar spent decreased 9% and 7% respectively
- **Channels**: 1. between-category subs., 2. within-category subs., 3. product reformulation



(a) Sugar intake



(b) Caloric intake

The breakfast cereal market

Descriptive evidence: Changes in equilibrium quantities

- Product: all bar codes with same name and brand (e.g. "Honey Nut Cheerios")

- We estimate the following regression

$$\log(q_{jst}) = \sum_k \beta_k L_j \mathbb{1}_{\{k=t\}} + \gamma \log(p_{jst}) + d_{js} + \delta_t + \varepsilon_{jst}$$

  where

  - q_{jst} are total grams of product j sold in supermarket s in period t (8 weeks long)
  - L_j is defined as whether the product gets any label (as in 2018)
  - Observations are weighted by pre-policy revenue
  - Standard errors clustered at the product level

Descriptive evidence: Changes in equilibrium quantities

- Product: all bar codes with same name and brand (e.g. "Honey Nut Cheerios")

- We estimate the following regression

$$\log(q_{jst}) = \sum_k \beta_k L_j \mathbb{1}_{\{k=t\}} + \gamma \log(p_{jst}) + d_{js} + \delta_t + \varepsilon_{jst}$$

  where

  - q_{jst} are total grams of product j sold in supermarket s in period t (8 weeks long)
  - L_j is defined as whether the product gets any label (as in 2018)
  - Observations are weighted by pre-policy revenue
  - Standard errors clustered at the product level

Descriptive evidence: Changes in equilibrium quantities

- Product: all bar codes with same name and brand (e.g. "Honey Nut Cheerios")

- We estimate the following regression

$$\log(q_{jst}) = \sum_k \beta_k L_j \mathbb{1}_{\{k=t\}} + \gamma \log(p_{jst}) + d_{js} + \delta_t + \varepsilon_{jst}$$

  where

  - q_{jst} are total grams of product j sold in supermarket s in period t (8 weeks long)
  - L_j is defined as whether the product gets any label (as in 2018)
  - Observations are weighted by pre-policy revenue
  - Standard errors clustered at the product level

Descriptive evidence: Changes in equilibrium quantities

- Product: all bar codes with same name and brand (e.g. "Honey Nut Cheerios")

- We estimate the following regression

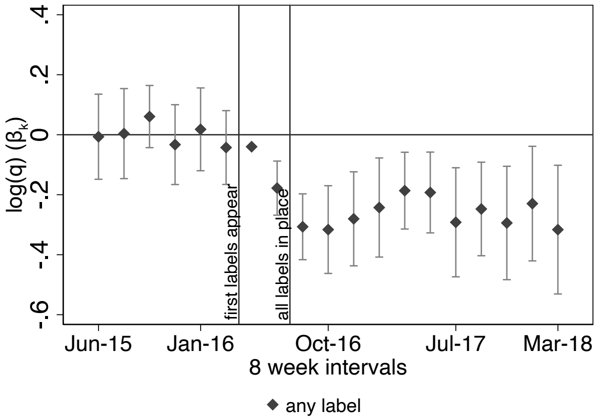
$$\log(q_{jst}) = \sum_k \beta_k L_j \mathbb{1}_{\{k=t\}} + \gamma \log(p_{jst}) + d_{js} + \delta_t + \varepsilon_{jst}$$

  where

  - q_{jst} are total grams of product j sold in supermarket s in period t (8 weeks long)
  - L_j is defined as whether the product gets any label (as in 2018)
  - Observations are weighted by pre-policy revenue
  - Standard errors clustered at the product level

Descriptive evidence: Changes in equilibrium quantities

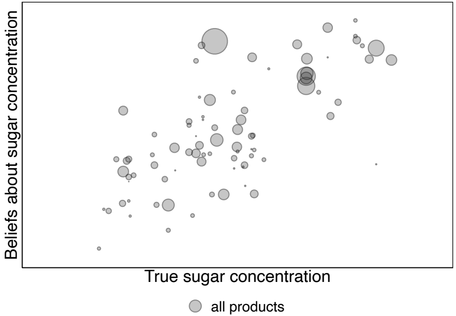
- Relative decrease in demanded quantities for labeled products of 26.4% on average



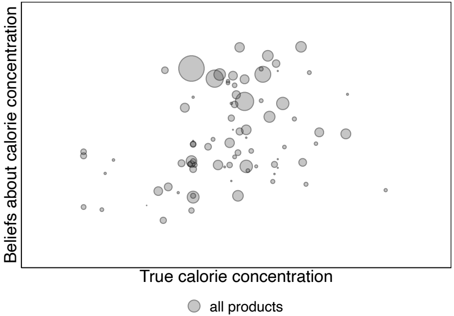
raw data

Descriptive evidence: The role of beliefs

- The correlation between beliefs about sugar and true sugar content is 0.73
- The correlation between beliefs about calories and true calorie content is 0.28



(a) Beliefs about sugar

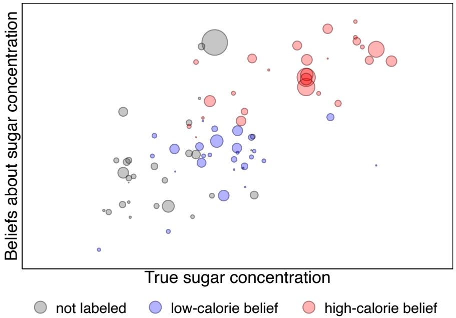


(b) Beliefs about calories

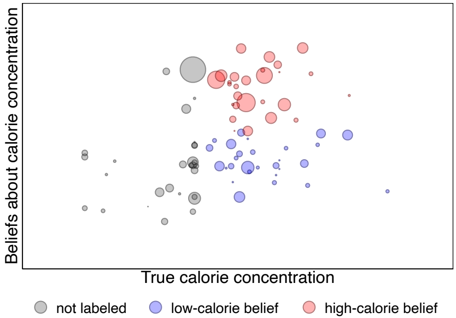
survey details

Descriptive evidence: The role of beliefs

- We divide product between labeled and unlabeled
- We split labeled products between above- and below-median in calorie beliefs



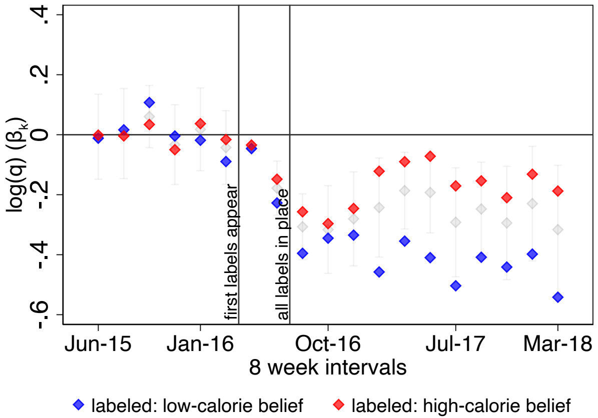
(a) Beliefs about sugar



(b) Beliefs about calories

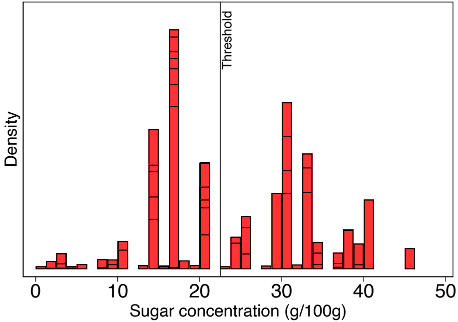
Descriptive evidence: The role of beliefs

- Products perceived as healthy that received a label were more affected

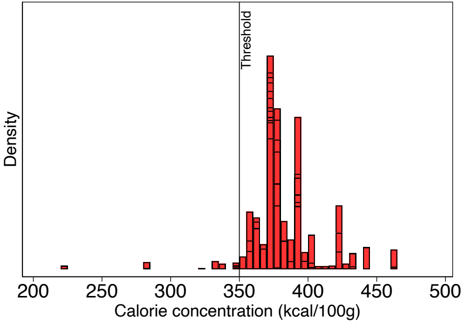


Descriptive evidence: Supply side - product reformulation

- Firms reformulated products to avoid receiving labels
- 33% and 23% of "high-in" products in sugar and calories respectively crossed the threshold



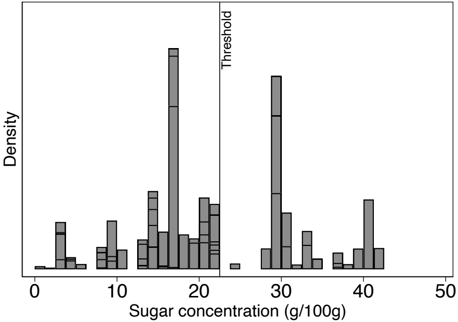
(a) Sugar content - 2016



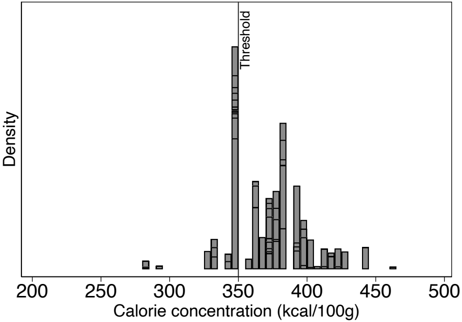
(b) Caloric content - 2016

Descriptive evidence: Supply side - product reformulation

- Firms reformulated products to avoid receiving labels
- 33% and 23% of "high-in" products in sugar and calories respectively crossed the threshold



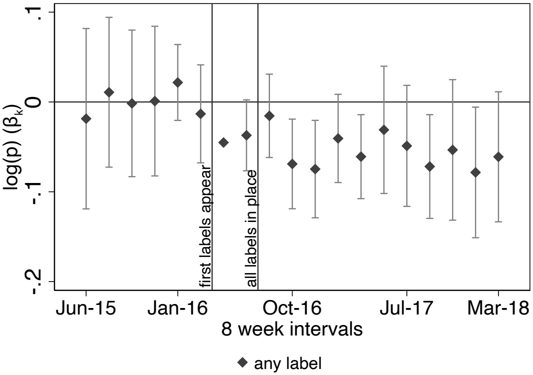
(a) Sugar content - 2018



(b) Caloric content - 2018

Descriptive evidence: Supply side - changes in prices

- Unlabeled products increased price relative to labeled ones
- Mix between: responses to changes in demand + increase in production costs



Descriptive evidence: Takeaways

- Demand for unlabeled products increased 26% relative to labeled ones
  - Beliefs play a key role in shaping demand
- Firms reacted by changing prices and reformulating products
  - Average sugar and calorie concentration decreased in 12% and 3%
  - Average price of unlabeled products increased 5.5% relative to labeled ones

Descriptive evidence: Takeaways

- Demand for unlabeled products increased 26% relative to labeled ones
  - Beliefs play a key role in shaping demand
- Firms reacted by changing prices and reformulating products
  - Average sugar and calorie concentration decreased in 12% and 3%
  - Average price of unlabeled products increased 5.5% relative to labeled ones
- We develop and estimate a model to:
  - Incorporate findings into an equilibrium framework
  - Disentangle the role of demand and supply
  - Study optimal policy design and compare to alternative policy instruments

This Talk

- Data
- Descriptive evidence
- Model
  - Demand
  - Supply
- Estimation
- Results

Model: Demand

- Utility obtained by individual i when purchasing product j:

$$u_{ijt} = \underbrace{\delta_{ijt}}_{\text{experience/taste}} - \underbrace{\alpha_i p_{jt}}_{\text{price paid}} - \underbrace{w_{jt}\phi_i}_{\text{health consequences}}$$

Model: Demand

- Utility obtained by individual i when purchasing product j:

$$u_{ijt} = \underbrace{\delta_{ijt}}_{\text{experience/taste}} - \underbrace{\alpha_i p_{jt}}_{\text{price paid}} - \underbrace{w_{jt}\phi_i}_{\text{health consequences}}$$

1. δ_{ijt}: is immediately observed by the consumer
   - Includes taste, relief of hunger, social status, or any other short term benefit of consuming the good

Model: Demand

- Utility obtained by individual i when purchasing product j:

$$u_{ijt} = \underbrace{\delta_{ijt}}_{\text{experience/taste}} - \underbrace{\alpha_i p_{jt}}_{\text{price paid}} - \underbrace{w_{jt}\phi_i}_{\text{health consequences}}$$

2. $\alpha_i p_{jt}$: disutility from paying price p_{jt}
   - α_i is the parameter that governs the price elasticity

Model: Demand

- Utility obtained by individual i when purchasing product j:

$$u_{ijt} = \underbrace{\delta_{ijt}}_{\text{experience/taste}} - \underbrace{\alpha_i p_{jt}}_{\text{price paid}} - \underbrace{w_{jt}\phi_i}_{\text{health consequences}}$$

3. $w_{jt}\phi_i$: long term damage from consuming unhealthy products
   - w_{jt} is a vector of the nutritional content of product j
   - We assume that consumers know ϕ_i but only observe $\mathbb{E}_i[w_{jt}|L_{jt}]$, where
     - $\mathbb{E}_i$ is defined over π_{ji}, the distribution of prior beliefs of consumer i over product j's nutritional content
     - $L_{jt} \in \{pre, no, yes\}$ is the labeling status of product j (pre policy, not labeled after policy, labeled after policy)

Model: Demand

- Taking expectation over u_{ijt}, the expected utility is

$$\mathbb{E}_i[u_{ijt}] \quad = \quad \delta_{ijt} - \alpha_i p_{jt} - \mathbb{E}_i[w_{jt}|L_{jt}]\phi_i$$

- The set of consumers buying product j in market t is given by:

$$\Theta_{jt} = \{i : \mathbb{E}_i[u_{ijt}] \geq \mathbb{E}_i[u_{ikt}] \; \forall k \in \{0, .., J\}\}$$

- Market share of product j in market t is given by $s_{jt}(\mathbf{p_t}, \mathbb{E}[\mathbf{w_t}|\mathbf{L}_t])$

Model: Supply

- **Key assumption**: Products are characterized by an invariant taste level
  - Achieved by combining critical nutrients w_{jt} with other substitute inputs
  - We denote by ν_j the optimal amount of w_{jt} to achieve taste at minimum cost

- In each period, firms choose prices and nutritional content to maximize profits

$$\max_{\{p_{jt},w_{jt}\}_{j\in\Im_j}} \sum_{j\in\Im_j}(p_{jt} - c_{jt}(w_{jt})) \cdot s_{jt}(\mathbf{p_t}, \mathbb{E}[\mathbf{w_t}|\mathbf{L_t}])$$

where $c_{jt}(w_{jt})$ is minimized at ν_j

Model: Supply

- In the **absence of the policy**, firms solve:

$$\max_{\{p_{jt}, w_{jt}\}_{j \in \Im_j}} \quad \sum_{j \in \Im_j} (p_{jt} - c_{jt}(w_{jt})) \cdot s_{jt}(\mathbf{p_t}, \mathbb{E}[\mathbf{w_t}])$$

- From the first order conditions, we have:

$$\begin{aligned} w_{jt}^* &= \nu_j \\ p_{jt}^* &= c_{jt}(w_{jt}^*) + \Delta_{(j,\cdot)}^{-1} \mathbf{s_t} \end{aligned}$$

where the (j, k) element of Δ is given by:

$$\Delta_{jk} = \begin{cases} \frac{-\partial s_k}{\partial p_j} & \text{if } k \in \Im_j \\ 0 & \text{otherwise} \end{cases}$$

Model: Supply

- When we introduce labels, demand $s_{jt}(\mathbf{p}_t, \mathbb{E}[\mathbf{w}_t|\mathbf{L}_t])$ becomes discontinuous in w_{jt}
  - Previous first order conditions might not hold with equality
- Firms have incentives to bunch below the threshold to get rid of the labels
  - Firms closer to the threshold are more likely to bunch

This Talk

- Data
- Descriptive evidence
- Model
- Estimation
  - Demand
  - Supply
- Results

Demand estimation: Parametrization

- We split consumers into two consumer-type bins $b \in \{\text{low SES}, \text{high SES}\}$
- The expected utility is given by:

$$\mathbb{E}_b[u_{ijt}] \quad = \quad -\alpha_i p_{jt} - \mathbb{E}_b[w_{jt}|L_{jt}]'\phi_i + \underbrace{\beta_i r_j + \delta_{jb} + \delta_{T(t)b} + \delta_{S(t)b} + \xi_{jtb} + \epsilon_{ijt}}_{\text{experience/taste}}$$

  - where $\begin{bmatrix} \alpha_i & \phi_i' \end{bmatrix}' \sim \log \mathcal{N}\left(\begin{bmatrix} \alpha_b & \phi_b' \end{bmatrix}', \Sigma_{\alpha,\phi}\right)$ and $\beta_i \sim \mathcal{N}(0, \Sigma_\beta)$
  - r_j is product j's subcategory (e.g. plain, sugary, chocolate, oatmeal, granola)
  - $\epsilon_{ijt} \sim$ GEV (nested logit) with intra-nest correlation ρ (inside vs outside goods)

- $\mathbb{E}_b[\cdot]$ is defined over prior beliefs π_{jb}, that are given by a normal distribution $\mathcal{N}(\mu_{jb}, \Omega_{jb})$
- Bayesian consumers update posteriors taking the labels as a binary signal

Demand estimation: Identification

- α_b: Instrument for prices ($\hat{p}_{jt}$)
  - We construct instruments using international commodity prices (corn, wheat, oat) interacted with the content of each commodity in product j
- ϕ_b: Variation in labeling status across and within products
  - We interact a predictor for labeling status $\hat{L}_j$ with a post dummy
  - We construct $\hat{L}_j$ via random forest using r_j and pre-policy nutritional content
- $(\rho, \Sigma_{\alpha,\phi}, \Sigma_\beta)$: Variation in other products' demand shifters
  - $z_t^{r,1} = \underset{j \in r,t}{\text{mean}}\{\hat{p}_{jt}\}, \quad z_t^{r,2} = \underset{j \in r,t}{\text{pctile}^{20,80}}\{\hat{p}_{jt}\}, \quad z_t^{r,3} = \sum_{j \in r,t} \mathbb{1}\{t \geq \tau_{jt}\}$
- (μ_{jb}, Ω_{jb}): Combination of beliefs' survey with additional moment conditions

identification details of μ

Demand estimation: Results

- The average consumer buys 5.2kg of cereal, spending $25 a year
- The average own-price elasticity is -3.09
- Keeping taste constant, an average consumer is willing to pay:
  - 10% extra ($2.5 a year) to reduce sugar content in 1sd
  - 7.6% extra ($1.9 a year) to reduce calorie content in 1sd
- Original Cheerios have 2sd less sugar than Honey Nut Cheerios

Supply estimation

- Marginal cost is given by $c_{jt}(w)$, where $\nabla c_{jt}(\nu_j) = 0$
- We use a second order Taylor approximation around ν_j

$$c_{jt}(w) = \bar{c}_{jt} + (w - \nu_j)' \Lambda_j (w - \nu_j)$$

- From the first order conditions we can recover $c_{jt}(w_{jt})$ and $\nu_j = w_{j,pre}$
- From equilibrium, we find cost at which firms are indifferent between bunching and not
- Assuming $\Lambda_j = \begin{bmatrix} \lambda_{jc} & 0 \\ 0 & \lambda_{js} \end{bmatrix}$ and that $\lambda_{jk} \sim \log \mathcal{N}(\mu_{\lambda_k}, \sigma_{\lambda_k})$, we can estimate $(\mu_{\lambda_k}, \sigma_{\lambda_k})$ via GMM: $\mathbb{E}_\Lambda[B_j - Pr(c_{jt}(\bar{w}) < c_j^{ind}) | \nu_j] = 0$, where B_j indicates whether the product bunched and c_j^{ind} is the cost at which the firm is indifferent between bunching or not.

Supply estimation: Results

- Products bunching in sugar decreased sugar content in 0.6sd (8gr/100gr)
  - Marginal cost increased 8.8% on average (4.4% of final price)

- Products bunching in calories decreased calorie content 1sd (25kcal/100gr)
  - Marginal cost increased 8.7% on average (3.9% of final price)

This Talk

- Data
- Descriptive evidence
- Model
- Estimation
- Results
  - Policy decomposition
  - Policy counterfactuals

Policy decomposition

- We run **counterfactuals** to answer:
  - What are the effects of labels in the absence of supply-side responses?
  - How does product differentiation and market power affect final prices?
  - How product reformulation can
    - $\rightarrow$ amplify the positive effects on nutritional intake
    - $\rightarrow$ increase consumer prices as a result of increased production costs
- Study **policy design** by changing regulatory thresholds
- Compare food labels to **sugar taxes**

Policy decomposition: Normative assumptions

- Our model can accommodate **additional market imperfections**
  - **Externalities**: Financial health-care costs, moral hazard
  - **Internalities**: Lack of self-control, time-inconsistency, misinformation about ϕ_i

- We add them to our model by having the following setup

$$\begin{aligned} \textbf{Expected utility}: \quad \mathbb{E}_b[u_{ijt}] &= \delta_{ijt} - \alpha_i p_{jt} - \mathbb{E}_b[w_{jt}|L_{jt}]'\phi_i \\ \textbf{Social planner utility}: \quad u_{ijt} &= \delta_{ijt} - \alpha_i p_{jt} - w'_{jt}\phi_i\lambda \end{aligned}$$

- We focus on the case where $\lambda = 1$ (i.e. no additional market imperfections)

Policy decomposition: Counterfactuals

- We estimate outcomes under four scenarios:

Counterfactual	**Description**
(0) no intervention	No intervention
(1) demand only	Labels & no supply responses
(2) price response	(1) + firms choose prices (p_{jt})
(3) equilibrium	(1) + (2) + firms choose nutritional content (w_{jt})

Policy decomposition: Counterfactuals

- We estimate outcomes under four scenarios:

Counterfactual	Description
(0) no intervention	No intervention
(1) demand only	Labels & no supply responses
(2) price response	(1) + firms choose prices (p_{jt})
(3) equilibrium	(1) + (2) + firms choose nutritional content (w_{jt})

- We measure average yearly consumer welfare in dollars using the **social planner utility**

$$CW = \frac{1}{\mathcal{I}} \sum_{i} \frac{1}{\alpha_i} \sum_{j} \left\{ \int_{\Theta_{jt}} (\delta_{ijt} - \alpha_i p_{jt} - w'_{jt}\phi_i \lambda) dP(\epsilon) \right\}$$

where $\Theta_{bjt} = \{i \in b : j \succeq_i k, \forall k\}$

Policy decomposition: Counterfactuals

- We study the effects of the policy under four scenarios:

Counterfactual	**Description**
(0) no intervention	No intervention
(1) demand only	Labels & no supply responses
(2) price response	(1) + firms choose prices (p_{jt})
(3) equilibrium	(1) + (2) + firms choose nutritional content (w_{jt})

- We can calculate $\Delta CW = CW - CW(0)$ and decompose it into:

$$\Delta CW = \frac{1}{\mathcal{I}} \sum_i \frac{1}{\alpha_i} \sum_j \underbrace{\int_{\Delta\Theta_{jt}} \delta_{ijt} dP(\epsilon) - (\alpha_i p_{jt} + w'_{jt}\phi_i\lambda)\Delta s_{ijt}}_{\text{substitution effects}} \underbrace{-(\alpha_i \Delta p_{jt} + \Delta w'_{jt}\phi_i\lambda) s^{(0)}_{ijt}}_{\text{supply effects}}$$

where $\Delta x = x - x^{(0)}$ and $\Delta\Theta_{jtb} = \{i \in b : j \succeq_i k, \forall k \cap i : \exists k | j \nsucceq^{(0)}_i k\}$

Policy decomposition: Counterfactuals

- We study the effects of the policy under four scenarios:

Counterfactual	Description
(0) no intervention	No intervention
(1) demand only	Labels & no supply responses
(2) price response	(1) + firms choose prices (p_{jt})
(3) equilibrium	(1) + (2) + firms choose nutritional content (w_{jt})

$$\Delta CW = \frac{1}{\mathcal{I}} \sum_i \frac{1}{\alpha_i} \sum_j \underbrace{\int_{\Delta\Theta_{jt}} \delta_{ijt}\, dP(\epsilon) - (\alpha_i p_{jt} + w'_{jt}\phi_i\lambda)\Delta s_{ijt}}_{\text{substitution effects}} \quad \underbrace{\cancelto{0}{-(\alpha_i \Delta p_{jt} + \Delta w'_{jt}\phi_i\lambda) s^{(0)}_{ijt}}}_{\text{supply effects}}$$

where $\Delta x = x - x^{(0)}$ and $\Delta\Theta_{jtb} = \{i \in b : j \succeq_i k, \forall k \cap i : \exists k | j \not\succeq_i^{(0)} k\}$

Policy decomposition: Counterfactuals

- We study the effects of the policy under four scenarios:

Counterfactual	**Description**
(0) no intervention	No intervention
(1) demand only	Labels & no supply responses
(2) price response	(1) + firms choose prices (p_{jt})
(3) equilibrium	(1) + (2) + firms choose nutritional content (w_{jt})

$$\Delta CW = \frac{1}{\mathcal{I}} \sum_i \frac{1}{\alpha_i} \sum_j \underbrace{\int_{\Delta\Theta_{jt}} \delta_{ijt}\, dP(\epsilon) - (\alpha_i p_{jt} + w'_{jt}\phi_i\lambda)\Delta s_{ijt}}_{\text{substitution effects}} \quad \underbrace{-(\alpha_i \Delta p_{jt} + \cancelto{0}{\Delta w'_{jt}\phi_i\lambda})\, s_{ijt}^{(0)}}_{\text{supply effects}}$$

where $\Delta x = x - x^{(0)}$ and $\Delta\Theta_{jtb} = \{i \in b : j \succeq_i k, \forall k \cap i : \exists k | j \not\succeq_i^{(0)} k\}$

Policy decomposition: Counterfactuals

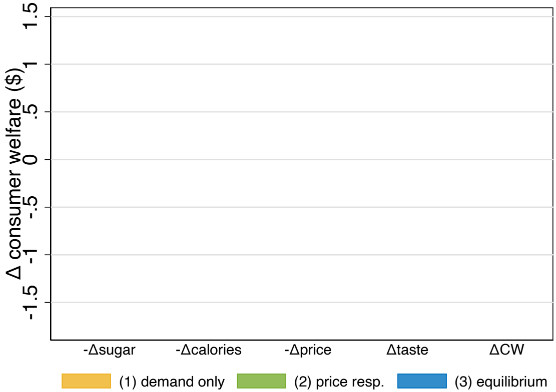
- We study the effects of the policy under four scenarios:

Counterfactual	**Description**
(0) no intervention	No intervention
(1) demand only	Labels & no supply responses
(2) price response	(1) + firms choose prices (p_{jt})
(3) equilibrium	(1) + (2) + firms choose nutritional content (w_{jt})

$$\Delta CW = \frac{1}{\mathcal{I}} \sum_i \frac{1}{\alpha_i} \sum_j \underbrace{\int_{\Delta\Theta_{jt}} \delta_{ijt} dP(\epsilon) - (\alpha_i p_{jt} + w'_{jt}\phi_i\lambda)\Delta s_{ijt}}_{\text{substitution effects}} \quad \underbrace{-(\alpha_i \Delta p_{jt} + \Delta w'_{jt}\phi_i\lambda) s^{(0)}_{ijt}}_{\text{supply effects}}$$

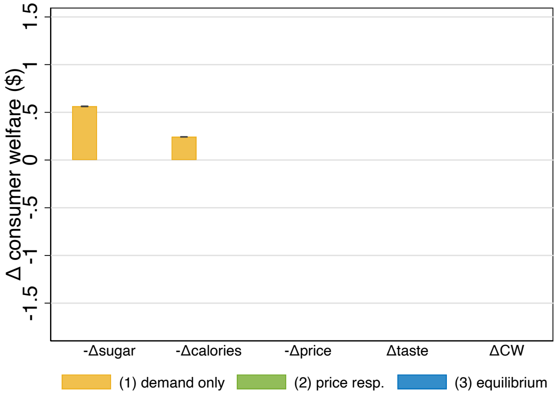
where $\Delta x = x - x^{(0)}$ and $\Delta\Theta_{jtb} = \{i \in b : j \succeq_i k, \forall k \cap i : \exists k | j \not\succeq^{(0)}_i k\}$

Policy decomposition: (0) No intervention



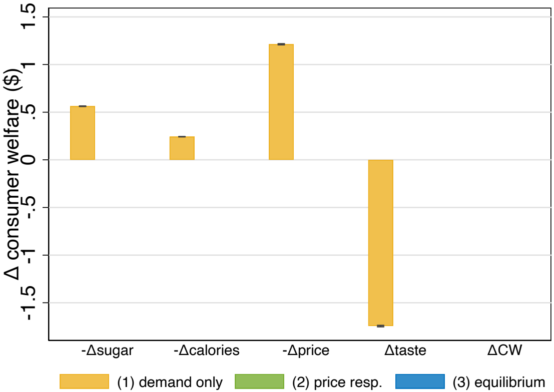
Policy decomposition: (1) Demand only

- Consumers substitute towards healthier products



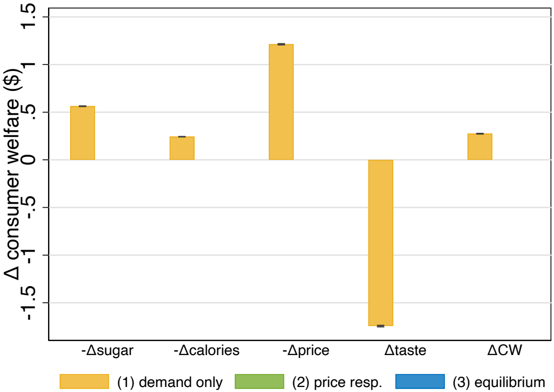
Policy decomposition: (1) Demand only

- Healthier products are cheaper and of lower taste



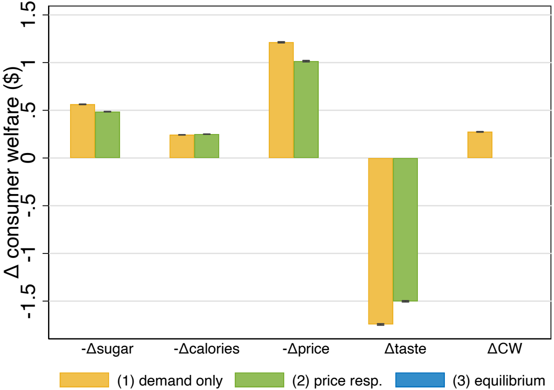
Policy decomposition: (1) Demand only

- Net increase in consumer welfare of 1.1% of total expenditure



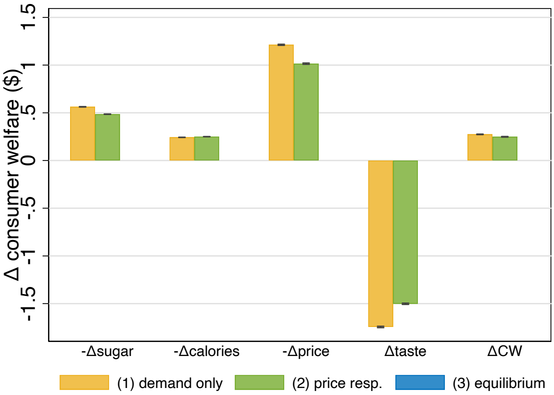
Policy decomposition: (2) Price response

- Firms respond by increasing (decreasing) prices of unlabeled (labeled) products



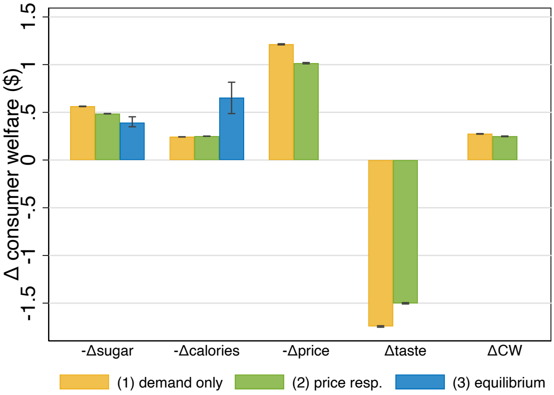
Policy decomposition: (2) Price response

- Gains in consumer welfare are lower with respect to (1)



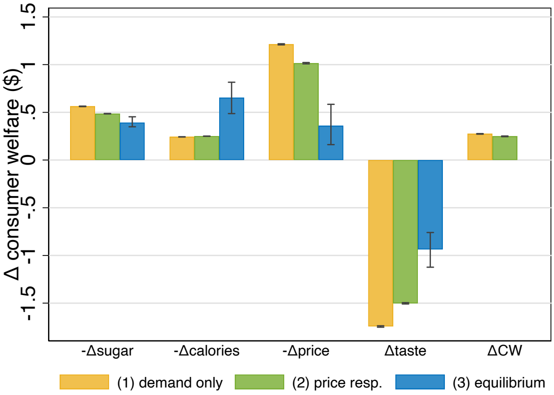
Policy decomposition: (3) Equilibrium

- Firms respond by reducing the concentration of regulated nutrients



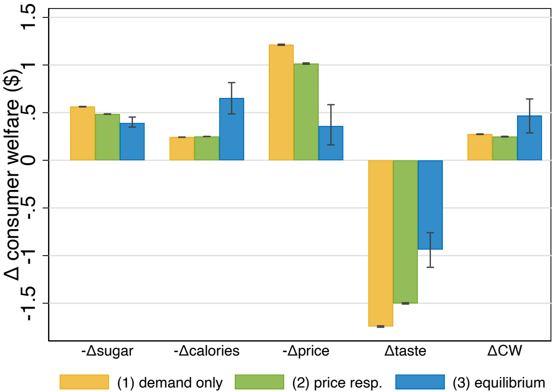
Policy decomposition: (3) Equilibrium

- Reformulation comes with higher production costs that translate to higher prices



Policy decomposition: (3) Equilibrium

- Gains in consumer welfare are 70% larger than in (1)



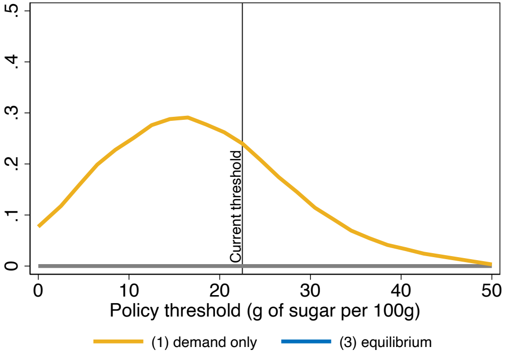
Policy counterfactuals

- We then use the model to:
  - Study optimal policy design by varying the regulatory thresholds
  - Compare food labels to sugar taxes

- We focus on the case where calorie content is perfectly observed and only sugar content is regulated

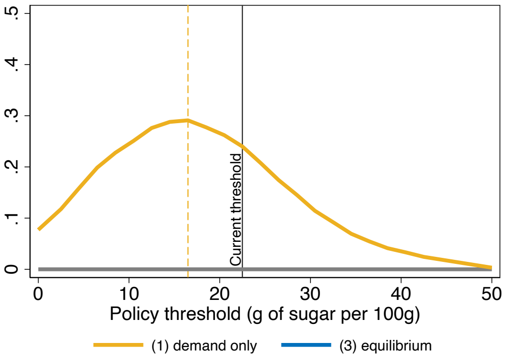
Policy counterfactuals: Optimal threshold

- Optimal threshold without supplier responses: maximize labels informativeness
- Taking supply responses into account: optimal threshold pushed to the left



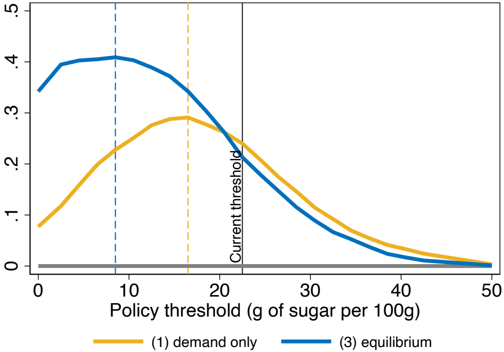
Policy counterfactuals: Optimal threshold

- Optimal threshold without supplier responses: maximize labels informativeness
- Taking supply responses into account: optimal threshold pushed to the left



Policy counterfactuals: Optimal threshold

- Optimal threshold without supplier responses: maximize labels informativeness
- Taking supply responses into account: optimal threshold pushed to the left



Policy counterfactuals: Sugar tax

- We compare the food labeling policy to alternative sugar taxes

- Firm's problem is now given by:

$$\max_{\{p_{jt}, w_{jt}\}_{j \in \Im_j}} \sum_{j \in \Im_j} (p_{jt} - c_{jt}(w_{jt}) - \tau w_{jt}) \cdot s_{jt}(\mathbf{p_t}, \mathbb{E}[\mathbf{w_t}])$$

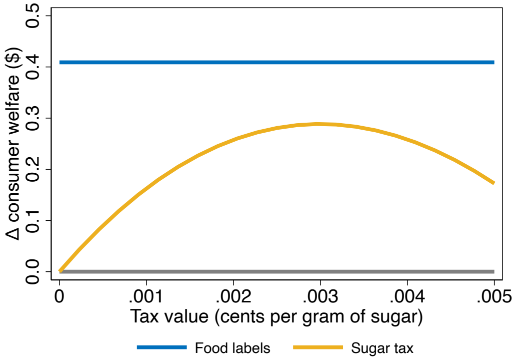
- From the first order conditions, we have:

$$\begin{aligned} w_{jt}^* &= \nu_j - (2\Lambda)^{-1}\tau \\ p_{jt}^* &= c_{jt}(w_{jt}^*) + \tau w_{jt}^* + \Delta_{(j,\cdot)}^{-1}\mathbf{s_t} \end{aligned}$$

- We denote by ψ the marginal value of public funds, and assume $\psi = 1$.

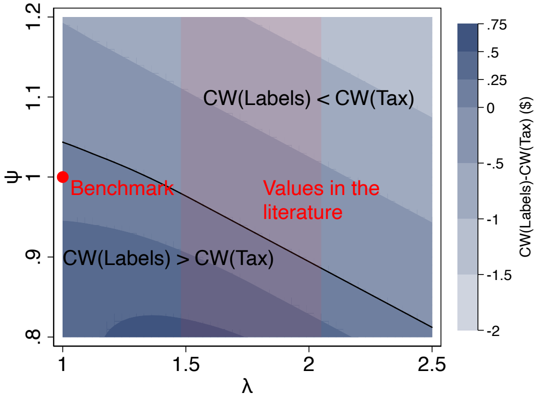
Policy counterfactuals: Sugar tax

- Soda sugar taxes in the US are equivalent to 0.3¢ per gram of sugar



Policy counterfactuals: Comparative statics

- The effectiveness of food labels and sugar taxes depend on
  - The presence of non-informational market imperfections (λ)
  - The marginal value of public funds (ψ)



Policy counterfactuals: Distributional consequences

- The progressivity of a policy depends on how the **benefits** and the **costs** vary across the income distribution

- Two key parameters:
  - **Sugar-income gradient**: when low-SES consumers prefer sugary products more, they are charged disproportionately higher taxes
  - **Misinformation-income gradient**: when low-SES consumers are more misinformed, the effects of food labels are better targeted towards them

- Food labels present distributional advantages when these gradients are positive

Sugar-income gradient Misinformation-income gradient

Beyond Cereal

- Our model sheds light on the effects of food labels on other categories
- Determinants of demand-side response:
  - Close substitutes goods $(+)$
  - Informativeness of labels $(+)$
- Determinants of supply-side response:
  - Expected demand-side responses $(+)$
  - Distance to policy threshold $(-)$
  - Cost of reformulation $(-)$
- We zoom out to other product categories to test these hypotheses
  - Soft drinks vs. cereal
  - Liquids vs. solids

Soft drinks vs cereal Liquids vs solids

Concluding remarks

1. Food labels can be an **effective** way to improve diet quality and combat obesity

2. **Equilibrium forces** are important
   - Price responses can undermine/augment the benefits
   - Reformulation increases healthiness at the expense of higher prices

3. Compared to sugar taxes, labels present **advantages** and **disadvantages**
   - More progessive and better targeted
   - Less effective against non-informational market imperfections

4. We should see more food labeling policies implemented in the future

Appendix: Regulatory thresholds

- The regulation is gradually tightened in three phases: June 2016, June 2018, June 2019

	Solids			Liquids		
Stage	S_1	S_2	S_3	S_1	S_2	S_3
Energy (kcal/100g)	350	300	275	100	80	70
Sodium (mg/100g)	800	500	400	100	100	100
Total Sugars (g/100g)	22.5	15	10	6	5	5
Saturated fats (g/100g)	6	5	4	3	3	3

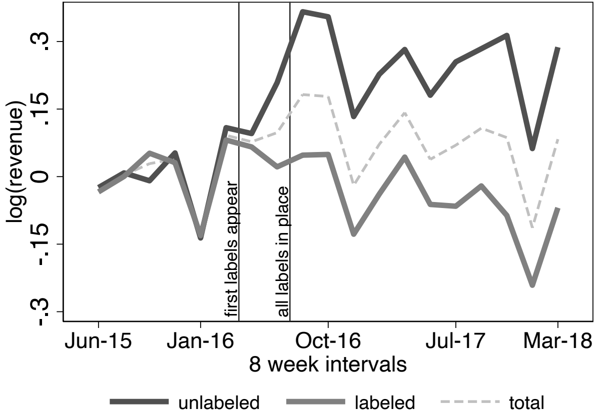
- Some examples as reference:

per 100 gr	Energy (kcal)	Sodium (mg)	Sugar (gr)	Fat (gr)	# of labels
Frosted Flakes	369	468	35	0.5	2
Cheetos	468	904	0.8	4.8	2
Snickers	488	189	47	13	3
Coca-Cola	44	10	10.5	0	1

back

Appendix: Change in total revenue

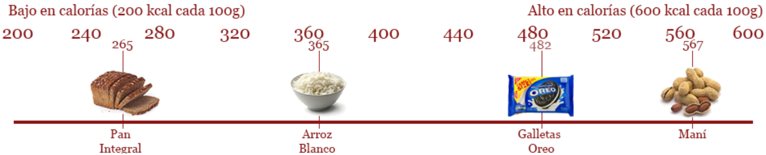
- Large substitution from labeled to unlabeled cereals



back

Appendix: Beliefs Survey

- We asked consumers to insert cereal products between these reference products:
  - Calories:

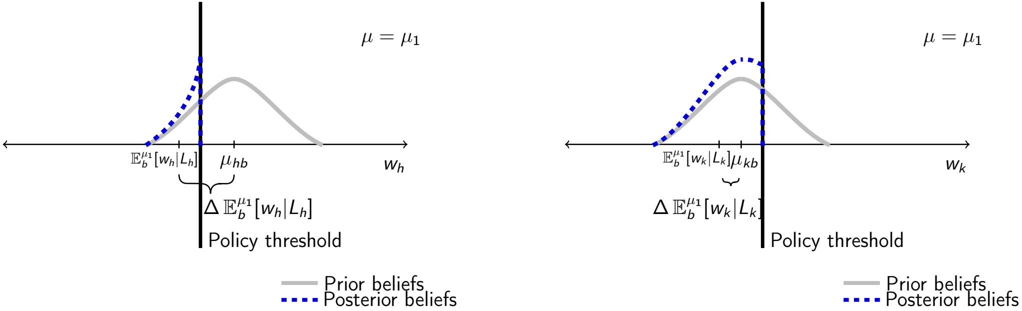


  - Sugar:

back

Appendix: Identification of μ_{jb}

- Change in beliefs when $\mu = \mu_1$



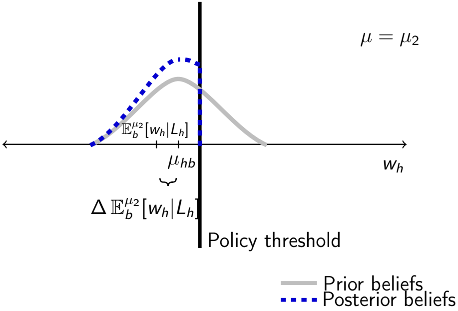
(a) Change in beliefs for product h

(b) Change in beliefs for product k

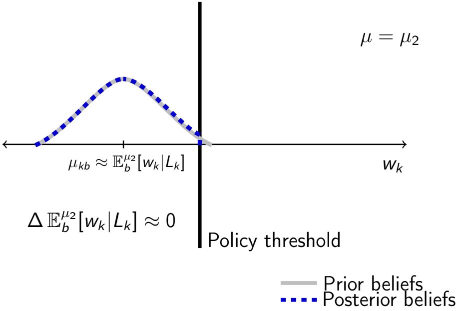
back

Appendix: Identification of μ_{jb}

- Change in beliefs when $\mu = \mu_2 < \mu_1$



(a) Change in beliefs for product h

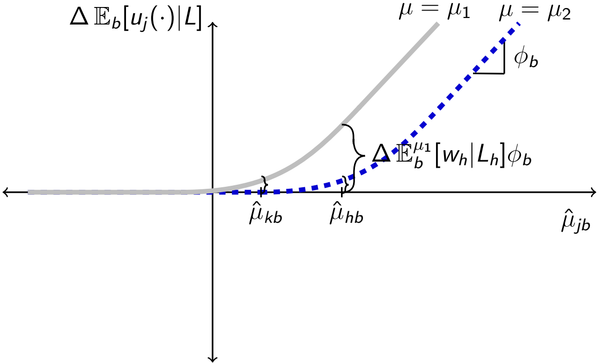


(b) Change in beliefs for product k

back

Appendix: Identification of μ_{jb}

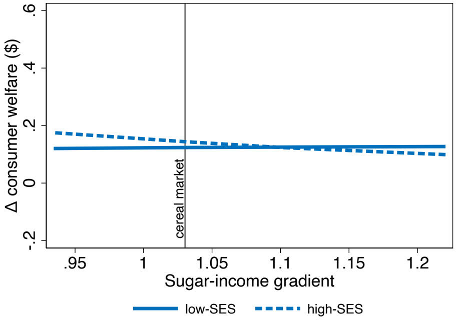
- Model gives different predictions for different values of μ:



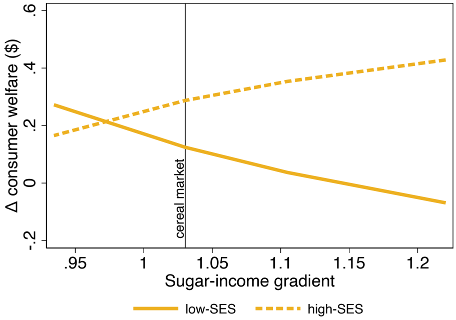
back

Appendix: Sugar-income gradient

- If low-SES consumers prefer high-in-sugar products more, taxes will disproportionally charge them more



(a) Food labels

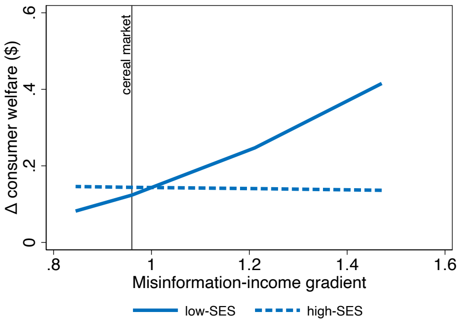


(b) Sugar taxes

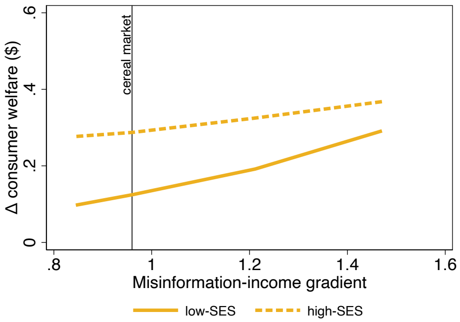
back

Appendix: Misinformation-income gradient

- If low-SES consumers are less informed, food labels will be better targeted



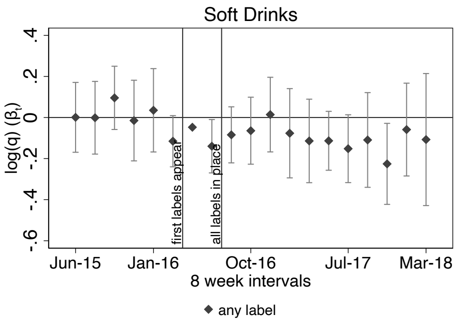
(a) Food labels



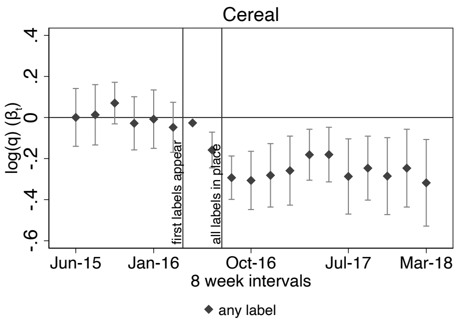
(b) Sugar taxes

back

Appendix: Soft drinks vs. cereal



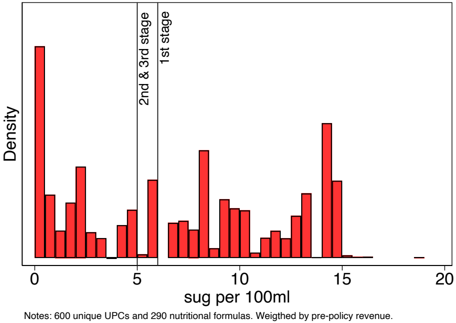
(a) Soft drinks



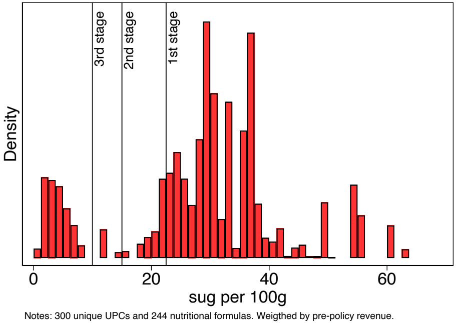
(b) Cereal

back

Appendix: Liquids vs. solids



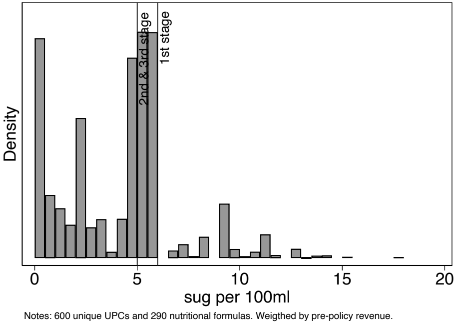
(a) Juice (2016)



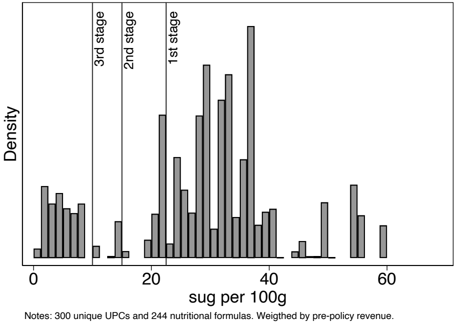
(b) Cookies (2016)

back

Appendix: Liquids vs. solids



(a) Juice (2018)



(b) Cookies (2018)

back