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

Maxime Tranchard

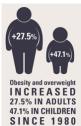
Université Paris-Saclay, INRAE, AgroParisTech

presenting on behalf of co-authors Olivier Allais (INRAE), Céline Bonnet (TSE), Vincent Requillart (TSE) and Marine Spiteri (TSE)



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,

- ullet 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
- \bullet 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_{it} : 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

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



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, ...

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_i :

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

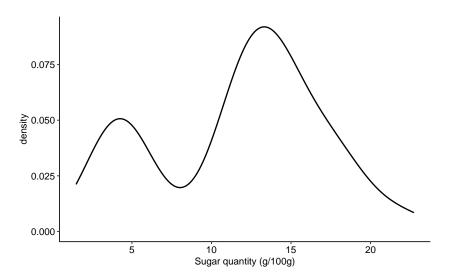
 \tilde{c}_{it} the new marginal cost

- Taxation only : $\tilde{c}_{it} = c_{it} + \tau_i$
- Reformulation only : $\tilde{c}_{it} = c_{it} + \Delta cc_i$
- Taxation with reformulation: $\tilde{c}_{it} = c_{it} + \tau_i + \Delta cc_i$

 $ilde{s_{it}}(p/\hat{ heta})$ taking into account exogenous change in product characteristics

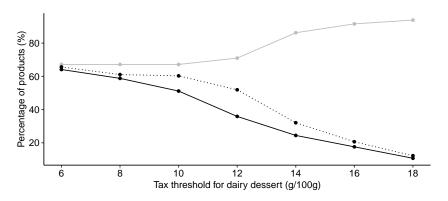
- Without reformulation: $\tilde{s_{it}}(p/\hat{\theta}) = s_{it}(p/\hat{\theta})$
- With reformulation: $\tilde{s_{it}}(p/\hat{\theta}) = s_{it}(p, \Delta Sugar, \Delta Lipids/\hat{\theta})$

Distribution of sugar in the dessert market



Magnitude of the tax implementation

- Reformulation policy: Share of non reformulated products
- Taxation-with-reformulation: Share of taxed products
- · · Taxation-without-reformulation: Share of taxed products



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

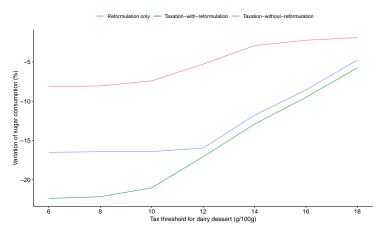


Figure: Changes in sugar consumption with respect to dairy dessert tax threshold for the three policy scenarios.

Firms are better of reformulating

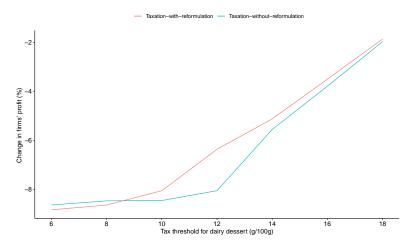


Figure: Variation in firms' profits with respect to dairy dessert tax threshold (set at 12g/100g for compotes) for the three policy scenarios.

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	Strategic pricing	
	no reformulation	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

$$\delta_{ijt} = \beta_{b(j)} + \gamma_{c(j)} + \delta_{Si}S_j + \delta_{Li}L_j + \delta_{SL}S_jL_j + \theta_NN_j + \theta_FF_j$$

- \bullet $\beta_{b(j)}$ and $\gamma_{c(j)}$ respectively brand and dessert category fixed effect
- \bullet N_j and F_j dummy related to nature flavor and presence of fruits
- ullet $heta_N$ and $heta_F$ captures consumer taste for these characteristics
- ullet $\delta_{SL}S_jL_j$ 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,

$$\delta_{Si}S_j = \delta_SS_j + \delta_S^cS_jC_i + \delta_S^oS_jO_i \text{ and, } \delta_{Li}L_j = \delta_LL_j + \delta_L^cL_jC_i + \delta_L^oL_jO_i$$

- ullet Ci and Ci the presence of children or obese individuals in the household
- \bullet δ^c_S and δ^c_L allow the marginal effects of sugar and fat taste to shift with the presence of children
- \bullet δ^o_S and δ^o_L 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, $\varepsilon_{ijt}=\xi_{jt}+\,e_{ijt}$

- \bullet ξ_{jt} a product-specific error term varying across periods
- ullet 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 $\frac{1}{2}$

Maxime Tranchard (PSAE) EARIE Version Rome, 2023

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	$B^- \leq rac{(B_m*y_m+B_s*y_s)}{(y_m+y_s)} \leq B^+$ 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	$\frac{B_{S}*y_{S}}{(ym+y_{S})} \leq F^{+}$ 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	$y_S + y_f \le 30\%$

Reformulation



Sugary drink taxes: Europe



BELGIUM: €0.068 per L (\$0.08) excise

on soft drinks with added sweeteners; €0.41/L (\$0.46) and €0.68/100 kg (\$0.77) excise on liquid and powder concentrates, respectively.

Implemented Jan. 2016

UNITED KINGDOM: £0.18 per L (\$0.24)

on drinks with 5-8 g total sugar/100 mL; £0.24 per L (\$0.28) on drinks with >8 g total sugar/100 mL. Exempts dairy drinks (>75% dairy) and 100% fruit/vegetable juices. Implemented Apr. 2018.

ISLE OF MAN: £0.18 per L (\$0.21)

on drinks with 5-8 g total sugar/100 mL; £0.24 per L (\$0.32) on drinks with >8 g /100 mL. Mirrors UK levy. Implemented Apr. 2019

IRELAND: €0.20 per L (\$0.23)

on drinks with >5 a total sugar/100 mL: €0.30 per L (\$0.34) on drinks with >8 g total sugar/100 mL. Implemented May 2018

FRANCE: €0.11 per 1.5 L (\$0.08 per L)

on drinks with added sugars or artificial sweeteners. Implemented Jan. 2012. 2018 UPDATE: Sliding scale tax. up to €20 per hL (\$0.23/L) if >11g sugar/100mL.

SPAIN: 21% VAT (increase from 10%)

on drinks containing added natural and derived sweeteners and/or sweetening additives, excluding dairy. Implemented January 2021

PORTUGAL: 4-tiered tax

€0.01 per L (\$0.01) on drinks with <25 g sugar per liter:

€0.06 per L (\$0.07) on drinks with 25 to <50 g sugar per L;

€0.08 per L (\$0.09) on drinks with 50 to <80 g sugar per L; or

€0.20 per L (\$0.23) on drinks with ≥80 grams sugar per L. Applies to non-alcoholic beverages; exempts milks-(cow or substitute) and 100% juices, Implemented Feb. 2017, updated 2018

ST HELENA: £0.75 per L (\$1.01) excise duty

on carbonated drinks with ≥15 g sugar/L

FINLAND: €0.22 per L (\$0.25)

on sugar-containing soft drinks: €0.12/L (\$0.14) on sugar-free soft drinks, mineral waters. Implemented 1940, undated 2011

LATVIA: €0.074 per L (\$0.08) excise

on drinks with added sugar, sweetener, or other flavoring; excludes fruit/vegetable juices with <10% added sugar and flavored/functional waters without added sugars, sweeteners, or flavorings, Implemented May 2004; increased tax rate 2016.

POLAND: PLN 0.5 per L (\$0.12)

on soft drinks with added sweeteners, caffeine, or taurine; PLN 0.05 (\$0.01) extra fee per gram of sugar >5 g/100 mL: PLN 0.09 per L (\$0.02) for drinks containing caffeine or taurine. Total soda fee

cannot exceed PLN 1.2 (\$0.32). Excludes sports or juice drinks with <5g sugar/100mL and dairy drinks. Drinks with >20% juice content and >5g sugar/100mL are not charged the base fee of PLN 0.5 per L. Implemented January 1, 2021

HUNGARY: HUF 7 per L (\$0.02)

on soft drinks: HUF 200 /L (\$0.62) on syrup concentrates. Implemented 2011

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Implemented May 2014

CATALONIA, SPAIN: €0.12 per L

(\$0.14) levy for drinks with added sugars and

>8 g sugar/100 mL, or €0.08 per L (\$0.09)

for 5-8 g sugar/100 mL. Implemented May 2017