Sugar-based tax design for healthier consumption:
Empirical evidence in the French Dessert market

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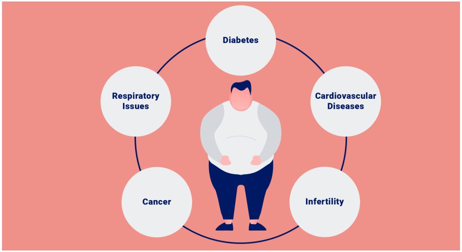
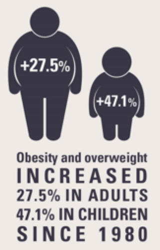
PARIS-SACLAY APPLIED ECONOMICS

Context: obesity and Public policy





- The prevalence of overweight and obesity has increased worldwide.
- The fundamental cause of overweight and obesity is an imbalance between energy intake and energy expenditure. A major driver of a positive energy balance is an unhealthy dietary pattern with excess consumption of energy-dense.

Context: obesity and Public policy

- Strong evidences of the large effects of tax on purchases of targeted beverage
- Modest impact on food choices generated by other implemented policies:
  - Informational campaign
  - food labelling
  - voluntary agreements
- Also effective in reducing purchases of targeted foods high in salt, sugars and fat, but less widely implemented (only 12 countries worldwide in 2020)

"There is need for a broader adoption of taxation on unhealthy foods" (WHO, 2015, 2022)

Context: Regulatory measure evaluation

- Deep analysis on the SSB market
  - Largely implemented worldwide and particularly in Europe. Implementation of SSB taxes
  - Sugar content instead of volume (Allcott et al, 2019), (Scarborough, 2020), (STOP WHO, 2022)
  - Tiered tax more effficient to reduce sugar content (Scarborough, 2020)
- Other market have less scientific evidences
  - less implementation
  - (Barahona et al. 2023) study the implementation of a mandatory label in Chile on the breakfast cereal market

Objectives

- How are excise sugar-based tax with tier design effective, when firms reformulate their products in order to avoid or limit the tax?
    - How tiers level affect sugar consumption, consumer surplus, profit and prices?
    - How are different households affected differently?
    - How reformulation and price strategies complement each other?

-> An empirical application on the french dessert market

French dessert market

- Second contributor of simple carbohydrate intakes for children (behind cake, biscuits and pastries, Anses 2017)
- Purchases: 46kg/person/year in 2009 (only 6kg without added sugar)
- Heterogeneity in added sugar content: room for reformulation

Data

- French representative consumer panel data of 20,144 households in January – May 2009 (KANTAR WorldPanel)
- 1,600,000 purchases of dessert
- Information: prices, quantity, brand, product characteristics
- We consider 131 differentiated products according to the brand, fat and sugar content, fruit and flavor content + 1 outside option
- Other substitutes: Fruits and pastries, cheese

Methodology

- 1 - Demand model: a random coefficient logit model
  - Preferences of consumers
- 2 - Supply model: oligopolistic competition between firms
  - Pricing strategy, marginal costs of products
- 3 - Reformulation model
  - Assumption: new recipes reducing the added sugar content considering technical constraints (texture, sweetness, quantity, fermentation, gelation, regulatory)
- 4 - Counterfactual experiments: taxation (€0.20/100g of sugar if above of the threshold) and/or reformulation for several threshold
  - Effect on cost, prices, consumption and profits

Demand for french dessert market

- Indirect utility function of individual i when buying good j:

$$V_{ijt} = \delta_{ijt} - \alpha_i p_{jt} + \varepsilon_{ijt}$$

Where,

  - δ_{ijt} is observed by both consumer and econometrician Specification
  - $\alpha_i = \exp(\alpha + \alpha^c C_i + \alpha^o O_i + \alpha^I I_i + \sigma \nu_i)$: disutility from paying price pj
  - $\nu_i \sim \mathcal{N}(0,1)$ captures unobserved consumer attributes
  - ε_{ijt} i.i.d. as an extreme value type I distribution Endogeneity

- Following (Nevo, 2001), the market share of product j at period t,

$$s_{jt}(\theta) = \int \frac{\exp(\delta_{ijt} - \alpha_i p_{jt})}{1 + \sum_{k=1}^{J_t} \exp(\delta_{ikt} - \alpha_i p_{kt})} \, dP_\nu(\nu_i) dP_D(D_i)$$

Estimate marginal cost

- F firms compete in prices
- Firms solve the profit maximization problem:

$$\Pi_{ft} = \sum_{j \in G_{ft}} [M_t(p_{jt} - c_{jt})s_{jt}(p)]$$

where

- G_{ft} : set of products sold by firm f at period t
- M_t : size of the market at period t
- c_{jt} : constant marginal cost to produce and sell product j at period t
- $s_{jt}(p)$: market share of product j at period t given the vector of product price

- From the FOC, we get estimates of margins and marginal costs for each product j at period t

$$\gamma_{jt} = p_{jt} - c_{jt} = f(p, I_{1t}, \ldots, I_{Ft}/\hat{\theta})$$

Product reformulation and cost implication

Prior the implementation of a tax:

- Nutritional information provided by the French Food Observatory (OQALI)
- Recipes are determined using the ingredient lists and nutrition facts
- Minimum amount of added sugar calculated subject to technical constraints of formulation (texture, fermentation, and gelation process, ... more)

Firms reformulate to avoid the tax or at minimum to mitigate

- $\Delta cc_j = \rho_S \Delta Q_{Sugar,j} + \rho_Y \Delta Q_{Yogurt,j} + \rho_{FBPS} \Delta Q_{FBPS,j} + \rho_F \Delta Q_{Fruit,j}$

Counterfactual experiments: 3 policy scenario

Firms solve the new profit maximization problem under tax τ_j:

$$\forall f \in F, \max_{\{p_{kt}\}_{k \in G_f}} \sum_{j \in G_f} (p_{jt} - \tilde{c}_{jt}) M_t \tilde{s}_{jt}(p/\hat{\theta})$$

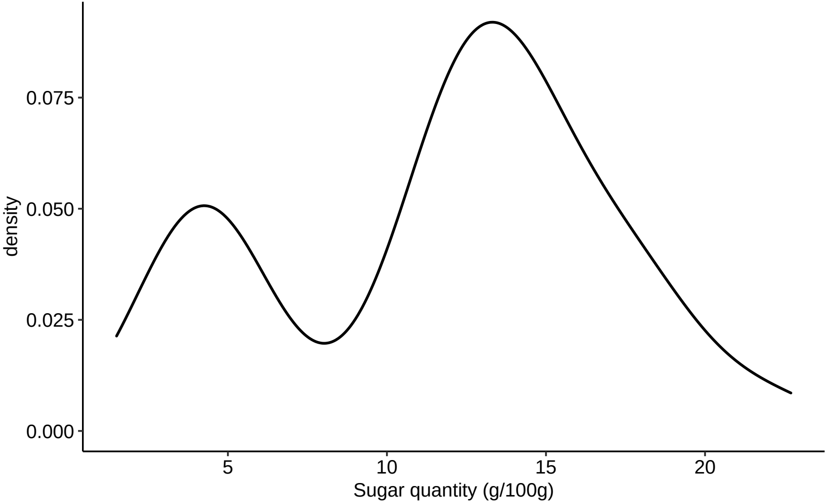
$\tilde{c}_{jt}$ the new marginal cost

- Taxation only : $\tilde{c}_{jt} = c_{jt} + \tau_j$
- Reformulation only : $\tilde{c}_{jt} = c_{jt} + \Delta cc_j$
- Taxation with reformulation: $\tilde{c}_{jt} = c_{jt} + \tau_j + \Delta cc_j$

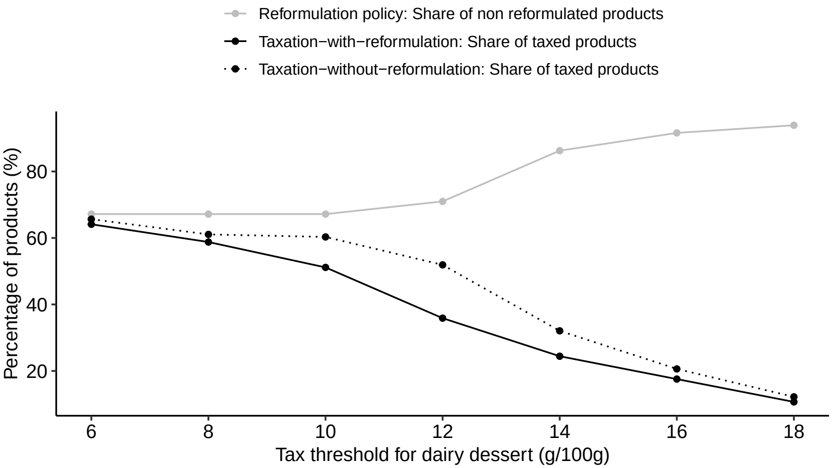
$\tilde{s_{jt}}(p/\hat{\theta})$ taking into account exogenous change in product characteristics

- Without reformulation: $\tilde{s_{jt}}(p/\hat{\theta}) = s_{jt}(p/\hat{\theta})$
- With reformulation: $\tilde{s_{jt}}(p/\hat{\theta}) = s_{jt}(p, \Delta Sugar, \Delta Lipids/\hat{\theta})$

Distribution of sugar in the dessert market



Magnitude of the tax implementation



How are excise sugar-based tax with tier design effective?

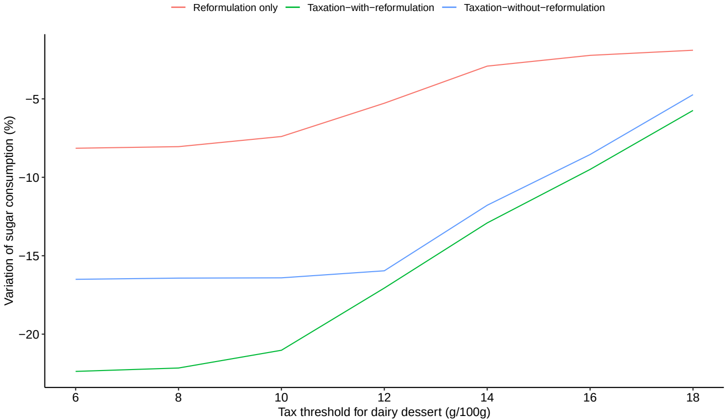


Figure: Changes in sugar consumption with respect to dairy dessert tax threshold for the three policy scenarios.

Firms are better of reformulating

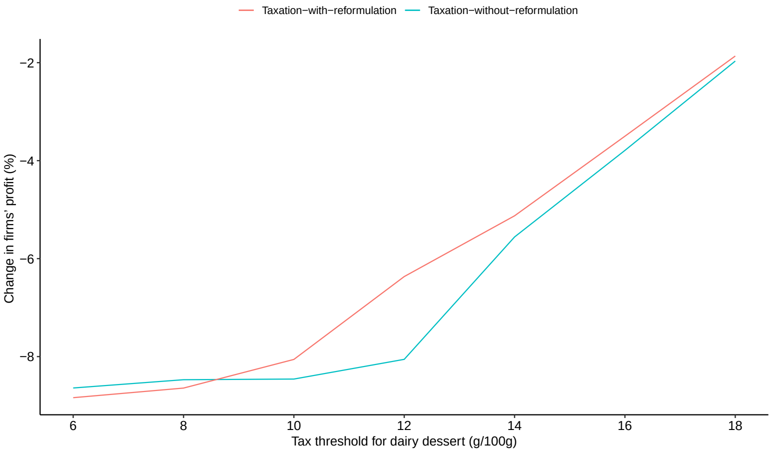


Figure: Variation in firms' profits with respect to dairy dessert tax threshold (set at 12g/100g for compotes) for the three policy scenarios.

On our application to the french dessert market

- Importance of the choice of the level of the sugar tax threshold
  - affects the share of taxed and reformulated products
  - impact the magnitude of tax-related price increase
  - strongly affects the magnitude of welfare effects
- Excise sugar-based tax are even more effective when firms reformulate
  - Few mechanical substitution toward lipids
  - Firms lose less profits
  - More impact on sugar intakes
  - Less elastic consumers will still be impact by reformulation

-> Setting the tax threshold based on the sugar content distribution is key

Reformulation and price strategies complement each other

Table: **Impact of alternative modelling assumptions on the nutrient intake from the four product categories**

	Strategic pricing no reformulation	Strategic pricing reformulation
Δ sugar	-16.4%	-21.1%
Δ lipid	-12.9%	-12.4%
Δ calorie	-14.1%	-15.9%

Well designed to target specifically population at risk

Table: **Taxation with product reformulation: Percent change in calories, lipid, and sugar intake**

Households		**Adults obese**		
	All	**None**	**One**	**All**
Sugar	-21.07	-21.00	-21.01	-21.28
	(-831)	(-830)	(-747)	(-988)
Lipid	-12.40	-12.37	-12.31	-12.59
	(-138)	(-137)	(-124)	(-164)
Calorie	-15.89	-15.84	-15.81	-16.09
	(-5252)	(-5240)	(-4722)	(-6246)

The percentage change in nutrient intakes is calculated over the initial intakes of the market under consideration. The corresponding intakes in grams/calorie per capita per year are in brackets.

Demand specification

$$\delta_{ijt} = \beta_{b(j)} + \gamma_{c(j)} + \delta_{Si} S_j + \delta_{Li} L_j + \delta_{SL} S_j L_j + \theta_N N_j + \theta_F F_j$$

- $\beta_{b(j)}$ and $\gamma_{c(j)}$ respectively brand and dessert category fixed effect
- N_j and F_j dummy related to nature flavor and presence of fruits
- θ_N and θ_F captures consumer taste for these characteristics
- $\delta_{SL} S_j L_j$ captures consumer preference for sugar and fat taste, S_j and L_j

We also allow sugar and fat tastes to vary across households characteristics,

$$\delta_{Si} S_j = \delta_S S_j + \delta_S^c S_j C_i + \delta_S^o S_j O_i \text{ and, } \delta_{Li} L_j = \delta_L L_j + \delta_L^c L_j C_i + \delta_L^o L_j O_i$$

- Ci and Oi the presence of children or obese individuals in the household
- δ_S^c and δ_L^c allow the marginal effects of sugar and fat taste to shift with the presence of children
- δ_S^o and δ_L^o with the number of obese individuals within the household.

back to Demand

Endogeneity of price

We use a control function approach (Petrin and Train, 2010)
Decomposition of the error term, $\varepsilon_{ijt} = \xi_{jt} + e_{ijt}$

- ξ_{jt} a product-specific error term varying across periods
- e_{ijt} an individual-specific error term

First we regress, $p_{jt} = W_{jt}\gamma + X_{jt}\mu + \eta_{jt}$

- X_{jt} included instruments
- W_{jt} a vector of excluded instruments (distance to competing products,...) Exogeneity of this BLP-type instrument rests on the common assumption that product characteristics are uncorrelated with ξ_{jt} (Berry, Levinsohn and Pakes, 1995) and some input cost (Here the exogeneity relies on the assumption that the french dessert industry represents only a small share of the world demand)

then, $$s_{jt}(\theta) = \int \frac{\exp(\delta_{ijt} - \alpha_i p_{jt} + \lambda\hat{\eta}_{jt})}{1 + \sum_{k=1}^{J_t} \exp(\delta_{ikt} - \alpha_i p_{kt} + \lambda\hat{\eta}_{kt})} \, dP_\nu(\nu_i) dP_D(D_i)$$

where λ is a parameter capturing the mean utility generated by unobserved product attributes that are correlated with retail prices

back to Demand

OQALI

Recipe assessment using Oqali dataset

- 476 marketed yogurts
- 183 FBPS
- 408 compotes and fruit purees.

To simplify, we considered that each recipe consists of three main ingredients:

- The sweetening ingredients
- A matrix ingredient (plain yogurt for yogurts, plain fromages blancs or petits suisses for FBPS and fruit puree for compotes)
- A fixed ingredient for which quantity remains constant when reformulating

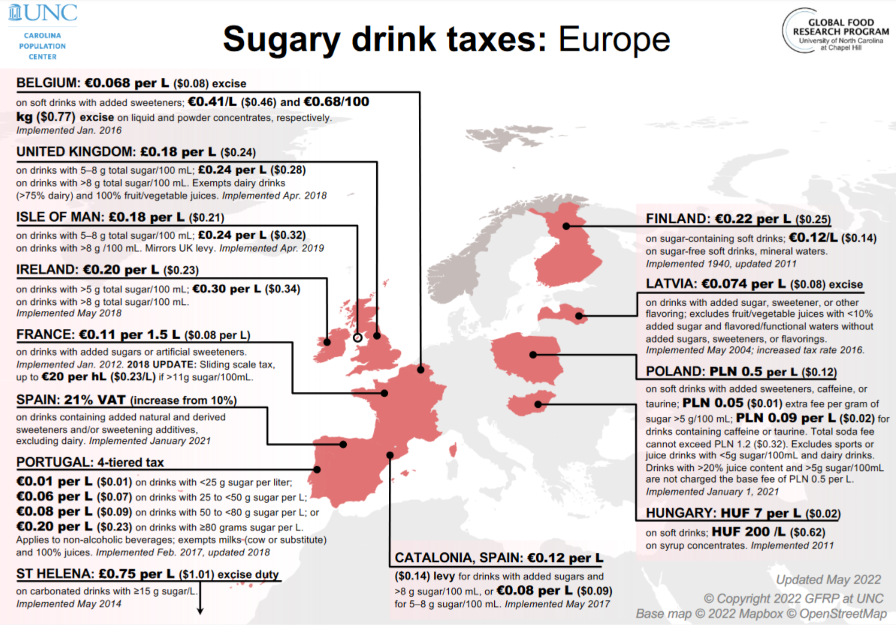
-> Computation of the minimum amount of added sugar for 18 recipes: Such as sweet yogurt with skimmed, semi-skimmed, or whole milk,fruit petits suisses with semi-skimmed, or whole milk, compotes, diet compotes ,...

back to Reformulation

Table: **Technical constraints of formulation**

Constraint	Description	Mathematical transcription
Texture	In order to obtain a satisfying texture, the dry extract of the product has to be in a certain scale of values	$B^- \leq \frac{(B_m * y_m + B_s * y_s)}{(y_m + y_s)} \leq B^+$ where B_i is the dry extract of ingredient i
Sweetness	In order to obtain a satisfying taste, the sweetness of the product has to be in a certain scale of values	$S^- \leq \frac{(S_m * y_m + S_s * y_s)}{(y_m + y_s)} \leq S^+$ where S_i is the sweetening power of ingredient i
Quantity	The sum of the proportions of each ingredient must be equal to 100%	$y_m + y_s + y_f = 100\%$
Fermentation	Sweetening ingredients, in too high proportion, can inhibit the growth of bacteria, and thus the fermentation process	$\frac{B_s * y_s}{(y_m + y_s)} \leq F^+$ where B_s is the dry extract of the sweetening ingredient
Gelation	Sweetening ingredients, in too high proportion, can dilute milk proteins and thus hinder the gelation process	$\frac{y_m * Prot_m}{(y_m + y_s)} \geq G^+$ where $Prot_m$ is the protein content of matrix ingredient
Regulatory	According to French regulations, fermented milks (such as yogurts) may be supplemented with ingredients (sugar, flavorings, fruit preparations, additives) to give it a specific flavor, provided that this addition does not exceed 30% of the weight of the finished product	$y_s + y_f \leq 30\%$

Reformulation



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