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

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**Abstract**

Many countries have implemented fiscal policies to promote healthier diets. However, policymakers still have little guidance on how to design taxes. The main objective of this paper is to investigate the impact of the tax threshold in a sugar-based tax on welfare when firms engage or not in product reformulation. We develop a structural econometric model that incorporates consumers' substitution patterns and firms' price competition. Using household scanner data from the French dessert market, we show that the choice of the tax threshold strongly affects the share of taxed and reformulated products, the magnitude of the price increase, and welfare effects: the lower the tax threshold, the lower sugar consumption reduction, but the greater the reduction in consumer surplus and firms profit. Moreover, a tiered sugar-based tax reduces more sugar consumption when firms reformulate and allows for better targeting of the at-risk population.

**JEL codes**: H32, L13, Q18, I18

**Key words: Excise sugar tax, tax threshold, strategic pricing, product reformulation**

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# 1 Introduction

Noncommunicable diseases (NCDs) were responsible for 74% of all deaths worldwide in 2019 (Institute for Health Metrics and Evaluation (IHME), 2020). The Global Action Plan (GAP) for the Prevention and Control of NCDs 2013-2020 provides a roadmap and menu of policy options to reduce mortality from NCDs and exposure to risk factors (World Health Organization et al., 2013). One of the policy options proposed is the use of economic instruments, including fiscal policy, to both discourage the consumption of less healthy foods and promote a healthier food environment. To illustrate, the World Health Organisation has recommended taxes on sugar-sweetened beverages (SSBs) as an effective intervention that can achieve both goals, particularly by encouraging SSB reformulation (World Health Organization and others, 2017). They were enacted in 38% of countries worldwide in 2019 (World Health Organization et al., 2022). A systematic review shows that SSB taxes have actually been effective in reducing purchases of the targeted SSBs by an average of -15% through price increases (Andreyeva et al., 2022). There is also evidence of beverage reformulation and reduction in sugar content when the tax design enacted is an excise tax with thresholds (Andreyeva et al., 2022). Food taxes are less widely implemented, but adoption is increasing, from seven member States of WHO in 2017 to 29 in 2022 (World Health Organization et al., 2022). They have also shown promise in reducing purchases of targeted foods, as observed in Mexico and Hungary.[1] However, due to the narrow scope of the existing taxes, their impact on overall dietary intake is correspondingly small (World Health Organization et al., 2022). Accordingly, health authorities are considering extending them to more unhealthy foods (World Health Organization et al., 2016; Department for Environment, Food and Rural Affairs, 2020; Hepatology, 2020).

To ensure their effectiveness in promoting healthy diets, both by reducing purchases of the targeted products and encouraging product reformulation, the elements of the tax should be carefully designed (i.e. the coverage of food and beverage taxed, the type and structure of tax, and the tax rate). However, little is known about the potential effects of different designs of a tax on unhealthy products on consumers' purchases, nutrient consumption and welfare, firms' strategic decisions and profits. The main objective of this study is to fill this knowledge gap for

[1] In Mexico, non-essential foods with an energy density greater than 275 kcal/100 g are taxed (World Cancer Research Fund International, 2022). The Hungarian "Public Health Product Tax" targets products high in sugar, salt and/or caffeine (Bíró, 2015; World Cancer Research Fund International, 2022).

an excise tax with a single threshold based on a nutrient content of the product above which it is taxed. Specifically, we analyse how and to what extent the level of nutrient tax threshold alters equilibrium market outcomes, nutrient consumption and consumer surplus, and secondly, how these outcomes are heterogeneously affected across firms and consumer types, when firms do or do not reformulate.

Although there is growing scientific evidence that an excise tax based on the nutrient content would have more health benefits than other types of taxes, such as sales taxes, VAT and excise taxes based on the volume of products (Allcott et al., 2019; Grummon et al., 2019), research on the influence of tax structure, in particular tax threshold effects, on purchases and health remains limited. However, setting the tax threshold is a key element of the tax design. It affects not only the set of taxed and untaxed products and so competition, prices and the effectiveness of the tax in reducing purchases, but also the decision of firms to reformulate products. Duvaleix-Tréguer et al. (2012) and Réquillart et al. (2016) show theoretically that a firm prefers reformulating its product to avoid such a tax, provided that the threshold is not too low, leading to positive health and welfare outcomes. Several empirical studies also show that the tax thresholds of the Soft Drinks Industry Levy (SDIL) influence the extent of sugar reduction in SSBs: firms tend to reduce the amount of added sugar to bring the sugar content just below the tax thresholds (Scarborough et al., 2020; Pell et al., 2021; Allais et al., 2023). This firms' strategic reaction of bunching at the threshold to avoid the tax was also found for warning label policy in Chile (Barahona et al., 2023). Moreover, analyzing the heterogeneity of the effects of the tax across firms and type of households is also crucial. In this paper, we propose to investigate the mechanisms that explain why a company suffers or benefits from the tax, and whether the tax is well targeted at high-risk populations. This analysis can thus provide important guidance to policy makers seeking to develop effective fiscal policies to promote healthier diets and food environment.

We focus our analysis on a sugar tax on the dessert market, i.e. compotes, yogurts, fromages blancs/petits suisses (FBPS) and other dairy desserts (ODD). [2] Desserts are important contributors to simple carbohydrate intake. In particular, yogurts and FBPS are the second largest contributors to the sugar intake of French children aged between 1 and 10 years in 2014-2015 (Agence nationale de sécurité sanitaire de l'alimentation, 2017). Desserts are well suited for this analysis because there is room for product reformulation, as there is great heterogeneity in

[2]We have decided to tax sugar. Taxing fat in desserts would have been another option. However, fat comes mainly from milk, the basic ingredient in yogurt and FBPS, and is also a source of essential minerals (e.g. calcium and magnesium). In contrast, most of the sugar in desserts, except compote, comes from manufacturers who add it.

the sugar content of products within each product family. Furthermore, these products consist of several ingredients in addition to sweeteners. This makes the analysis of product reformulation more interesting in the sense that a reduction in the sugar content of a product from added caloric sweeteners may be accompanied by an increase in the content of some other nutrients, such as fat from milk or fructose from fruit. The net impact on nutrient intakes may be positive or negative, depending on the product recipe changes and consumer response to changes in product characteristics, including taste and price.

To achieve our main objectives, we develop and estimate a model of supply and demand for dessert. On the demand side, consumers care about the price and taste of products. We model consumer preferences using a random coefficient logit model, controlling for endogeneity of prices. It captures heterogeneity in observed and unobserved consumer preferences and allows for flexible substitution patterns between differentiated products in the market. Consumer preferences are estimated using household-level scanner data from a representative panel of French households on dessert purchases and product and household characteristics. On the supply side, firms compete in prices to maximize their profit. We model the supply side as an oligopoly proposing differentiated products and competing à la Nash in a Bertrand game, in the spirit of Berry et al. (1995) and Nevo (2001). We use the estimated demand curves to identify the price-cost margins for each product and the unit costs of production for firms. We use our estimated model to quantify the impact of the tax on the new market equilibrium, knowing all parameters of firm pricing strategies and consumer purchasing behaviors. Since our tax design creates a sharp discontinuity that may induce firms to reformulate, we simulate two counterfactuals of the tax: one in which firms do not reformulate products, and another in which they reformulate and bunch at the threshold, as observed in response to the UK SDIL (Scarborough et al., 2020; Pell et al., 2021; Allais et al., 2023). All our reformulation responses incorporate technical formulation constraints, such as sweetness, texture, fermentation, and gelling processes, as well as regulatory constraints, if any. For these two counterfactuals, we assume that firms respond strategically in price.

Our results highlight two key insights. First, the choice of the tax threshold strongly affects the share of taxed and reformulated products, the magnitude of the tax-related price increase, and the magnitude of the welfare effects: the lower the tax threshold, the more efficient the tax policy in terms of sugar consumption reduction, but the greater the reduction in consumer surplus and profit. Secondly, to determine whether reformulation in response to a nutrient-based excise tax with a threshold would benefit or harm business profits, substitution effects within and between product categories and between taxed and non-taxed products need to be analysed. We show that those substitution effects are mainly determined by the impact of changes in price and nutrient characteristics on demand, and the firm's portfolio position in the sugar distribution of the dessert market. Furthermore, our analysis shows that the tax-with-reformulation scenario allows for better targeting of the highest consumption households and households with obese individuals, i.e. the at-risk population.

This paper contributes to the existing literature on the reaction of firms facing a regulatory measure. While previous studies have examined the price adjustments firms are likely to make due to taxation (Bonnet and Réquillart, 2013; Nesheim et al., 2018; Allais et al., 2015; Dubois et al., 2018), to our knowledge only one empirical study has integrated the potential changes in product characteristics resulting from food policy interventions (Barahona et al., 2023). In contrast to this study, which assumes that sugar is replaced by artificial ingredients to maintain taste as firms reformulate their products, our analysis includes the demand response to changes in product taste due to sugar reduction, which is assumed to be compensated by an increase in milk for yogurt and FBPS, or fruit for compote. Our assumption seems to be a more credible reformulation scenario for our market given the low proportion of dessert products with artificial sweeteners marketed in France (10% in our dataset). There is also a theoretical rational for including in our methodology the possibility that firms may reformulate their products in the face of a nutrient based tax policy (e.g., Duvaleix-Tréguer et al., 2012; Réquillart et al., 2016). By considering this demand-side response, we provide an analysis of how consumers may adjust their choices and behavior in the face of tax-induced changes in both prices and product taste, and thus contribute to a more accurate and relevant assessment of nutrient based taxes. According to our results, ignoring the combined effect of price reactions and product reformulation leads us to significantly underestimate the impact of taxes on nutrient intake. In our case, integrating these two effects into the analysis yields a change in the estimated reduction in caloric sweetener intake of 36%, which is of the order of Bercholz et al. (2022).

The rest of the paper is organized as follows. Section 2 introduces the data and provides a descriptive analysis of the French dessert market. Section 3 describes our demand and supply model and presents estimates. The simulation method, including product reformulation and cost implications, is detailed in Section 4. Section 5 presents the equilibrium effects of our two tax counterfactuals, including welfare, of changing sugar tax threshold level. Finally, Section 6 focuses on the heterogeneity of the impacts of tax in the two counterfactuals, while Section 7 outlines the implications of our main assumptions about the behavior of firms and consumers. In the last section, we acknowledge some limitations and highlight what could be done in subsequent work.

## 2 Data and dessert market

We use data from a French representative consumer panel data of 20,144 households collected by KANTAR Worldpanel. This is a home-scan data set providing detailed information on all purchases of food products. We consider all purchases of desserts over the period January-May 2009, corresponding to more than 1,600,000 observations. In particular, quantities, prices, brands, and characteristics of goods are registered. The relevant market is the whole dessert market, except ice cream; a rarely purchased product in France during the period of time chosen, accounting for less than 1% of the average dessert budget share over the period. Specifically, we define four broad dessert categories as follows: yogurts (plain; sweetened; flavored; with fruits), Fromages Blancs/Petits suisses - FBPS - (plain; flavored; with fruits),[3] Other Dairy Desserts - ODD - (cream desserts; 'crême brulée' desserts; coffee and chocolate mousses; style custard flans, French rice puddings; floating Island desserts[4]) and fruit compotes or stewed fruits. We classify yogurts and FBPS into brand, fat content, sugar content and flavor categories.[5] We distinguish 13 primary national brands (NBs), and merge all private label brands into one brand (PL). We get 75 different yogurts and 41 different FBPS. We have nine different compotes defined by brand and sugar content level.[6] ODDs are only brand differentiated. Overall, the household product set is composed of 131 differentiated products. Consumers can substitute the considered products with an alternative product, the so-called 'outside option', which includes other desserts (fruits and pastries), as well as cheese that is a substitute for dairy products

[3]Fromage blanc is a creamy, soft, fresh, white cheese made with whole, semi-skimmed or skimmed milk. Petit suisse is creamy fresh cheese, with a cylindrical shape, the fat and dry extract contents of which are regulated, often targeted for children.

[4]A classic French dessert that consists of meringue floating on a sea of vanilla custard

[5]We define three fat content categories: full-fat (more than 3% fat for yogurts, more than 5% fat for FBPS), semi-skimmed (between 1% and 3% fat for yogurts, between 2% and 5% fat for FBPS), and skimmed (fat close to 0%); and four sugar content and flavor categories (plain, sweet, flavored, and with fruits) for yogurts and three sugar content and flavor categories (plain, flavored, with fruits) for FBPS.

[6]We define three sugar content categories: pure blended fruit without added sugar; low-added-sugar; and with-added sugar.

in desserts in many cases in France. The outside option represents 60% of the entire market on average.[7]

Products' nutritional characteristics are not collected by Kantar. We use data from the French Food Observatory Oqali[8] and other data sources[9] to obtain the ingredient lists and the nutritional composition (values of the sugar, fat, protein and calorie content) of the desserts.

Table A.1 reports weighted average prices and market shares for the four broad dessert categories by brands. Compote, yogurts, FBPS, and ODD account for about 4%, 16%, 6%, and 13% of all dessert purchases, respectively. Their respective average price per kg is €2.58, €2.24, €2.89, and €3.31. For each of the four product categories, PL brands are the cheapest and have the highest market shares. This is a market feature now common to many food product categories and may be due to the fact that consumers do not perceive large quality differences between PL and NB products. Another feature of this market is the heterogeneity in NB product prices within each category, except for NB compotes that are produced by two firms only. Yogurt prices are the highest for brands that sell products reducing cholesterol (Brand 3), probiotics (Brand 4 and Brand 5 to a lesser extent), and with soy milk (Brand 13). The other dairy dessert prices range from €2.72 to €6.12 per kg. The large difference in prices is mainly due to the high heterogeneity of the products within the category.

The quantities of caloric sweetener per 100g of the 131 products and the presence of non-caloric sweeteners are retrieved from the ingredients lists and the nutrition facts provided by the French Food Observatory Oqali (see appendix sub-section B.1 for details). The caloric sweetener content includes both naturally present sweeteners, such as lactose in milk or fructose in fruits, and added caloric sweeteners, such as sugar or glucose. We also provide a product sweetness index as our proxy for product 'sugar' taste, including both the quantity of caloric sweeteners and the presence of non-caloric sweeteners. We proxy the sweetness index of products without artificial sweeteners by their sugar content. For products that contain some (or only) artificial sweeteners, we proxy their sweetness index by the sweetness of a similar product that does not contain any artificial sweetener. On average, the taste index is greater than the content in caloric sweetener for eight brands over the 13 brands of the yogurt category, and the difference, in some cases, is greater than 50% (see Table A.4). Figure 1 shows the distribution of the

[7]The outside option also includes minor brands producing products from the four categories analyzed. All of these minor brands account for only 2% of the whole market. Because we do not have precise information on these brands, we integrate them into the outside option.

[8]Oqali is the French Food Observatory. It aims to monitor changes in processed foods' supply available on the French market, by measuring nutritional quality evolution, over time (nutritional composition and labelling information).

[9]The other data sources were Open Food Facts, a free, online and crowd-sourced database, or the brand or manufacturer's website.

sugar content of products within the French market. Although there are some products that contain few sugar (4-6g per 100g) that corresponds to plain yogurt and FFPS, the distribution of products is more dense between 12-18g of sugar per 100g of product. Therefore, a taxation scheme with a threshold higher than 6-8g per 100g should encourage the substitution towards less sweetened products and reduce the consumption of a wide range of products. Table A.4 in the Appendix shows a large heterogeneity in the average caloric sweetener content and fat content of products by brand and category. ODDs have the highest sugar content with an average of 17.0 g per 100 g of product, followed by compotes with 14.7 g and yoghurts and FBPS with 9.7 g and 7.8 g respectively. Compotes have practically no fat (0.3g on average), ODD are characterised by a large heterogeneity in fat content and have the highest content (5.4g on average), followed by FBPS (4.0g) and lastly yoghurts (2.6g).

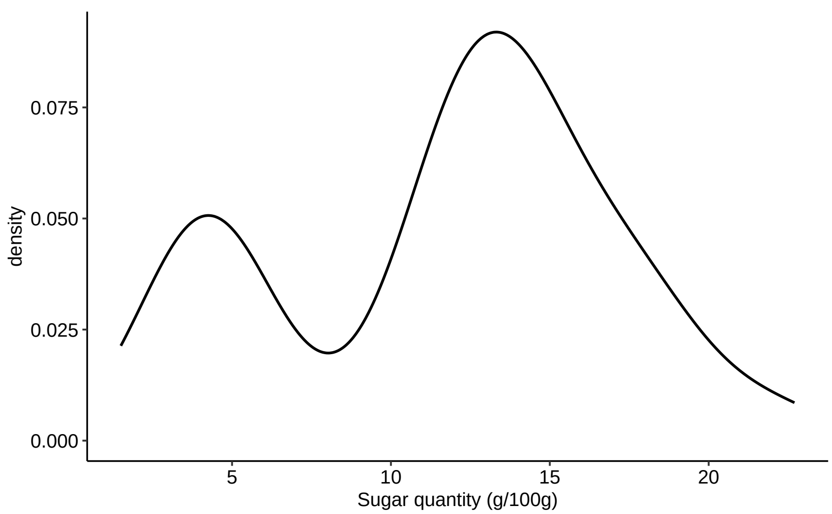


Figure 1: Distribution of sugar content in the dessert market

Overall, according to Table A.5, French households buy 32 kg of desserts (dairy dessert and compote) per year and per capita[10] in our sample, which corresponds to a sugar intake of 3.9 kgs per year and per capita or to an individual consumption of almost 2 tea-spoons per day on average for the dessert consumption. This dessert consumption varies according to the household characteristics. Households without children consume more desserts, 39 kgs on average, resulting in twice the sugar intake from desserts compared to households with children. We also observe a higher consumption if the household is made up of obese individuals or if the household

[10]Per capita consumption is calculated as 1 unit for persons aged 15 and over and 0.5 unit for others.

is richer.

# 3 Conceptual and empirical framework

In this section we specify the demand and supply model. It provides estimates of household preferences, price elasticities, marginal costs and margins.

## 3.1 The demand model: a random coefficient logit model

We use a random coefficient logit model (Berry et al., 1995; McFadden and Train, 2000). The indirect utility function $V_{ijt}$ for household $i$ buying product $j$ belonging to brand $b$, denoted $b(j)$, for $j = 1,...,J_t$, in period $t$ is given by:

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

where $\beta_{b(j)}$ is a brand fixed effect that capture time-invariant unobserved brand characteristics, $\gamma_{c(j)}$ is a dessert category fixed effects that controls for time-invariant unobserved household's preferences for the categories, $p_{jt}$ is the price of product $j$ in period $t$, $\alpha_i$ is the marginal disutility of price for household $i$, $S_j$ is the sugar taste of product $j$, and $\delta_{Si}$ captures the taste for sugar of the household $i$, $L_j$ is the fat content of product $j$, and $\delta_{Li}$ captures the preference for fat taste of the household $i$, $\delta_{SL}$ captures consumer preference for fat and sugar taste, $N_j$ is a dummy related to the natural flavor of product $j$ and $\theta_N$ captures consumer taste for this characteristic, $F_j$ is a dummy if product $j$ contains fruits in dairy desserts and $\theta_F$ captures consumer taste for this characteristic and $\varepsilon_{ijt}$ is an unobserved individual error term.

We allow sugar and fat tastes to vary across households characteristics.

$$\delta_{Si} S_j = \delta_S S_j + \delta_S^c S_j C_i + \delta_S^o S_j O_i$$

$$\delta_{Li} L_j = \delta_L L_j + \delta_L^c L_j C_i + \delta_L^o L_j O_i$$

Households are differentiated according to the presence of children below 18 years-old $C_i$ (household with or without children) and the number of obese individuals within the household $O_i$ (no obese, at least one obese individual or all individuals are obese). The coefficients $\delta_S^c$ and $\delta_L^c$ allow the marginal effects of sugar and fat taste on the utility function $V_{ijt}$ to shift with the presence of children, and the coefficients $\delta_S^o$ and $\delta_L^o$ to shift with the number of obese individuals within the household.

In our model, households can have a different price disutility; the $\alpha_i$ varies across households. First, we assume that the distribution of $\alpha_i$ follows a lognormal distribution and is a function of household characteristics with $\alpha$, $\alpha^c$, $\alpha^o$, $\alpha^I$ and $\sigma$ as parameters:

$$\alpha_i = \exp(\alpha + \alpha^c C_i + \alpha^o O_i + \alpha^I I_i + \sigma \nu_i) \quad \text{where} \quad \nu_i \sim \mathcal{N}(0,1) \text{ captures unobserved consumer attributes}$$

where $I_i$ stands for a socio-economic class (poor, middle, and rich).

The household can decide not to choose one of the considered products. Thus, we introduce an outside option that permits substitution between the considered products and a substitute, define in section 2. The utility of the outside option is normalized to zero. The indirect utility of choosing the outside good is $V_{i0t} = \varepsilon_{i0t}$.

Assuming that $\varepsilon_{ijt}$ is independently and identically distributed as an extreme value type I distribution, we are able to write the market share of product $j$ at period $t$ in the following way (Nevo, 2001):

$$s_{jt}(\theta) = \int \frac{\exp(\beta_{b(j)} + \gamma_{c(j)} - \alpha_i p_{jt} + \delta_{Si} S_j + \delta_{Li} L_j + \delta_{SL} S_j L_j + \theta_N N_j + \theta_F F_j)}{1 + \sum_{k=1}^{J_t} \exp(\beta_{b(k)} + \gamma_{c(k)} - \alpha_i p_{kt} + \delta_{Si} S_k + \delta_{Li} L_k + \delta_{SL} S_k L_k + \theta_N N_k + \theta_F F_k)} \, dP_\nu(\nu_i) dP_D(D_i) \quad (1)$$

where $P_\nu$ is the cumulative normal distribution function of $\nu$, $D_i = (O_i, I_i, C_i)$ is the vector of demographics, $P_D$ is cumulative distribution function of $D$ and $\theta$ is the vector of demand parameters to be estimated.

The random coefficient logit model generates a flexible pattern of substitutions between products that is driven by the different household price disutilities $\alpha_i$, such that, the own- and cross-price elasticities of the market share $s_{jt}$ take the following forms:

$$\frac{\partial s_{jt}}{\partial p_{kt}} \frac{p_{kt}}{s_{jt}} = \begin{cases} -\frac{p_{jt}}{s_{jt}} \int \alpha_i s_{ijt}(1 - s_{ijt}) \, dP_\nu(\nu_i) dP_D(D_i) & \text{if } j = k \\ \frac{p_{kt}}{s_{jt}} \int \alpha_i s_{ijt} s_{ikt} \, dP_\nu(\nu_i) dP_D(D_i) & \text{otherwise,} \end{cases} \quad (2)$$

where $s_{ijt}$ stands for the probability that a household $i$ chooses product $j$ at time $t$.

### 3.2 Supply model

We assume an oligopolistic competition between manufacturers. We consider F manufacturers that compete in prices on the dessert market. By doing so, we abstract from the role of retailers in setting prices of NBs. We assume that the prices of PLs are chosen by a 'specific' manufacturer representing the retailers price decisions. Formally, a manufacturer maximizes its profit:

$$\Pi_t^f = \sum_{j \in G_{ft}} [M_t (p_{jt} - c_{jt}) s_{jt}(p|\theta)]$$

where $G_{ft}$ is the set of products that are sold by manufacturer $f$ at period $t$, $M_t$ is the size of the market at time $t$, $p_{jt}$ is the final price of product $j$ at time $t$, $c_{jt}$ is the constant marginal cost to produce and sell product $j$ at time $t$, $s_{jt}(p)$ is the market share of product $j$ at time $t$, given the vector of product price $p$. The first order conditions that determine the prices of products are given by:

$$s_{kt}(p|\theta) + \sum_{j \in G_{ft}} (p_{jt} - c_{jt}) \frac{\partial s_{jt}(p|\theta)}{\partial p_{kt}} = 0 \quad \forall k \in G_{ft} \tag{3}$$

Using the above conditions, prices, and estimates of the demand model, we are able to recover margins of manufacturers $\gamma_{jt} = p_{jt} - c_{jt}$ and so marginal costs for each product $j$ at time $t$ and we note $\gamma_t(p|\theta)$ the vector of margins.

### 3.3 Results on demand and supply

We estimate the demand model using household purchase data, a control function approach for identification issue (see details in the Appendix C.1) and a simulated maximum likelihood method as in Revelt and Train (1998). Table C.2 in the Section C.2 in the Appendix shows the estimated coefficients of the demand model.

We see that the marginal utility of price is heterogeneous. This is mainly due to unobserved household characteristics, as the effects of income, obesity status and the presence of children on price are weak (see Table C.2). Households prefer compote more than the three other dairy dessert categories, on average. They also prefer yogurt with fruit (0.49). Surprisingly, the sweetness of a product decreases household average utility. However, purchasing a fat and sweet dairy dessert increases household average utility (0.86). Figure (2) shows that households draw a positive estimated utility from sugar when the sugar content of products is sufficiently high, particularly for households without children. This positive preference for sugar in high sugar content product is mainly true for the ODD category and the FBPS category at a lower extent. On the contrary, the sugar preference for compote products is very weak. This is in line with the market trend of consumers increasingly choosing low-sugar fruit compotes.

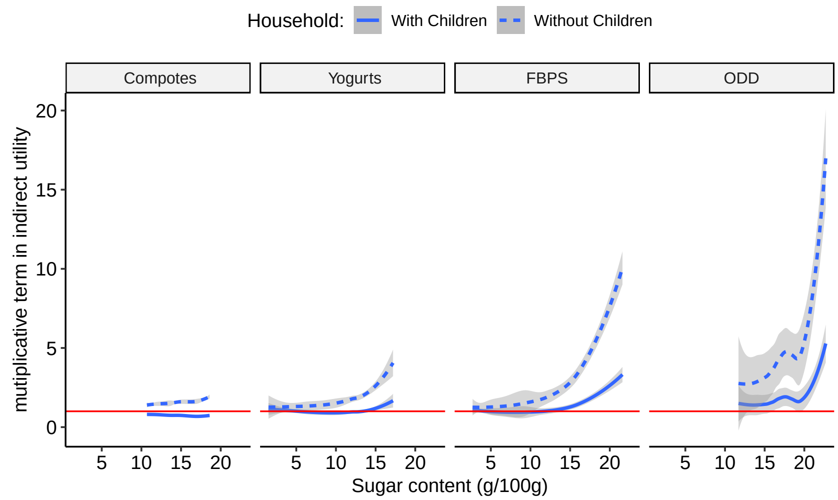


Figure 2: Sugar preferences for households with and without children and by product category

*Notes*: The estimated indirect utility of sugar was regressed on quantity of sugar. We plot the line y=1 in order to see when it has a positive impact on the indirect utility. FBPS stands for Fromages Blancs/Petits Suisses, and ODD for Other Dairy Dessert.

Using the structural demand estimates, we compute price elasticities for each differentiated product. Table A.2 provides aggregated own- and cross-price elasticities by categories.[11] Own-price elasticities are close to -2.2, except for yogurt products for which the demands are less elastic (about -1.7). Cross-price elasticities by food category are also almost equal. There is no second-best product category following a price change in a given dessert category. Consumers shift to another product proportionally to its initial market share. At the brand level (Table C.3 in the Appendix), we find that yogurts are less elastic, except for three brands that are characterized by the lowest caloric sweetener contents and, for two of them, high artificial sweetener contents.[12] Consumers react more to a change in prices for these expensive yogurts. For FBPS and ODD, we also find an heterogeneity in own-price elasticities for NB products. Furthermore, in each category, PL products are less price sensitive than those of NBs, a result which is commonly found.

From the supply model, we deduce the margins and marginal costs (see Table A.3). Margins vary from 27%

[11] Computational details for aggregated elasticities are provided in Bonnet et al. (2018).

[12] The first brand is specialized in soy products, the second in ‘probiotics’ products and the third in cholesterol lowering products.

to 73%, and they are higher on average in the yogurt category. This is in line with the empirical literature which typically finds margins in this range (Bonnet et al., 2016). For each product category, PLs have both the lowest marginal cost and the highest percent margin. This latter result is consistent with the theoretical literature showing that percent margins on PLs are likely to be larger than those on NBs (Mills, 1995). In each category, except ODD, marginal costs of brands are, in most cases, similar. Larger marginal costs correspond to brands producing specific products (Brands 3, 4, 13 for yogurt and 6 and 12 for FBPS). In the ODD category, the comparison of marginal costs is more difficult as products are very heterogeneous.

# 4 Simulation method

In this section, we present the simulation method used to assess the impact of an excise tax proportional to the sugar content of the product if its sugar content is above a given threshold level on several market outcomes, such as equilibrium prices, market shares, firm profits, and nutrient consumption. The objective is to find the new vector of equilibrium prices $p_t^*$ in each counterfactual, described in more detail in the next section, given the estimated marginal costs, input prices and changes in recipes (if any), as well as the other estimated structural demand parameters.

These assessments are carried out if all the firms reformulate in reaction to tax and if none reformulate. In the former scenario, the marginal cost of production is modified not only by the excise tax but also by the cost of reformulation. The profit-maximization program for firm $f$ is now given by:

$$\max_{\{p_{kt}\}_{k \in G_f}} \sum_{j \in G_f} (p_{jt} - \tilde{c}_{jt}) M_t \tilde{s}_{jt}(p|\hat{\theta}) \tag{4}$$

where $\tilde{c}_{jt} = c_{jt} + \tau_j + \Delta cc_j$ is the new marginal cost including the per-unit level of the tax $\tau_j$ which depends on the caloric sweetener content of product $j$ and $\Delta cc_j$, the variation in cost due to reformulation;[13] and the market share $\tilde{s}_{jt}(p|\hat{\theta}) = s_{jt}(p, \Delta S, \Delta L|\hat{\theta})$ that takes into account the changes in the sugar and lipid content of products due to reformulation. If no firm reformulate despite tax, there is no change in product characteristics other than price, $\tilde{s}_{jt}(p|\hat{\theta}) = s_{jt}(p, |\hat{\theta})$, and the marginal cost $\tilde{c}_{jt} = c_{jt} + \tau_j$.

[13] The tax $\tau_j$ is 0 for non-taxed product $j$ and there is no reformulation, $\Delta cc_j = 0$.

The new price equilibrium vector $p_t^*$ is deduced from the following optimization program:

$$\min_{\left\{p_{jt}^*\right\}_{j=1,..,J_t}} \left\| p_t^* - \gamma_t\left(p^*|\hat{\theta}\right) - \tilde{c}_t \right\|$$

where $\|.\|$ is the Euclidean norm in $\mathbb{R}^J$, $\gamma_t\left(p^*|\theta\right)$ is the vector of manufacturer margins deduced from (4), and the vector $\tilde{c}_t$ is the sum of the vectors of marginal costs obtained from (3), $c_t = (c_{1t},..,c_{jt},..,c_{Jt})$, tax levels, $\tau = (\tau_1,..,\tau_j,..,\tau_J)$, and input variations caused by reformulation, $\Delta cc = (\Delta cc_1,..,\Delta cc_j,..,\Delta cc_J)$.

**Product reformulation scenario** An exogenous product reformulation based on a set of hypothesis is considered. First, we assume that only items belonging to compotes, yogurts, and FBPS with added sugar are reformulated. The recipes of items in the ODD category are assumed to remain constant, due to their complex recipes and because of manufacturers' uncertainty about consumers' reaction to the reformulation of gourmet foods (Réquillart et al., 2016). Second, when firms face taxes, we assume that firms decide to avoid the tax altogether, where possible: they set the level of the sugar content of their products just below the tax threshold to fully escape the tax, if reaching this level is technically feasible and sensory acceptable for consumers. This manufacturers' strategic reaction of bunching just below the threshold to avoid the tax or mitigate its effects was found not only for the SDIL (Scarborough et al., 2020; Pell et al., 2021; Allais et al., 2023), but also for warning label in Chile (Barahona et al., 2023; Alé-Chilet and Moshary, 2022). We also assume that firms compensate sugar reduction by an equivalent increase in the quantity of the ingredient plain yogurt for yogurts, ingredient plain FBPS for FBPS or ingredient fruit for compotes, such as $\Delta Q_{Yogurt,j} = -\Delta Q_{Sugar,j}$ for yogurts, $\Delta Q_{FBPS,j} = -\Delta Q_{Sugar,j}$ for FBPS, and $\Delta Q_{fruit,j} = -\Delta Q_{Sugar,j}$ for compotes.[14] The other ingredients such as fruits in fruity yogurts or FBPS, aroma in flavored yogurts or FBPS, and additives (e.g. preservatives) in compotes, yogurts, and FBPS with added sugar are assumed to be constant.

If setting product sugar content just below tax threshold is not technically feasible or sensory acceptable, we assume that the firm sets the level of added sugar of the product to its minimum content in order to mitigate the effects of the tax. To calculate the minimum amount of added sugar, we first determine the recipes prior to

[14] Given the low proportion of artificially sweetened dessert products marketed in France (10% in our dataset), preserving the sugar taste by adding artificial sweeteners to the product is unlikely. We interviewed food scientists who confirmed that this is the most credible scenario of how reformulation would be achieved in the dessert market.

food reformulation. They are determined using the ingredient lists and nutrition facts provided by the French Food Observatory Oqali (see appendix sub-section B.1 for details). To simplify the determination of yogurt and FBPS recipes, the quantity of milk is approximated by the quantity of the ingredient "plain yogurt" or "plain FBPS" respectively. The minimum amount of added sugar is then calculated for all compotes, yogurts, and FBPS with added sugar by minimizing the amount of sweetening ingredients per 100 g of product subject to technical constraints of formulation, such as product sweetness, texture, fermentation, and gelation process, and regulatory constraints if any, knowing the recipes prior to food reformulation. The computation of this amount for each reformulated product, including the exact specification of each constraint, is detailed in the appendix sub-section B.2. The resulting contents in sugar and fat are reported by brand and product category in Table B.1.

**Product cost implications** As the recipes change with product reformulation, so do the production costs. We assume that the variation in marginal cost due to reformulation $\Delta cc_j$ for product $j$ follows this linear function :

$$\Delta cc_j = \rho_S \Delta Q_{Sugar,j} + \rho_Y \Delta Q_{Yogurt,j} + \rho_{FBPS} \Delta Q_{FBPS,j} + \rho_F \Delta Q_{Fruit,j} \tag{5}$$

where $\Delta Q_{I,j}$, for $I = Sugar, Yogurt, FBPS, Fruit$ is the variation in the quantity of ingredient $I$ due to reformulation of product $j$ and $\rho_I$ represent the average price of the ingredient $I$ per kilo in €. We set sugar price at €555 per ton, $\rho_S = 0.555$ (see the report of the European Commission 2013). The price of plain yoghurt and plain FBPS is derived from the price of milk, taking into account that 1 litre of milk is needed to make 1 kg of yoghurt and it is set at 2.5 litres of milk to make 1 kg of FBPS. The price of milk is set at €274 per ton, $\rho_Y = 0.274$ and $\rho_{FBPS} = 0.685$ (see the report of the French national inter-professional center for the dairy industry 2014). The average price of fruits for industry is calculated from trade figures in volume and value included in a report of Adepale (2006), the French Association of Elaborated Food Products Companies. We set the price of fruit at €407 per ton on average, $\rho_F = 0.407$. The resulting cost variations reported in Table B.1 are weak, less than 1 cent per kg.

# 5 The welfare effects of changing sugar tax threshold level

In this section, we present the impact of three counterfactuals on sugar consumption, consumer welfare, firms' profit, tax revenue, and total welfare for a broad range of sugar tax threshold levels, on the four product categories within the French dessert market, and thereby enriching the public debate on tax policy design.

First, we consider a tax policy assuming that firms only react in price, called below tax policy without reformulation. The tax is as an excise tax proportional to the sugar content of the product if its sugar content is above a given threshold level. The chosen rate of tax is €0.20 per 100g of sugar per kilo of product.[15] Consistently with the sugar content distribution of the two categories in Table A.4, we choose a range of tax threshold levels for dairy desserts (6, 8, 10, 12, 14, 16 and 18) and a range of tax thresholds for compote (12, 14 and 16).

Second, we analyze the same tax policy that not only allows for strategic price reactions, but also allows firms to reformulate products based on the exogenous reformulation scenario presented in section 4, called below tax policy with reformulation. The third counterfactual is the exogenous reformulation scenario considered in the tax policy reformulation calculated for each tax threshold level considered, called below the reformulation scenario. It is used to disentangle the effects of product reformulation from the effects of the tax-induced product price increase.

All variations displayed below are measured against the status quo scenario, i.e. no tax implementation. For simplicity of representation, we display our results considering a threshold level for compotes at 12g per sugar for 100g of product. We discuss how results change with the level of the sugar tax threshold of compote in the Appendix E.

## 5.1 Impact of policies for consumers

We present in this section the impact of the different policies on sugar consumption and consumers' welfare.

**Variations in sugar consumption** Figure 3 shows how sugar consumption varies with the level of the sugar tax threshold of dairy desserts for the three counterfactuals. The nutritional composition of the outside option is not taken into account in the calculations of variations in nutrient consumption. It is considered in subsection 7.3. We find that the two tax policy scenarios yield stronger sugar consumption reductions than the reformulation scenario

[15]This rate results in a price increase of between 10 and 20% for taxed products, depending on their sugar content.

for all sugar tax threshold levels. There are two explanations. First, ODDs are taxed in the two tax policy scenarios resulting in a reduction in the purchase of ODDs in favor of less sweetened desserts. Whereas, ODDs, which have the highest sugar content on average (see Table A.4), are not reformulated by assumption in the reformulation scenario. It results that consumers shift away from reformulated desserts toward ODDs, as displayed in Figure D.1 in the Appendix. Second, variations in market shares are overall smaller in the reformulation scenario (up to less than 3% maximum) than in the two tax policy scenarios (up to more than 20%) yielding lower reduction in sugar consumption (see Figure D.1 in the Appendix). These adjustments are smaller, partly because the change in prices is close to zero (see Figure 4).

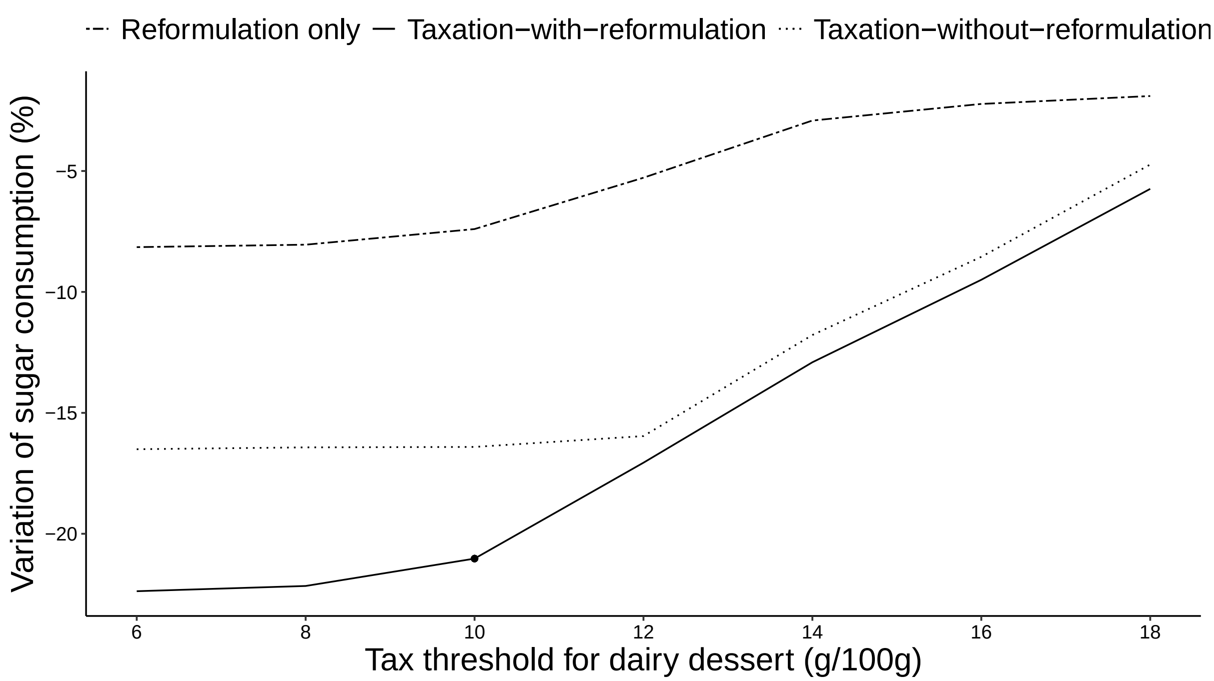


Figure 3: Changes in sugar consumption with respect to dairy dessert tax threshold (set at 12g/100g for compotes) for the three scenarios

We also find that the higher the tax threshold level, the lower the decrease in sugar consumption for all scenarios considered, as fewer products are taxed/reformulated. However, the change in sugar consumption is not linear. Increasing the tax threshold for dairy desserts from 6 to 10g of sugar per 100g of dairy dessert has a quite small impact on sugar consumption for the tax policy with reformulation (e.g. a less than 0.5 percentage point difference in variation of sugar consumption per 1g increase in the threshold). In contrast, the drop in sugar consumption decreases sharply for a sugar tax threshold above 10g of sugar per 100g of dairy product (e.g. about 2 percentage points in variation of sugar consumption for every 1g per 100g increase in the threshold). A similar pattern of variation in sugar consumption is also found for the tax policy without reformulation in Figure 3, but with a kink at 12g of sugar per 100g of dairy dessert. The non-linear pattern of sugar consumption variation observed for the three scenarios and the levels of the kink mainly result from the non-linear pattern of the evolution of the share of non-reformulated products and/or taxed products (see Figure 5) and the non linear pattern of the evolution of tax-related price increase (see Figure 4).

Figure 3 also shows that the tax scenario with reformulation is more efficient in reducing sugar consumption than the tax policy without reformulation. In the tax policy with reformulation, two consumers' responses work in favor of reducing sugar consumption. First, consumers only slightly change their purchases of products that have been reformulated to avoid the tax (see sub-section 7.1), and second they switch to less sweet products due to tax-related price increase of taxed products. Whereas only the latter substitution effect exists for the tax policy without reformulation.[16] The reductions are particularly greater (up to about 10 percentage points difference) for a tax threshold below or equal to 10g of sugar per 100g of dairy dessert because the two consumers' response are at stake for the tax with reformulation. Above this tax threshold level, the reduction in sugar consumption converges between the two tax scenarios as the tax threshold for dairy deserts increases: the proportion of non reformulated products increases and both the changes in price and the proportion of taxed products converge in the two tax scenarios (see Figures 4 and 5).[17]

**Variations in consumer welfare** Figure 6.A shows how the consumer welfare varies with the sugar tax threshold level of dairy dessert for the three scenarios. The curves of the variation in consumer surplus and sugar consumption for the two tax policy scenarios have similar shape. However, the percentages of utility loss in the three scenarios are smaller than the percentages of reduction in sugar consumption. Analogous explanations to those for variation in sugar consumption can be given: (i) The utility losses induced by tax policy scenarios are higher than in the reformulation scenario due to the non-reformulation of ODDs, the relatively smaller changes in demand and the

[16] The effect of the tax on the market share of the outside option is similar with and without reformulation for a tax threshold below or equal to 10g of sugar per 100g of dairy dessert (see Figure D.1) and then does not explain the difference in reduction of sugar consumption.

[17] The change in the reduction in sugar consumption is larger in the tax with reformulation than without because the two consumers' responses still apply for compote. The tax threshold for compote is set to 12g per 100g of compote.

much smaller price variations in the reformulation scenario (see Figure 4); (ii) The higher the threshold levels, the fewer products taxed/reformulated, and so the lower the decrease in consumer surplus for the three scenarios; (iii) The non-linear pattern of consumer surplus variation mainly results from the non-linear pattern of the evolution of both the share of non-reformulated and/or taxed products and tax-related price increase.

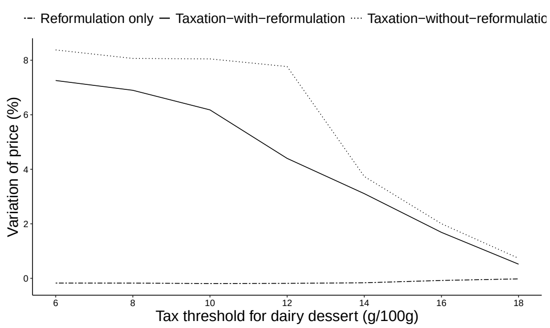


Figure 4: Changes in price with respect to dairy dessert tax threshold (set at 12g/100g for compotes) for the three scenarios

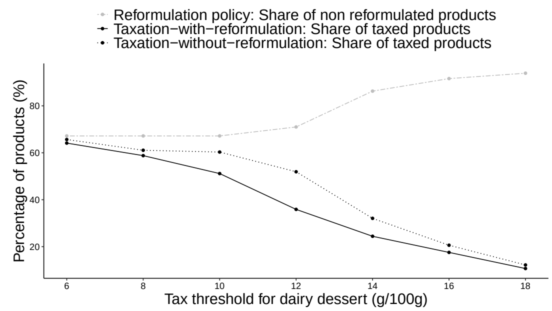


Figure 5: Changes in the shares of taxed products for the tax policies with and without reformulation and non-reformulated products for the reformulation scenario with respect to dairy dessert tax threshold (set at 12g/100g for compotes)

Figure 6.A also shows that the utility costs for the two tax policy scenario are almost similar, except for a tax threshold level equal to 12g of sugar per 100g of dairy product where they are lower for the taxation with reformulation. The explanation lies in the magnitudes of the utility costs bring about by tax-related price increase and the consumption of less sweetened and fat products (see demand model estimates reported in Table C.2). Specifically, the sum of the disutilities of consuming less sugar and fat, and paying higher prices is smaller in the tax policy with reformulation than without at this tax threshold level: the reduction in fat consumption and the tax-related price increase are smaller in the tax policy with reformulation, while the reductions in sugar consumption are almost similar in the two tax scenarios.

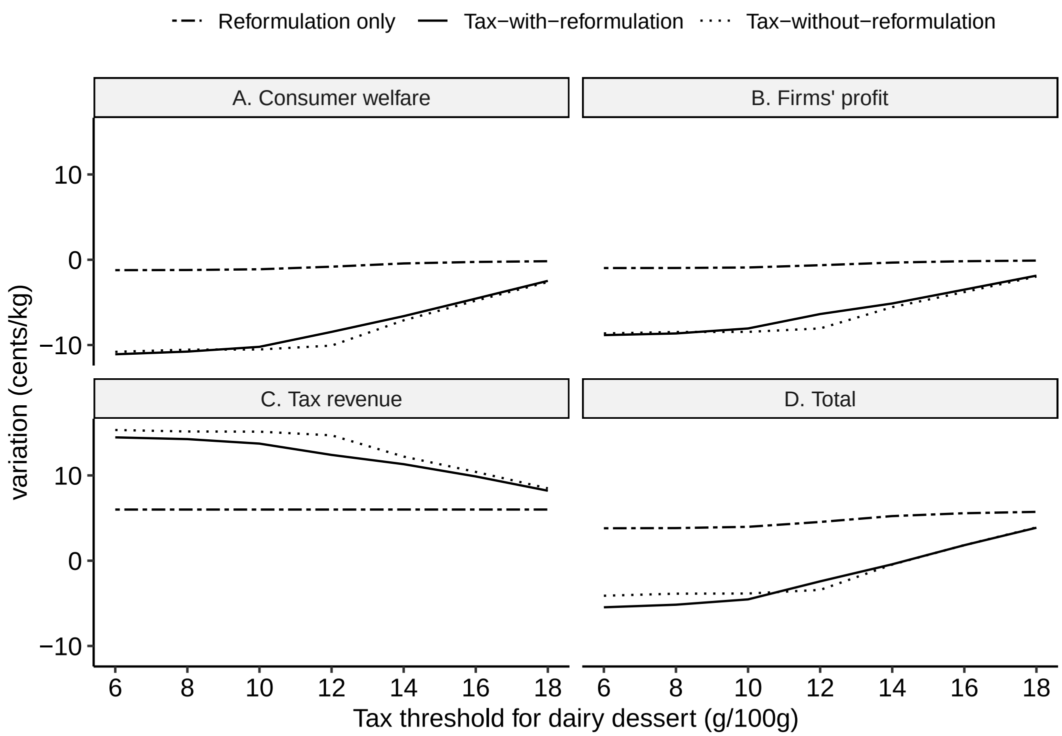


Figure 6: Consumer welfare, firms' profit, tax revenue and total welfare variations with respect to dairy dessert tax threshold in the three counterfactual scenario (set at 12g /100g for compotes)

## 5.2 Firms' profit

Figure 6.B shows how firms' profit varies with respect to the sugar tax threshold level of dairy dessert for the three scenarios. Four main results emerge. First, the two tax policy scenario generate much stronger profit reductions than the reformulation scenario for all sugar tax threshold levels. As we will show in sub-section 7.1, reformulation involves, on average, small adjustments in demand due to changes in product recipes and small changes in prices, partly owing to small reformulation costs (see Table B.1). In contrast, the tax policy brings about much stronger variations in product market shares (see Figure D.1 in the Appendix), notably ODDs that are strongly taxed, which leads to relatively greater reductions in profit. Second, the lower threshold level, the higher profit loss. The share of taxed products and prices increase as the tax threshold falls (see Figures 4 and 5). Third, the marginal impact of modifying the threshold level for dairy desserts is small in the range of 6 to 10 g/100g, but much higher in the range of 10 to 18 g/100g. This result comes mainly from the non linearity in the evolution of the share of taxed

products and tax-related price variations (see Figures 4 and 5). Fourth, the reduction in firms' profit is similar in the two tax policy scenario, except for a tax threshold levels equal to 12g of sugar per 100g of dairy product. At this tax threshold, the (negative) impact of tax policy on firms' profit becomes lower when firms reformulate their products than when they do not. This is mainly due to a much lower tax-related product price increase in the tax scenario with reformulation than without (see Figure 4), yielding lower drops in product market shares and a smaller increase in the market share of the outside option (see Figure D.1 in the Appendix). The next section provides more detail by analysing the heterogeneity of the effects of the two tax scenarios by product category, brand and firm.

### 5.3 Tax revenue and total welfare

Figure 6.C displays how tax revenue varies with the sugar tax threshold level of dairy desserts for the three counterfactual scenarios. As expected, tax revenue decreases as tax threshold level increases since less products are taxed. Moreover, the amount of tax revenue is smaller for the tax policy with reformulation for all tax threshold levels, as we assume that firms decrease the sugar content of their products to fully escape the tax or to mitigate its effects when this is not possible. The non-linear pattern of tax revenue also results from the non-linear pattern of the evolution of the share of taxed products with respect to tax threshold level.

The tax revenues are high but they are not high enough to outweight the losses of profit and consumer welfare below a tax threshold level of 14g of sugar per 100g of dairy product (see Figure 6). Moreover, the changes in total welfare across tax threshold levels are similar in the two tax policy scenarios.

### 5.4 Key messages

Overall, we find that the tax with reformulation generates greater reductions in sugar consumption than the tax without reformulation in the dessert market when the tax threshold is low enough to affect a large proportion of products. The two tax policy scenarios yield the same patterns in the variations of consumers' welfare, firms' profit or tax revenues with respect to the sugar tax threshold, except at the sugar tax threshold for dairy dessert equal to 12g of sugar per 100g of product where the costs of taxation are larger than the costs of taxation and reformulation for consumers and firms. This is mainly due to a much larger difference in both tax-related product price increases and the share of taxed products between the two tax scenarios for this threshold level than for other tax threshold levels (see Figure 4). Symmetrically, tax revenues are greater in the tax policy without reformulation than with reformulation since less products are taxed in latter policy.

Our results highlight two critical findings. First, the choice of the level of the sugar tax threshold strongly affects the share of taxed and reformulated products, the magnitude of tax-related price increase, and the magnitude of welfare effects: the lower the tax threshold, the more effective the tax policy is in reducing sugar consumption, but the greater the reduction in consumers' surplus and profit, whether or not firms reformulate. Second, there is certain of level of tax threshold for which firms may experience less profit loss from the taxation policy if they reformulate, thereby generating greater sugar consumption reduction and less consumers' welfare losses due to smaller tax-related price increase than under the tax policy without reformulation. We recommend setting the sugar tax threshold based on the sugar content distribution of compotes, yogurts and FBPS in order not only to tax a large proportion of products, but also to maximize the number of products close to but above the threshold so that their reformulation is not too costly compared to the cost of the tax.

# 6 Heterogeneity of the impact of the tax policies

In this section, we analyze the heterogeneity of the effects of taxation with and without reformulation on prices, profits and market shares by product category, brand and firm, and on nutrient consumption by type of consumers. The analysis is carried out using a single set of tax thresholds: 12g/100g and 10g/100g of sugar for compotes and dairy desserts, respectively. We chose these thresholds because, firstly, they lead to a significant reduction in sugar consumption (see figure 3) and, secondly, firms have an economic interest, albeit a small one, in reformulating products at these tax thresholds (see figure 6.B), except except firm 1 (see the last two columns *Total* of Table 1). However, the difference in profit between the tax scenario in which firms reformulate and that in which they do not reformulate varies considerably from one firm to another and from one category to another, excluding ODDs that are not reformulated.[18]

Several effects combine and compete to explain how firms are affected by the policy. The introduction of a tax

[18] Firms producing ODDs suffer almost similar profit losses in the two tax scenarios. This is partly because price changes are similar in the two scenarios.

Table 1: **Change in firm profit in the two tax scenarios (in %)**

| | Product categories | | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Compotes | | Yogurts | | FBPS | | ODD | | | |
| Reformulation | Without | With | Without | With | Without | With | Without | With | Without | With |
| Firm 1 | | | 0.19 | -0.21 | 1.68 | -1.47 | -19.72 | -19.73 | -4.59 | -5.55 |
| Firm 2 | | | -0.77 | 2.53 | -11.76 | -30.71 | -14.54 | -14.53 | -10.43 | -10.15 |
| Firm 3 | | | -9.63 | -2.99 | 6.80 | 6.11 | -14.73 | -14.71 | -6.38 | -1.70 |
| Firm 4 | -7.29 | 0.73 | -13.97 | -17.18 | 11.13 | 10.57 | -11.25 | -11.16 | -9.59 | -7.66 |
| Firm 5 | -6.90 | -6.64 | | | | | -9.37 | -9.32 | -7.60 | -7.40 |
| Firm 6 | | | 6.89 | 10.71 | 11.52 | 11.08 | -10.73 | -10.54 | -4.09 | -2.84 |
| PL provider | -10.57 | -9.55 | -5.63 | -5.31 | 0.49 | 1.78 | -19.28 | -19.43 | -10.29 | -9.88 |
| All | -9.65 | -7.76 | -3.76 | -2.79 | 1.39 | 0.54 | -17.47 | -17.53 | -8.46 | -8.06 |

*Notes*: A proportional tax of € 0.20 per 100g of sugar per kilo of product is implemented when sugar content is above 12g for compote and 10g for other product categories. Columns 'without' indicate the change in profit when firms do not reformulate their products, and columns 'with' when firms do reformulate their products. Firm 1 owns brands 1 to 5; firm 2 owns brand 6; firm 3 owns brands 7 to 9; firm 4 owns brand 10; firm 5 owns brand 11; and firm 6 owns brands 12 and 13. FBPS and ODD stand for fromage blanc and petit suisse, and other dairy desserts, respectively.

primarily affects the cost of the product. The higher the sugar content, the higher the tax. Thus, the direct effect for the firm is an increase in the cost of the products targeted by the tax scheme. An indirect effect comes from the competitive environment in the market. The impact of the tax on a firm's profit will vary depending on the position of its products in the sugar content distribution.

When reformulation occurs, the introduction of a tax leads to several effects. The direct cost change due to reformulation is very small, as shown in Table B.1. However, even if costs are not affected, the changes in product characteristics can lead to significant changes in market shares at brand and category level (see Table F.1), although the average change is quite small (-0.86%). In addition, reformulation reduces the sugar content of products which reduces the amount of the tax or eliminates it if products can be reformulated below the tax threshold. Finally, reformulation affects all products on the market as it changes the distribution of sugar content and the degree of competition between products.

In the following paragraphs, we describe the change in costs in the market resulting from the two policies and how this affects price and demand.

**Effects on costs** According to tables F.2 and F.3 in the appendix, compotes and ODDs, which are the sweetest products (see Table A.4), are taxed the most, on average €0.27/kg (€0.32/kg in the tax policy without reformulation) and €0.34/kg in the reformulation tax scenario with reformulation, respectively. Yoghurt and FBPS are taxed at similar average levels in the reformulation tax scenario (€0.23/kg and €0.24/kg, respectively) and in the no reformulation tax scenario (€0.27/kg and €0.28/kg, respectively). We observe a decrease in the share of taxed products when firms reformulate: the share of taxed products is 67%, 50% and 37% for compotes, yogurts and FBPS respectively in the tax scenario without reformulation, and 56%, 35% and 30% of compotes, yogurts and FBPS respectively in the tax scenario with reformulation.

**Effects on prices** We find that firms choose to pass on more than the tax to consumers in both tax policy scenarios (see Table F.4 in the appendix). The prices of taxed products increase by about 18% more than the amount of the tax in the two tax scenarios. This result is consistent with analyses of taxation in other food categories, such as sugar-sweetened beverages, butter and margarine, and fresh dairy products (Bonnet and Réquillart, 2013; Nesheim et al., 2018; Allais et al., 2015). Tables 2 and F.5 show the average price change for each brand in each category in the tax scenario with and without reformulation. We find that the price changes of the brands within the product category are quite heterogeneous, ranging from 0 to €0.51. Comparing the two tables, we observe as expected a smaller price increase for compotes, yogurts and FBPS on average in the tax scenario with reformulation than in the tax scenario without reformulation.

**Effects on demand** Table F.6 shows the effect of the tax on market shares by dessert category and firm in the two tax scenarios. We find similar patterns of variation as in profits in the two tax scenarios. However, the losses (gains) in market shares are larger (smaller) than the losses (gains) in profits, as firms increase their markups for all brands and product categories. All product categories lose market shares, except FBPS in the two tax scenarios (+1.6% and +1.3% without and with reformulation, respectively), for which the change in average price is much lower than for the other categories (1.8% and -0.3% without and with reformulation, respectively, see last row of Table F.7). Overall, the lower the average price increase for a firm in a product category, the less it loses or the more it gains market shares in the two tax scenarios (see Tables F.6 and F.7 ). We find that PLs lose more than average NBs, despite quite similar tax levels, which is a consequence of a larger relative price effect of the tax

Table 2: **Taxation with product reformulation: Changes in average price (€/kg) and market share (%) across brands and product categories**

| | Compotes | | Yogurts | | FBPS | | ODD | | All |
|---|---|---|---|---|---|---|---|---|---|
| | Price | MS | Price | MS | Price | MS | Price | MS | MS |
| **Firm 1** | | | | | | | | | |
| Brand 1 | | | 0.03 | -5.47 | 0.01 | -5.64 | 0.51 | -27.18 | -14.35 |
| Brand 2 | | | 0.00 | 10.30 | 0.01 | 11.23 | 0.28 | -9.31 | 5.03 |
| Brand 3 | | | 0.00 | 12.02 | | | | | 12.02 |
| Brand 4 | | | 0.07 | 5.00 | | | | | 5.00 |
| Brand 5 | | | 0.13 | -3.98 | 0.14 | -1.66 | | | -3.43 |
| **Firm 2** | | | | | | | | | |
| Brand 6 | | | 0.07 | 1.08 | 0.51 | -33.52 | 0.43 | -18.47 | -12.41 |
| **Firm 3** | | | | | | | | | |
| Brand 7 | | | 0.34 | -16.92 | 0.03 | 4.99 | 0.42 | -18.79 | -7.92 |
| Brand 8 | | | 0.08 | -3.91 | | | | | -3.91 |
| Brand 9 | | | 0.00 | 5.56 | | | | | 5.56 |
| **Firm 4** | | | | | | | | | |
| Brand 10 | 0.09 | -0.81 | 0.33 | -21.43 | 0.01 | 9.93 | 0.38 | -14.22 | -10.22 |
| **Firm 5** | | | | | | | | | |
| Brand 11 | 0.26 | -10.05 | | | | | 0.43 | -13.15 | -10.84 |
| **Firm 6** | | | | | | | | | |
| Brand 12 | | | 0.01 | 10.30 | 0.01 | 10.59 | 0.41 | -13.95 | -5.00 |
| Brand 13 | | | 0.00 | 9.87 | | | 0.30 | -11.65 | -0.99 |
| **Pls** | 0.24 | -11.63 | 0.05 | -4.81 | -0.01 | 3.41 | 0.49 | -23.63 | -10.90 |
| **All** | 0.23 | -9.82 | 0.08 | -3.57 | -0.01 | 1.26 | 0.50 | -21.68 | -9.53 |

*Notes*: A proportional tax of € 0.20 per 100g of sugar is implemented when the sugar content is above 12g for compote and 10g for other product category. The reported change in price of a brand and a category is the weighted average (using market shares as weights) of the change in price of all products from this brand in this category. FBPS, ODD and MS stand for fromage blanc and petit suisse, other dairy dessert, and market share respectively.

when expressed as a percentage change.[19] As price changes are highly heterogeneous across firms and categories, so are market share changes.

The variation in market shares between the two tax scenarios depends on a comparison of the net effects due to price and nutrient characteristics changes. We find that the larger the average price decrease due to switching to the tax scenario with reformulation for a firm's products in a given category, the less the firm suffers or the more it benefits from the tax (see tables F.6 and F.7).

However, the impact on sales cannot be fully explained by the price mechanism alone. Changes in product formulation also play a role. Reducing the amount of sugar in a product may not be well appreciated by consumers, even if reformulation brings about a lower price, as it is displayed for yogurt and FBPS categories in Table F.1. This second effect is strikingly strong for the yogurts and FBPS of brand 1 and yogurts of brand 10: the tax scenario with reformulation results in a smaller price increase (e.g. €0.03/kg against €0.11/kg in the tax scenario without reformulation for yogurts marketed by brand 1, as presented in tables 2 and F.5) but a larger market share loss compared to the tax scenario without reformulation (e.g. -5.47% against -4.77% for yogurts marketed by brand 1).

These changes in market shares lead to decreases in sugar, lipid and calorie intakes: 21.1%, 12.4% and 15.9%, respectively (see Table 3).[20] These values correspond to an annual per capita reduction of 0.8 kg of sugars, 0.1 kg of lipids and 5,252 kcal, or an average reduction of 14 kcal per day. These large reductions are partly due to the redistribution of market shares within and between product categories. However, it is also the result of a loss of market shares among the four categories, with the total market share falling by 3.8 percentage points. We also find some heterogeneity by household characteristics. Households without children experience higher sugar, fat and calories reductions than households with children in percentage. As their initial consumption is also larger, the nutrient reduction per capita per year for households without children is twice than the nutrient reduction of households with children (1,082g versus 494g for sugar intake variation, 179g versus 82g for lipid intake variation, and 6,828 calories versus 3,125 calories for calorie intake variation). Nutrient reductions increase slightly in percentage with socio-economic class but we can observe higher variations in absolute effect for rich

[19] NB prices increase by 5%, 4%, 0%, and 12% for compotes, yogurts, FBPS, and ODD, respectively, while PL prices increase by 11%, 3%, 0%, and 18%, respectively. The price transmission of the tax is slightly lower for PLs than for NBs (see Table F.4), but this is not sufficient to avoid a larger decrease in market shares.

[20] The nutritional composition of the outside option is not taken into account in the calculations of variations in nutrient intake. It is considered in subsection 7.3.

households due to higher consumption levels (see Table A.5). The percentage change are almost identical whatever the number of obese adults in the household. As it exists a difference in consumption, we observe a slightly greater reduction of sugar, fat and calorie intake per capita and year for households with obese adults. For example, we observe a difference in the reduction of sugar intake of 19% as the table shows -988g for households with all obese individuals compared to -830g for households without obese individuals. As we have highlighted in Section 5, the reduction in sugar and calorie intake is weaker in the tax-without-reformulation scenario (see Table F.8).

Table 3: **Taxation with product reformulation: Percent change in calorie, lipid, and sugar intakes**

| **Household** | | **Children** | | **Social classe** | | | **Adults obese** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **All** | **With** | **Without** | **Rich** | **Medium** | **Poor** | **None** | **One** | **All** |
| Sugar | -21.07 | -19.80 | -21.62 | -21.25 | -21.07 | -20.89 | -21.00 | -21.01 | -21.28 |
| | (-831) | (-494) | (-1082) | (-1031) | (-850) | (-616) | (-830) | (-747) | (-988) |
| Lipid | -12.40 | -10.86 | -13.13 | -12.72 | -12.39 | -12.06 | -12.37 | -12.31 | -12.59 |
| | (-138) | (-82) | (-179) | (-171) | (-141) | (-102) | (-137) | (-124) | (-164) |
| Calorie | -15.89 | -14.40 | -16.56 | -16.16 | -15.89 | -15.60 | -15.84 | -15.81 | -16.09 |
| | (-5252) | (-3125) | (-6828) | (-6057) | (-5371) | (-3899) | (-5240) | (-4722) | (-6246) |

*Notes*: The percentage change in nutrient intake is calculated using the initial intake from dessert consumption as a baseline. Change in nutrient intake in grams/calorie per capita per year are shown in brackets. The per capita consumption of a household is calculated using the following rule: we add one point for an individual 15 years of age or older, and 0.5 point for an individual less than 15 years of age.

**Key messages** Overall, firms choose to pass on more than the tax to consumers in both tax policies with and without reformulation. Hence, they increase their margins to compensate for the loss of market share. Moreover, they lose less profit from the tax policy when they reformulate at the tax thresholds of 12g/100g and 10g/100g of sugar for compotes and dairy desserts, respectively. However, this result does not hold systematically at the category-firm level. Switching to the tax-with-reformulation scenario can either benefit or harm a firm. Determining whether it benefits or harms the firm's profits in a product category requires an analysis of substitution effects within and between product categories, and between taxed and non-taxed products. We show that those substitution effects are mainly determined by the impact of changes in price and nutrient characteristics on demand, and the firm's portfolio position in the sugar distribution of the dessert market. Moreover, our analysis shows that the tax-with-reformulation scenario allows targeting the households with the highest consumption levels. We find a higher sugar reduction for households with obese individuals.

# 7 Implications of assumptions

Throughout the paper we have made a number of assumptions about the behaviour of firms and consumers. Their implications for the assessment of nutrient intake changes due to fiscal policies are presented in this section. First, we disentangle the mechanisms of the effects of the chosen reformulation policy. Second, we evaluate how our assumptions on the firms' behavior (pricing strategy and product reformulation) change the main results. Third, we discuss the implications of the definition of the outside option.

## 7.1 The impact of product reformulation

The reformulation scenarios considered imply a change in the nutrient composition and prices of products (due to changes in the cost and pricing strategy of firms), and the demand (due to changes in product taste and price). In order to understand which effect is predominant in modifying nutrient intake, we study three cases that break down the potential effects of the product reformulation scenario.

In the first case, we assume that the policy causes no change in market shares. Consumers continue to buy products as if nothing has changed in terms of taste and price. This provides the mechanical impact of product reformulation on consumer nutrient intakes. We find that the sugar intake decreases by 6.7%, whereas fat intake slightly increases (0.9%) because caloric sweeteners in yogurt and FBPS categories are substituted by plain yogurt and FBPS. Overall, it results in a 2.8% reduction in calorie intake (Table G.1).

In the second scenario, we assume that prices remain constant, but consumers respond to the change in nutrient composition of products. Consumers are aware that products have been reformulated and thus reassess their utility. As shown in Table C.2, both sugar and fat taste affect the utility of consumption, but the changes in nutrient intakes due to reformulation are small. Compared to the previous scenario, consumers, on average, switch to products with less sugar and less fat, resulting in a slightly higher reduction in sugar and fat consumption.

In the third scenario, we allow manufacturers to have strategic price reactions as both demand and production costs have changed. Prices are adjusted but vary only slightly compared to pre-scenario prices, partly owing to small reformulation costs. The production costs of compotes slightly decrease (by less than 1 €cent /kg), those of yogurts remain unchanged, and those of FBPS slightly increase (by less than 1 €cent /kg). This results in almost no change in nutrient consumption compared to the scenario in which prices remain constant.

We conclude that from the three simulations, the main impact of product reformulation on nutrient intake is mechanical. In our setting, adjustments in demand due to changes in product recipes have a small impact. Firms' strategic price response is small and thus has a small impact on demand. However, the magnitude of price and market share changes is very heterogeneous across firms and reformulated categories as shown in Table F.1.

### 7.2 Assumption on the firms' behavior

We also assess to what extent firms' behavior assumptions affect the estimated impact of the policy on the change in nutrient intake. Table G.2 provides a comparison of the changes in nutrient intake for three alternative modeling assumptions presented in Section 6. The first case refers to passive pricing and no reformulation of products. This is a frequent assumption made to evaluate the impact of taxation. The second case refers to strategic pricing without product reformulation. Last, the third case refers to strategic pricing and product reformulation.

Assuming passive pricing and no reformulation, we estimate that taxation induces a decrease in caloric sweetener intake by 13.5%. Considering strategic pricing leads to an estimated decrease by 16.4%. Finally integrating both strategic pricing and product reformulation leads to an estimated decrease in the caloric sweetener content by 21.1%. In other words, when strategic pricing is considered, ignoring reformulation leads to under-estimate tax impact by 22.2%. While ignoring both strategic pricing and product reformulation leads to under-estimate its impact by 36% in relative term.

### 7.3 Nutrient intake implications of the outside option considered

When consumers face a global price increase and do not want to buy any desserts in the market, it is unlikely that they stop consuming, they rather buy alternative substitutes, namely the outside option. In our set-up, the outside option includes other desserts (fruit and pastry) and cheese, which seems to be a common substitute for dairy desserts in France. We assume that this substitute exerts a weak competition pressure on the French dessert market, its definition then does not affect prices. However, the choice of the outside option has some implications on demand and then on nutrient intake. In this subsection, the nutritional composition of the outside option is taken into account in the calculations of change in nutrient consumption.

When considering the increase in the market share of the outside option of 3.8 percentage point due to the tax scenario with reformulation (Table G.3) and its nutritional composition, the consumption of sugar still decreases, but more moderately (8.7%) (see Table 3). A significant difference compared to the results that disregard the increase in the outside option market share is the 1.5% increase in fat consumption, as the fat content of the outside option is much higher than the average fat content of the four product categories considered. Overall, there is a fall in calories (-1.8%).[21]

# 8 Conclusion

We propose an analysis of the effects of a tax design that has been shown to be effective in both reducing purchases of taxed products and encouraging product reformulation: an excise tax proportional to the sugar content of products with a tier above which the product is taxed. We simulated its effects on consumer sugar purchases and surplus, as well as firms' profits, market shares and equilibrium prices for the French dessert market considering two tax scenarios. A first scenario in which no firm reformulate, and a second in which they set the caloric sweetener content of their products slightly below the tier to escape the tax and, when this is not possible, at the minimum level that is technically and sensory feasible. In our setting, reformulation is exogenous, but consumer choices can shift as product characteristics, such as sweetness and price, change in response to the tax.

Our results highlight four critical findings for the French dessert market. First, the choice of the level of the sugar tax threshold strongly affects the magnitude of tax-related price increase, the share of taxed and reformulated products, and therefore the magnitude of welfare effects: the lower the tax threshold, the most efficient the tax policy in terms of sugar consumption reduction, but the greater decrease in consumers' surplus and firms' profit whether or not firms reformulate. Second, a tiered sugar-based tax is more effective in reducing sugar consumption when firms reformulate to avoid or mitigate the tax. Third, we have shown that there is a strong heterogeneity in the variation of welfare at both category-firm level and across households. Switching to the tax-with-reformulation scenario can either benefit or harm a firm. Determining whether it benefits or harms the firm's profits in a product category requires an analysis of substitution effects within and between product categories, and between taxed

[21] The reported percent changes in nutrient intake including the change in the outside option market share cannot be directly compared with percent changes in nutrient intake in Table 3 as they are computed over the initial intake of the considered market; that is, the $J$ products for the four categories and the $J+1$ products when the outside option is included.

and non-taxed products. The position of the firm's portfolio in the sugar distribution of the dessert market and the impact of reformulation on cost and nutrient characteristics are key determinants in the variation in profits. Moreover, our analysis shows that the tax-with-reformulation scenario allows for better targeting the households with the highest consumption levels. Fourth, this paper has shown that ignoring the combined effects of price reactions and product reformulation leads to greatly under-estimate the impact of taxes on the intake of taxed nutrients. In our case, integrating these two effects into the analysis yields a change in the estimated reduction in sugar intake of 36%, which is of the order of Bercholz et al. (2022).

Although we acknowledge that our findings should be validated in other food markets, particularly in a market where the technical costs of product reformulation would be higher, we recommend setting the sugar tax threshold based on the sugar content distribution of targeted products in order not only to tax a large proportion of products, but also to maximize the number of products close to but above the threshold so that the reformulation is not too costly compared to the costs of the tax.

One limit of our analysis is that product reformulation is not endogenous in our setting, and we cannot claim that the scenario in which all firms reformulate their products is an equilibrium (in terms of characteristics). Modeling how firms endogenously adjust/reformulate their product portfolio would involve adding a second stage to the supply model in which firms simultaneously choose product offerings, including product characteristics, with the understanding that their actions and the actions of their rivals will affect demand and markups. We leave these developments to future research.

Moreover, the reformulation scenario is to some extent conservative, as it uses what is observed on the market as the range of possible changes to the product recipe. For a given type of a product, the amount of caloric sweetener used in a reformulated product will not be lower than the observed value of a product available on the market. As a consequence, we do not explore further reduction. Nor do we take into account the fact that companies may reformulate their products by replacing a caloric sweetener with a non-caloric one to maintain the sweetness. Evaluating this reformulation scenario would require estimating consumer preferences for non-caloric sweeteners in the demand model. However, only 14 out of 131 products contain non-caloric sweeteners, making it difficult to estimate preferences for non-caloric sweeteners and suggesting that this reformulation scenario may not yet be credible for the French dessert market.

The overall impact of the taxation scenarios on nutrient intake depends on the choice of the outside option. For example, in this study, the outside option is highly caloric (much more than the dessert products considered), and consequently the overall impact of taxation on caloric intake is only slightly negative. Therefore, some of the results should be interpreted with caution.

There are other debates about taxes that are not covered in this paper. In particular, there is no discussion of the possible regressivity of taxes and, more generally, of tax optimality, as in Allcott et al. (2019). To carry out this analysis, a more comprehensive optimal taxation setting should be developed. We leave these developments for further work.

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# Online appendix

## A Additional tables for descriptive statistics

Table A.1: **Average prices (€/kg) and market shares (%) by brands and product categories**

| | Product category | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Compote | | Yogurt | | Fromage blanc, petits suisse | | Other dairy dessert | |
| | Price | MS | Price | MS | Price | MS | Price | MS |
| **Firm 1** | | | | | | | | |
| Brand 1 | | | 2.58 | 1.78 | 3.32 | 1.19 | 3.08 | 2.04 |
| Brand 2 | | | 2.08 | 0.56 | 3.22 | 0.31 | 4.01 | 0.34 |
| Brand 3 | | | 4.96 | 0.13 | | | | |
| Brand 4 | | | 3.58 | 0.59 | | | | |
| Brand 5 | | | 2.70 | 1.92 | 4.05 | 0.60 | | |
| **Firm 2** | | | | | | | | |
| Brand 6 | | | 2.42 | 1.19 | 5.52 | 0.11 | 3.87 | 2.30 |
| **Firm 3** | | | | | | | | |
| Brand 7 | | | 1.95 | 0.62 | 2.74 | 0.54 | 3.91 | 0.12 |
| Brand 8 | | | 2.23 | 0.99 | | | | |
| Brand 9 | | | 2.30 | 0.38 | | | | |
| **Firm 4** | | | | | | | | |
| Brand 10 | 3.33 | 0.62 | 2.75 | 0.42 | 2.68 | 0.09 | 4.88 | 0.72 |
| **Firm 5** | | | | | | | | |
| Brand 11 | 3.34 | 0.59 | | | | | 4.67 | 0.20 |
| **Firm 6** | | | | | | | | |
| Brand 12 | | | 2.94 | 0.21 | 3.60 | 0.08 | 6.12 | 0.49 |
| Brand 13 | | | 3.71 | 0.19 | | | 3.82 | 0.20 |
| **PL firms** | 2.28 | 3.00 | 1.80 | 7.21 | 2.41 | 3.25 | 2.72 | 6.92 |
| **All** | 2.58 | 4.20 | 2.24 | 16.20 | 2.89 | 6.16 | 3.31 | 13.33 |

*Notes*: The reported price of a brand in a category is the average of the prices of that brand in that category across retailers, weighted by product market shares. MS stands for Market Shares.

Table A.2: **Aggregated own- and cross-price elasticities by product category**

| | Effect of 1% price increase on cross demand for: | | | |
|---|---|---|---|---|
| | Compote | Yogurt | Fromage blanc, petit suisse | Other dairy dessert |
| Compote | -2.26 | 0.12 | 0.12 | 0.13 |
| Yogurt | 0.42 | -1.73 | 0.41 | 0.41 |
| Fromage blanc, petit suisse | 0.20 | 0.20 | -2.32 | 0.21 |
| Other dairy dessert | 0.51 | 0.48 | 0.51 | -2.17 |

*Notes*: For each of the four categories we compute the change in demand for that category resulting from a 1% price increase. Computational details for aggregated elasticities are provided in Bonnet et al. (2018).

Table A.3: **Average margins (%) and marginal costs (€/kg) by brand and product category**

| | Product category | | | | |
|---|---|---|---|---|---|
| | Compote | Yogurt | Fromage blanc, petit suisse | Other dairy dessert | All |
| | | | *Margin* | | |
| **Firm 1** | | | | | |
| Brand_1 | | 53.38 | 41.77 | 43.41 | 46.57 |
| Brand_2 | | 54.98 | 43.07 | 36.92 | 46.84 |
| Brand_3 | | 33.82 | | | 33.82 |
| Brand_4 | | 39.53 | | | 39.53 |
| Brand_5 | | 47.47 | 36.88 | | 44.96 |
| **Firm 2** | | | | | |
| Brand_6 | | 48.10 | 28.86 | 36.87 | 40.37 |
| **Firm 3** | | | | | |
| Brand_7 | | 56.54 | 42.41 | 33.69 | 48.42 |
| Brand_8 | | 47.23 | | | 47.23 |
| Brand_9 | | 46.19 | | | 46.19 |
| **Firm 4** | | | | | |
| Brand_10 | 37.08 | 46.72 | 42.10 | 29.86 | 36.69 |
| **Firm 5** | | | | | |
| Brand_11 | 36.18 | | | 31.09 | 34.90 |
| **Firm 6** | | | | | |
| Brand_12 | | 40.20 | 35.17 | 27.05 | 31.40 |
| Brand_13 | | 35.17 | | 33.74 | 34.45 |
| **PLs** | 59.60 | 72.79 | 58.74 | 58.66 | 63.82 |
| **All** | **53.00** | **59.35** | **50.06** | **48.29** | **53.55** |
| | | | *Marginal cost* | | |
| **Firm 1** | | | | | |
| Brand_1 | | 1.36 | 1.96 | 1.77 | 1.67 |
| Brand_2 | | 0.95 | 1.88 | 2.53 | 1.63 |
| Brand_3 | | 3.33 | | | 3.33 |
| Brand_4 | | 2.17 | | | 2.17 |
| Brand_5 | | 1.45 | 2.56 | | 1.71 |
| **Firm 2** | | | | | |
| Brand_6 | | 1.32 | 3.94 | 2.54 | 2.18 |
| **Firm 3** | | | | | |
| Brand_7 | | 0.95 | 1.60 | 2.60 | 1.38 |
| Brand_8 | | 1.18 | | | 1.18 |
| Brand_9 | | 1.24 | | | 1.24 |
| **Firm 4** | | | | | |
| Brand_10 | 2.10 | 1.62 | 1.55 | 3.42 | 2.48 |
| **Firm 5** | | | | | |
| Brand_11 | 2.14 | | | 3.28 | 2.43 |
| **Firm 6** | | | | | |
| Brand_12 | | 1.78 | 2.34 | 4.53 | 3.57 |
| Brand_13 | | 2.43 | | 2.53 | 2.48 |
| **PLs** | 0.93 | 0.56 | 1.03 | 1.30 | 0.94 |
| **All** | **1.27** | **1.04** | **1.53** | **1.91** | **1.43** |

*Notes*: The reported marginal cost (margin) of a brand and a category is the weighted average (using market shares as weight) of the marginal costs (margins) of the products for each brand in each category.

Table A.4: **Content in fat, sugar and sweetness index by brand and product category (g / 100g of product)**

| | Compote | | | Yogurt | | | Fromage blanc, petit suisse | | | Other dairy dessert | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sugar | Sweetness | Fat | Sugar | Sweetness | Fat | Sugar | Sweetness | Fat | Sugar | Sweetness | Fat |
| **Firm 1** | | | | | | | | | | | | |
| Brand 1 | | | | 9.96 | 9.96 | 4.12 | 9.20 | 9.20 | 5.56 | 20.05 | 20.05 | 5.74 |
| Brand 2 | | | | 6.42 | 10.18 | 0.10 | 4.97 | 8.09 | 0.10 | 11.20 | 17.70 | 0.90 |
| Brand 3 | | | | 5.27 | 8.82 | 0.64 | | | | | | |
| Brand 4 | | | | 7.33 | 11.06 | 0.84 | | | | | | |
| Brand 5 | | | | 9.72 | 11.09 | 2.62 | 8.46 | 8.46 | 3.15 | | | |
| **Firm 2** | | | | | | | | | | | | |
| Brand 6 | | | | 9.11 | 10.60 | 2.17 | 19.37 | 19.37 | 8.11 | 16.46 | 16.68 | 7.03 |
| **Firm 3** | | | | | | | | | | | | |
| Brand 7 | | | | 11.08 | 11.08 | 4.77 | 5.91 | 5.91 | 2.42 | 16.90 | 16.90 | 2.20 |
| Brand 8 | | | | 11.16 | 13.88 | 1.90 | | | | | | |
| Brand 9 | | | | 12.20 | 12.20 | 1.40 | | | | | | |
| **Firm 4** | | | | | | | | | | | | |
| Brand 10 | 14.52 | 14.52 | 0.46 | 13.83 | 13.83 | 3.66 | 2.80 | 2.80 | 3.00 | 15.92 | 15.92 | 8.57 |
| **Firm 5** | | | | | | | | | | | | |
| Brand 11 | 14.82 | 14.82 | 0.50 | | | | | | | 14.11 | 14.11 | 3.21 |
| **Firm 6** | | | | | | | | | | | | |
| Brand 12 | | | | 5.46 | 7.75 | 1.03 | 3.29 | 3.29 | 2.88 | 17.66 | 17.66 | 7.42 |
| Brand 13 | | | | 6.09 | 6.09 | 2.40 | | | | 12.10 | 12.10 | 2.10 |
| **PLs** | 14.77 | 14.77 | 0.26 | 9.76 | 10.79 | 2.52 | 7.56 | 7.62 | 4.20 | 16.76 | 16.76 | 4.65 |
| **Average** | 14.74 | 14.74 | 0.32 | 9.69 | 10.91 | 2.56 | 7.77 | 7.96 | 4.03 | 16.95 | 17.15 | 5.36 |
| Min | 10.70 | 10.70 | 0.20 | 1.50 | 1.50 | 0.00 | 2.70 | 2.70 | 0.00 | 11.20 | 11.70 | 0.80 |
| First quartile | 11.65 | 11.65 | 0.28 | 4.80 | 6.00 | 0.90 | 3.60 | 3.60 | 2.20 | 14.75 | 15.20 | 2.95 |
| Median | 14.40 | 14.40 | 0.30 | 10.15 | 12.10 | 2.15 | 4.55 | 4.55 | 3.30 | 16.40 | 16.85 | 5.65 |
| Third quartile | 17.53 | 17.53 | 0.53 | 13.10 | 13.50 | 3.30 | 12.60 | 12.90 | 6.50 | 18.60 | 18.60 | 8.40 |
| Max | 18.60 | 18.60 | 0.90 | 17.20 | 17.20 | 10.10 | 21.60 | 21.60 | 9.50 | 22.70 | 22.70 | 12.50 |

*Notes*: For each brand and product category, we report the weighted average sugar and fat content calculated across all brand products.

Table A.5: **Initial dessert consumption (kg/year) and sugar, lipid (kg/year) and calorie (thousand Kcal) intake per capita by household type**

| **Household** | | **Children** | | **Social class** | | | **Adults obese** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **All** | **With** | **Without** | **Rich** | **Medium** | **Poor** | **None** | **One** | **All** |
| Dessert | 32 | 21 | 39 | 39 | 33 | 24 | 32 | 29 | 38 |
| Sugar | 3.9 | 2.5 | 5.0 | 4.9 | 4.0 | 3.0 | 4.0 | 3.6 | 4.6 |
| Lipid | 1.1 | 0.8 | 1.4 | 1.3 | 1.1 | 0.8 | 1.1 | 1.0 | 1.3 |
| Calorie | 33.1 | 21.7 | 41.2 | 40.3 | 33.8 | 25.0 | 33.1 | 29.9 | 38.8 |

*Notes*: The per capita consumption and intake of a household are calculated using the following rule: we count one point for an individual 15 years of age or older, and 0.5 point for an individual less than 15 years of age.

## B Reformulation scenario

Table B.1: **Variations in sugar and lipid product content and production cost due to reformulation**

| | Compotes | | | Yogurts | | | Fromages blancs, petits suisses | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sugar | Lipid | Cost | Sugar | Lipid | Cost | Sugar | Lipid | Cost |
| **Firm 1** | | | | | | | | | |
| Brand 1 | | | | -1.61 | 0.10 | -0.47 | -1.59 | 0.10 | 0.22 |
| Brand 2 | | | | 0.00 | 0.00 | -0.00 | 0.00 | 0.00 | -0.00 |
| Brand 3 | | | | 0.00 | 0.00 | -0.00 | | | |
| Brand 4 | | | | -0.45 | 0.01 | -0.13 | | | |
| Brand 5 | | | | -0.42 | 0.02 | -0.12 | -0.95 | 0.04 | 0.13 |
| **Firm 2** | | | | | | | | | |
| Brand 6 | | | | -1.11 | 0.04 | -0.33 | -5.95 | 0.79 | 0.81 |
| **Firm 3** | | | | | | | | | |
| Brand 7 | | | | -0.81 | 0.02 | -0.24 | -0.16 | 0.01 | 0.02 |
| Brand 8 | | | | -2.04 | 0.07 | -0.60 | | | |
| Brand 9 | | | | -2.30 | 0.04 | -0.68 | | | |
| **Firm 4** | | | | | | | | | |
| Brand 10 | -2.46 | 0.00 | -0.41 | -2.26 | 0.10 | -0.66 | 0.00 | 0.00 | 0.00 |
| **Firm 5** | | | | | | | | | |
| Brand 11 | -1.44 | 0.00 | -0.24 | | | | | | |
| **Firm 6** | | | | | | | | | |
| Brand 12 | | | | 0.00 | -0.00 | -0.00 | 0.00 | -0.00 | -0.00 |
| Brand 13 | | | | -0.40 | 0.01 | -0.11 | | | |
| **PLs** | -1.95 | 0.00 | -0.32 | -1.28 | 0.06 | -0.38 | -0.75 | 0.05 | 0.10 |
| **Average** | -1.96 | 0.00 | -0.32 | -1.17 | 0.05 | -0.34 | -0.90 | 0.06 | 0.12 |

*Notes*: Variations in sugar and lipid are calculated in grams per 100g of product. Variations in cost are in cents per kg.

### B.1 Recipe calculation

**Step 1: Determination of recipes prior to food reformulation**

Since nutritional information necessary to determine the recipes is not reported in the Kantar database, we used Oqali database which records the ingredient lists and nutrition facts label as displayed on the packaging, at the branded product level. We used compotes and fruit purees, and milk products Oqali dataset, built in 2009. We documented product characteristics for 476 marketed yogurts, 183 FBPS and 408 compotes and fruit purees. These data were completed by carrying out an Internet research for products not collected by Oqali. This concerned 67 additional products.

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

- the sweetening ingredients. Different sweeteners can be used to cook the product. Sugar is the most common but glucose syrup, inverted sugar and other types of sweetening ingredients can also be used;
- a matrix ingredient, which substitutes the sweetening ingredients in case of reformulation. The matrix ingredient is 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. This corresponds to the aroma used in flavored yogurts or fruits in fruity yogurts, for example.

The amounts of each main ingredient were deduced from both the ingredients list and the nutrition facts. In the ingredients statement, ingredients are listed in descending order of weight. Moreover, in some cases, the ingredients list indicates precisely the quantity of one or several ingredients. Thus, in the best case, all the necessary information to determine the recipe of a product was found in the ingredients list. In other cases, the ingredients list provided some indications that were not precise enough to determine the recipe. In such cases, we used the fact that the nutrient content of a product is the quantity-weighted average of the nutrient content of its ingredients. We were able, in most cases, to determine the quantity of each main ingredients, by solving the system of equations. Otherwise, some realistic hypotheses based on the usual recipe of the product or its ingredients had to be made. When the information displayed on the packaging was not sufficient to determine the recipe without making strong assumptions, the recipe was not estimated and its characteristics have not been taken into account when aggregating data at the group of products' level (see step 2). This was the case for only a few products.

**Step 2: Aggregation into the 131 groups of products of our demand model**

Individual marketed products recorded in Oqali dataset were assigned to one of the 131 groups of products, as defined in the demand model. Thus, they were aggregated based on their type (yogurts, fromages blancs/petits suisses, compotes, other dairy desserts), brand, aroma (plain, sweetened, flavored, fruits), and nutritional composition (fat and sugar contents). Mean nutritional composition and mean recipe (amounts of sweetening and matrix ingredients) were computed for the 131 groups of products.

### B.2 Computation of the minimum amount of added sugar

The minimum amount of added sweeteners to use has then been estimated for each of the following 18 recipes:

- sweet yogurt with skimmed, semi-skimmed, or whole milk;
- flavored yogurt with skimmed, semi-skimmed, or whole milk, and flavored Greek yogurt;
- fruit yogurt with skimmed, semi-skimmed, or whole milk and fruit Greek yogurt;
- fruit petits suisses with semi-skimmed, or whole milk;
- flavored fromages blancs with skimmed milk;
- fruit fromages blancs with semi-skimmed, or whole milk;
- compotes, diet compotes.

To simplify, we considered that sugar is the only sweetener used when minimizing the amount of added sweeteners. In order to determine the minimum content of sugar technically feasible and sensory acceptable in a given product, we applied an optimization model. Specifically, we minimized the proportion of sugar $y_s$ subject to the technical constraints of formulation, such as product sweetness, texture or other constraints related to manufacturing. Constraints were identified during previous interviews with manufacturers. They are defined in Table B.2. The limit values of constraint were derived from Oqali dataset, by neglecting the extreme observations corresponding to very specific recipes. Table B.3 reports those extrema and the values set to calibrate the optimization models for the 18 recipes. Ingredient characteristics used in the constraints are shown in table B.4. The optimization models were solved using Simplex LP Solving method of Excel Solver, except for fruit dairy products for which we ran the non-linear GRG algorithm, starting from different sets of initial values in order to make sure the solution is not a local optimum. The calculated minimum amount of sugar are reported in Table B.5.

Then we assigned the minimum amount of sugar to be added to each of the 131 groups of products defined for the demand model, by matching the recipes.

Tables B.6 and B.7 provide the mean contents in sugar and fat, before and after minimizing the amount of added sweeteners, by brands and product categories.

Table B.2: **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 | $B^- \leq \frac{(B_m * y_m + B_s * y_s)}{(y_m + y_s)} \leq B^+$ <br> 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 | $S^- \leq \frac{(S_m * y_m + S_s * y_s)}{(y_m + y_s)} \leq S^+$ <br> where $S_i$ is the sweetening power of ingredient i |
| Quantity | The sum of the proportions of each ingredient must be equal to 100% | $y_m + y_s + y_f = 100\%$ <br> Due to other ingredients encountered such as water or starch, this constraint has been released for sweet and flavored dairy product with skimmed milk, as follows: $y_m + y_s + y_f \leq 100\%$ |
| Fermentation | Sweetening ingredients, in too high proportion, can inhibit the growth of bacteria, and thus the fermentation process | $\frac{B_s * y_s}{(y_m + y_s)} \leq F^+$ <br> 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 | $\frac{y_m * Prot_m}{(y_m + y_s)} \geq G^+$ <br> where $Prot_m$ is the protein content of matrix ingredient |
| Regulation | 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 | $y_s + y_f \leq 30\%$ |

*Notes*: fermentation and gelation constraints could have been released in the case of fruit dairy products because part of the sugar can be added after fermentation and gelation, via the fruits mix.

Table B.3: **Constraints specifications**

| **Recipe** | **Matrix ingredients** | **Fixed ingredients** | $B^-$ | $B^+$ | $S^-$ | $S^+$ | $F^+$ | $G^+$ |
|---|---|---|---|---|---|---|---|---|
| Sweet yogurt with skimmed milk | Plain yogurt with skimmed milk | - | 18.6% | 18.9% | 10.6 | 12 | 11.7% | 3.50% |
| Sweet yogurt with semi-skimmed milk | Plain yogurt with semi-skimmed milk | - | 19.5% | 22.4% | 9.7 | 11.9 | 11.7% | 3.85% |
| Sweet yogurt with whole milk | Plain yogurt with whole milk | - | 21.1% | 22.1% | 9.4 | 14.2 | 11.7% | 3.80% |
| Flavored yogurt with skimmed milk | Plain yogurt with skimmed milk | Aroma 0.5% | 18.6% | 18.9% | 10.7 | 12 | 11.8% | 3.50% |
| Flavored yogurt with semi-skimmed milk | Plain yogurt with semi-skimmed milk | Aroma 0.5% | 18.0% | 21.3% | 8.3 | 11.8 | 11.8% | 3.80% |
| Flavored yogurt with whole milk | Plain yogurt with whole milk | Aroma 0.5% | 20.4% | 22.6% | 9.3 | 11.2 | 11.8% | 3.63% |
| Flavored Greek yogurt | Plain yogurt with whole milk and cream | Aroma 0.5% | 21.4% | 24.8% | 9.0 | 13.3 | 11.8% | 3.38% |
| Fruit yogurt with skimmed milk | Plain yogurt with skimmed milk | Fruits $\leq$ 13% | 18% | 19.4% | 9.5 | 10 | 16.1% | 4.10% |
| Fruit yogurt with semi-skimmed milk | Plain yogurt with semi-skimmed milk | Fruits $\leq$ 7.4% | 19.4% | 24.3% | 9.2 | 14.4 | 16.1% | 3.60% |
| Fruit yogurt with whole milk | Plain yogurt with whole milk | Fruits $\leq$ 19% | 20.3% | 27.4% | 8.7 | 16.3 | 16.1% | 3.50% |
| Fruit Greek yogurt | Plain yogurt with whole milk and cream | Fruits $\leq$ 9% | 22% | 29.3% | 8.5 | 16.9 | 16.1% | 3.30% |
| Fruit "petit suisses" semi-skimmed milk | Plain "petit suisses" semi-skimmed milk | Fruits $\leq$ 7% | 25.7% | 26% | 11.4 | 16.3 | - | - |
| Fruit "petit suisses" whole milk | Plain "petit suisses" whole milk | Fruits $\leq$ 13% | 25.58% | 30.1% | 13 | 15.7 | - | - |
| Flavored fromages blancs with skimmed milk | Plain fromages blancs with skimmed milk | Aroma 0.5% | 21.3% | 22.8% | 10.9 | 11.8 | - | - |
| Fruit fromages blancs with semi-skimmed milk | Plain fromages blancs with semi-skimmed milk | Fruits $\leq$ 8% | 22.95% | 30.4% | 8.3 | 18.1 | - | - |
| Fruit fromages blancs with whole milk | Plain fromages blancs with whole milk | Fruits $\leq$ 10% | 28.2% | 33.4% | 11.6 | 19.3 | - | - |
| Compotes | Fruit puree | Additives such as ascorbic acid 0.1% | 19.4% | 30.1% | 16.5 | 26.8 | - | - |
| Diet compotes | Fruit puree | Additives such as ascorbic acid 0.1% | 17.4% | 23.1% | 14.5 | 21.5 | - | - |

Table B.4: **Dry extract, sweetening power and protein content of ingredients**

| **Ingredient** | **Type of ingredient** | **Dry extract** $B_i$ | **Sweetening power** $S_i$ | **Protein content** $Prot_i$ |
|---|---|---|---|---|
| Plain yogurt with skimmed milk | Matrix ingredient (m) | 11.70% | 1.42 | 4.50% |
| Plain yogurt with semi-skimmed milk | Matrix ingredient (m) | 12.30% | 1.39 | 4.25% |
| Plain yogurt with whole milk | Matrix ingredient (m) | 14.30% | 1.36 | 4.20% |
| Plain yogurt with whole milk and cream | Matrix ingredient (m) | 15.75% | 1.21 | 3.92% |
| Plain "petit suisses" semi-skimmed milk | Matrix ingredient (m) | 16.3% | 0.576 | - |
| Plain "petit suisses" whole milk | Matrix ingredient (m) | 19.5% | 0.544 | - |
| Plain fromages blancs with skimmed milk | Matrix ingredient (m) | 13.2% | 0.680 | - |
| Plain fromages blancs with semi-skimmed milk | Matrix ingredient (m) | 16.3% | 0.576 | - |
| Plain fromages blancs with whole milk | Matrix ingredient (m) | 19.5% | 0.544 | - |
| Fruit puree | Matrix ingredient (m) | 15.3% | 12.70 | - |
| Sugar | Sweetening ingredient (s) | 100% | 100 | - |

Table B.5: **Optimized minimum amount of added sugar**

| **Recipe** | **Minimum amount of added sugar** $Y_s min$ |
|---|---|
| Sweet yogurt with skimmed milk | 9.5% |
| Sweet yogurt with semi-skimmed milk | 8.4% |
| Sweet yogurt with whole milk | 8.2% |
| Flavored yogurt with skimmed milk | 9.5% |
| Flavored yogurt with semi-skimmed milk | 7.0% |
| Flavored yogurt with whole milk | 8.0% |
| Flavored Greek yogurt | 7.8% |
| Fruit yogurt with skimmed milk | 7.1% |
| Fruit yogurt with semi-skimmed milk | 7.5% |
| Fruit yogurt with whole milk | 6.0% |
| Fruit Greek yogurt | 6.8% |
| Fruit "petit suisses" with semi-skimmed milk | 10.4% |
| Fruit "petit suisses" with whole milk | 10.9% |
| Flavored fromages blancs with skimmed milk | 10.2% |
| Fruit fromages blancs with semi-skimmed milk | 7.3% |
| Fruit fromages blancs with whole milk | 10.0% |
| Compotes | 4.8% |
| Diet Compotes | 2.5% |

Table B.6: **Sugar content of products before and after reformulation by brand and product category (g/100g of product)**

| | Product category | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Compote | | Yogurt | | Fromage blanc, petit suisse | | Other dairy dessert | |
| | Before | After | Before | After | Before | After | Before | After |
| **Firm 1** | | | | | | | | |
| Brand_1 | | | 9.96 | 7.97 | 9.20 | 6.92 | 20.05 | 20.03 |
| Brand_2 | | | 6.42 | 6.42 | 4.97 | 4.97 | 11.20 | 11.20 |
| Brand_3 | | | 5.27 | 5.26 | | | | |
| Brand_4 | | | 7.33 | 6.64 | | | | |
| Brand_5 | | | 9.72 | 8.86 | 8.46 | 7.03 | | |
| **Firm 2** | | | | | | | | |
| Brand_6 | | | 9.11 | 7.65 | 19.37 | 11.31 | 16.46 | 16.45 |
| **Firm 3** | | | | | | | | |
| Brand_7 | | | 11.08 | 9.83 | 5.91 | 5.42 | 16.90 | 16.90 |
| Brand_8 | | | 11.16 | 8.79 | | | | |
| Brand_9 | | | 12.20 | 9.90 | | | | |
| **Firm 4** | | | | | | | | |
| Brand_10 | 14.52 | 11.87 | 13.83 | 11.60 | 2.80 | 2.80 | 15.92 | 15.83 |
| **Firm 5** | | | | | | | | |
| Brand_11 | 14.82 | 13.14 | | | | | 14.11 | 14.01 |
| **Firm 6** | | | | | | | | |
| Brand_12 | | | 5.46 | 5.46 | 3.29 | 3.29 | 17.66 | 17.61 |
| Brand_13 | | | 6.09 | 5.69 | | | 12.10 | 12.10 |
| **PLs** | 14.77 | 12.64 | 9.76 | 7.93 | 7.56 | 6.34 | 16.76 | 16.73 |
| **Average** | 14.74 | 12.59 | 9.69 | 8.06 | 7.77 | 6.30 | 16.95 | 16.85 |
| Min | 10.70 | 10.70 | 1.50 | 1.50 | 2.70 | 0.00 | 11.20 | 11.20 |
| First quartile | 11.65 | 11.65 | 4.80 | 4.80 | 3.60 | 3.60 | 14.75 | 14.75 |
| Median | 14.40 | 12.56 | 10.15 | 9.85 | 4.55 | 4.50 | 16.40 | 16.40 |
| Third quartile | 17.53 | 13.44 | 13.10 | 10.84 | 12.60 | 10.49 | 18.60 | 18.60 |
| Max | 18.60 | 15.80 | 17.20 | 13.36 | 21.60 | 15.65 | 22.70 | 22.70 |

Note: Products are reformulated when the sugar content exceeds 12 g for compotes and 10 g for other product categories in order to reduce the amount of the tax or even avoid it altogether, if possible. These reformulations take place within the limits calculated in section B.

Table B.7: **Fat content of prodcuts before and after reformulation by brand and product category (g/100g of product)**

| | Product category | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Compote | | Yogurt | | Fromage blanc, petit suisse | | Other dairy dessert | |
| | Before | After | Before | After | Before | After | Before | After |
| **Firm 1** | | | | | | | | |
| Brand_1 | | | 4.12 | 4.23 | 5.56 | 5.75 | 5.74 | 5.70 |
| Brand_2 | | | 0.10 | 0.10 | 0.10 | 0.10 | 0.90 | 0.90 |
| Brand_3 | | | 0.64 | 0.64 | | | | |
| Brand_4 | | | 0.84 | 0.80 | | | | |
| Brand_5 | | | 2.62 | 2.54 | 3.15 | 3.22 | | |
| **Firm 2** | | | | | | | | |
| Brand_6 | | | 2.17 | 2.20 | 8.11 | 8.04 | 7.03 | 7.14 |
| **Firm 3** | | | | | | | | |
| Brand_7 | | | 4.77 | 5.19 | 2.42 | 2.38 | 2.20 | 2.20 |
| Brand_8 | | | 1.90 | 1.87 | | | | |
| Brand_9 | | | 1.40 | 1.44 | | | | |
| **Firm 4** | | | | | | | | |
| Brand_10 | 0.46 | 0.41 | 3.66 | 3.77 | 3.00 | 3.00 | 8.57 | 8.60 |
| **Firm 5** | | | | | | | | |
| Brand_11 | 0.50 | 0.51 | | | | | 3.21 | 3.17 |
| **Firm 6** | | | | | | | | |
| Brand_12 | | | 1.03 | 1.04 | 2.88 | 2.88 | 7.42 | 7.43 |
| Brand_13 | | | 2.40 | 2.41 | | | 2.10 | 2.10 |
| **PLs** | 0.26 | 0.27 | 2.52 | 2.42 | 4.20 | 4.11 | 4.65 | 4.82 |
| **Average** | 0.32 | 0.32 | 2.56 | 2.48 | 4.03 | 3.95 | 5.36 | 5.48 |
| Min | 0.20 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.80 | 0.80 |
| First quartile | 0.28 | 0.28 | 0.90 | 0.90 | 2.20 | 2.20 | 2.95 | 2.95 |
| Median | 0.30 | 0.30 | 2.15 | 2.20 | 3.30 | 3.32 | 5.65 | 5.65 |
| Third quartile | 0.53 | 0.53 | 3.30 | 3.31 | 6.50 | 6.73 | 8.40 | 8.40 |
| Max | 0.90 | 0.90 | 10.10 | 10.10 | 9.50 | 10.09 | 12.50 | 12.50 |

Note: Products are reformulated when the sugar content exceeds 12 g for compotes and 10 g for other product categories in order to reduce the amount of the tax or even avoid it altogether, if possible. These reformulations take place within the limits calculated in section B.

## C Estimation and results of the demand model

### C.1 Identification of demand estimates

This method relies on the assumption that all product characteristics are independent of the error term $\varepsilon_{ijt}$. However, assuming $\varepsilon_{ijt} = \xi_{jt} + e_{ijt}$ where $\xi_{jt}$ is a product-specific error term varying across periods and $e_{ijt}$ is an individual-specific error term, the independence assumption cannot hold if unobserved factors included in $\xi_{jt}$ (and hence in $\varepsilon_{ijt}$) such as promotions, displays, and advertising are correlated with observed characteristics $X_{jt}$. For instance, we do not know the amount of advertising expenditure that firms incur each month for their brand. This effect is thus included in the error term because advertising might play a role in the choice of products by households. As advertising is an appreciable share of production costs, it is obviously correlated with prices. To solve the problem that omitted product characteristics might be correlated with prices, we use a control function approach, as in Petrin and Train (2010). We then regress prices on instrumental variables ($W_{jt}$) and the exogenous variables $X_j$ of the demand equation :

$$p_{jt} = W_{jt}\gamma + X_{jt}\mu + \eta_{jt}$$

where $\eta_{jt}$ is an error term that captures the remaining unobserved variations in prices. The estimated error term $\widehat{\eta}_{jt}$ of the price equation includes some omitted variables such as advertising variations and promotions that could explain price variations across products and time periods. Prices are now uncorrelated with the new product-specific error term varying across periods ($\zeta_{jt} = \xi_{jt} - \lambda\widehat{\eta}_{jt}$). We then write the equation 1

$$s_{jt}(\theta) = \int \frac{\exp(\beta_{b(j)} + \gamma_{c(j)} - \alpha_i p_{jt} + \delta_{Si}S_j + \delta_{Li}L_j + \delta_{SL}S_jL_j + \theta_N N_j + \theta_F F_j + \lambda\widehat{\eta}_{jt})}{1 + \sum_{k=1}^{J_t} \exp(\beta_{b(k)} + \gamma_{c(k)} - \alpha_i p_{kt} + \delta_{Si}S_k + \delta_{Li}L_k + \delta_{SL}S_kL_k + \theta_N N_k + \theta_F F_k + \lambda\widehat{\eta}_{kt})}\, dP_\nu(\nu_i)dP_D(D_i) \tag{6}$$

where $\lambda$ is the estimated parameter associated with the estimated error term of the first stage.

In practice, we use BLP's instruments as the total number of competing products offered by the other manufacturers in each category, the percentage of fruit products and plain products, and the average sugar taste offered by the other manufacturers in each category. Table C.1 shows the results of the estimation of the price regression. All instrumental variables are significant and the F-test amounts to 12.08, meaning that the instrumental variables are not weak.

Table C.1: **Results on Price Equation**

| **Variable** | **Mean (Std)** |
|---|---|
| **Instrumental Variables** | |
| Distance of competing products: nature | 0.18 (0.01)* |
| Distance of competing products: sugar content | 0.00 (0.00)*** |
| Number of competing products | -0.16 (0.04)*** |
| Input cost: cream | 0.00 (0.00)*** |
| **Exogenous Variables of the utility Function** | |
| Compote | - |
| Yogurt | 0.68 (0.67) |
| FBPS | -0.88 (0.72) |
| ODD | -3.03 (0.84)*** |
| Fruit | -0.10 (0.13) |
| Nature | -0.30 (0.19) |
| Taste: sweetness | 0.04 (0.02) |
| Taste: fat | 0.15 (0.03)*** |
| Interaction sweetness × fat | 0.00 (0.00)* |
| $R^2$ | 0.95 |
| IV F-test | 12.37 (0.00) |
| Number of observations | 653 |

* $p < 0.05$, *** $p < 0.001$; Coefficients $\beta_{b(j)}$ not shown.

### C.2 Results of the random coefficient logit model and price elasticities

Table C.2: **Results of the random coefficient logit model**

| | Estimate (std) |
|---|---|
| Price | |
| $\alpha$ | 0.130*** (0.000) |
| Without children | 0.029*** (0.000) |
| Middle income | 0.013*** (0.000) |
| Poor income | 0.031*** (0.000) |
| One obese | 0.009*** (0.000) |
| All obese | 0.017*** (0.000) |
| $\sigma$ | 0.547*** (0.000) |
| Compote | - |
| Yogurt | -1.434*** (0.000) |
| FFPS | -1.005*** (0.000) |
| ODD | -0.184*** (0.000) |
| Fruit in Yogurt | 0.491*** (0.000) |
| Nature | 0.010*** (0.000) |
| Sugar taste | -0.023*** (0.000) |
| Without children | 0.051*** (0.000) |
| One obese | -0.002*** (0.000) |
| All obese | -0.006*** (0.000) |
| Fat taste | 0.022*** (0.000) |
| Without children | -0.012*** (0.000) |
| One obese | 0.004*** (0.000) |
| All obese | 0.002*** (0.000) |
| Sugar taste* Fat taste | 0.857*** (0.000) |
| Error term | 0.509*** (0.000) |
| | |
| LL | -3,677,800 |
| Number of observations | 1,528,220 |
| Coefficients $\beta_{b(j)}$ not shown | |

*Notes*: FBPS and ODD stand for fromage blanc and petit suisse, and other dairy dessert, respectively. *** means that coefficients are significant at 1% level.

Table C.3: **Average own-price elasticities by brands and product categories**

| | Compote | Yogurt | Fromage blanc, petit suisse | Other dairy dessert |
|---|---|---|---|---|
| **Firm 1** | | | | |
| Brand 1 | | -2.29 | -2.76 | -2.65 |
| Brand 2 | | -2.08 | -2.70 | -3.10 |
| Brand 3 | | -3.45 | | |
| Brand 4 | | -2.91 | | |
| Brand 5 | | -2.43 | -3.10 | |
| **Firm 2** | | | | |
| Brand 6 | | -2.26 | -3.69 | -2.97 |
| **Firm 3** | | | | |
| Brand 7 | | -1.94 | -2.46 | -3.07 |
| Brand 8 | | -2.18 | | |
| Brand 9 | | -2.23 | | |
| **Firm 4** | | | | |
| Brand 10 | -2.78 | -2.39 | -2.44 | -3.45 |
| **Firm 5** | | | | |
| Brand 11 | -2.80 | | | -3.33 |
| **Firm 6** | | | | |
| Brand 12 | | -2.57 | -2.90 | -3.86 |
| Brand 13 | | -2.94 | | -3.02 |
| **PLs** | -2.19 | -1.85 | -2.26 | -2.37 |
| **All** | -2.37 | -2.13 | -2.52 | -2.68 |

Note: The reported own-price elasticity of a brand and a category is the weighted average (using market shares as weight) of the own-price elasticity of products of this brand in this category.

## D Additional tables and figures for Section 5

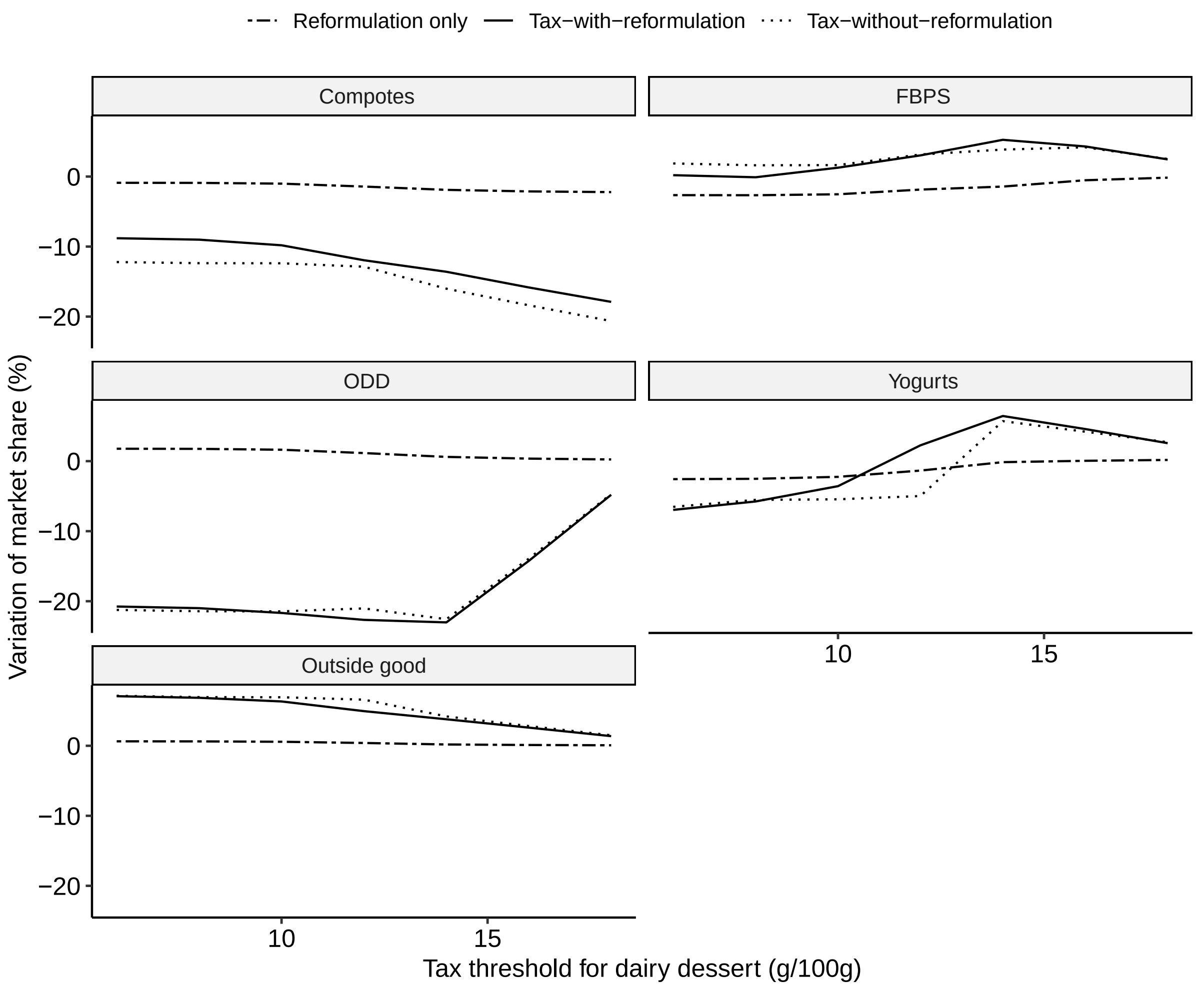


Figure D.1: Changes in the market shares by dessert category with respect to dairy dessert tax threshold (set at 12g/100g for compotes) for the three policy scenarios

## E The welfare effects of changing the sugar tax threshold for compote

We also analyze how sugar consumption, consumer welfare, firms' profit and tax revenue change with respect to the sugar tax threshold for compote. The variations in sugar consumption for other levels of compote tax thresholds are displayed in Figure E.1 in Appendix for the tax policy with reformulation. Only the magnitude of sugar consumption fall varies with the level of the tax threshold of compote: the overall pattern of sugar consumption variation is similar for the three levels of the tax thresholds of compotes. We get similar results for the tax policy scenarios without reformulation (not shown). Profit variations are almost identical for compote threshold values equal to 14 and 16g/100g, while they are higher for value equal to 12g/100g (see Figure E.2 in Appendix). Regarding tax revenues, we obtain exactly the same shape (see Figure E.3 in Appendix) for the three tax threshold levels, and only the magnitudes of the variations in revenue vary. Analogous explanations to those for the variations in sugar consumption, consumer welfare, firms' profit and tax revenue with respect to dairy tax threshold can be given. The higher the compote threshold, the fewer products taxed/reformulated, the lower the decrease in sugar consumption and consumers' surplus, and profit loss, and the smaller the tax revenue. The non-linear pattern of the variations in the four welfare measures mainly results from the nonlinear pattern of the evolution of the share of non-reformulated/taxed products and the tax-related price increase with respect to dairy tax threshold (see Figure E.4).

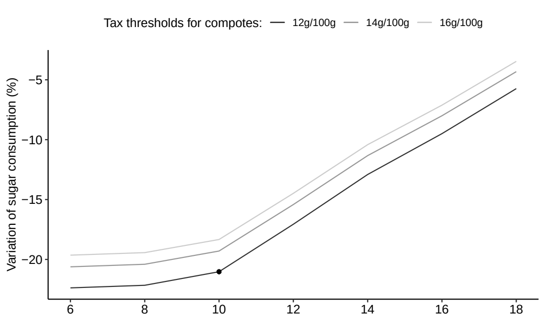


Figure E.1: Changes in sugar consumption with respect to three levels of sugar tax threshold for compotes (12, 14 and 16g/100g), for the tax policy with reformulation

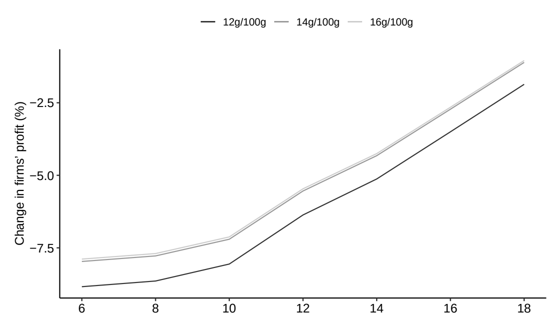


Figure E.2: Changes in firms' profit with respect to three levels of sugar tax threshold for compotes (12, 14 and 16g/100g), for the tax policy with reformulation

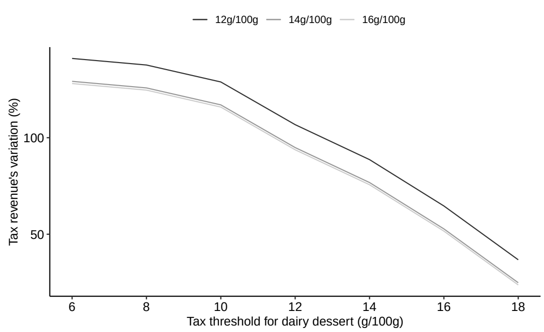


Figure E.3: Changes in tax revenue with respect to three levels of sugar tax threshold for compotes (12, 14 and 16g/100g), for the tax policy with reformulation

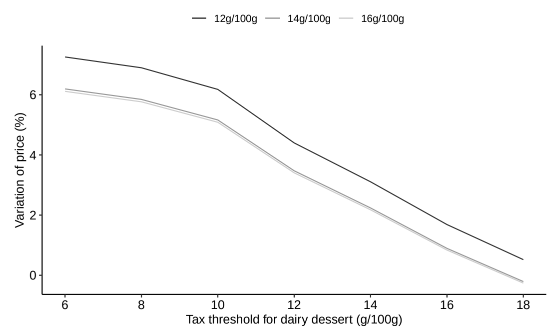


Figure E.4: Changes in price with respect to three levels of tax threshold for compotes (12, 14 and 16g/100g), for the tax policy with reformulation

# F Additional tables and figures for Section 6

Table F.1: **Product reformulation only: Changes in average price (€/kg) and market share (%) across brands and product categories**

| | Compote | | Yogurt | | FBPS | | ODD | | All | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Price | MS | Price | MS | Price | MS | Price | MS | Price | MS |
| **Firm 1** | | | | | | | | | | |
| Brand 1 | | | -0.09 | -5.35 | -0.06 | -5.52 | 0.00 | 1.69 | -0.04 | -2.52 |
| Brand 2 | | | 0.00 | 1.24 | 0.00 | 1.45 | 0.00 | 1.87 | 0.00 | 1.47 |
| Brand 3 | | | 0.00 | 1.73 | | | | | 0.00 | 1.73 |
| Brand 4 | | | 0.00 | 0.82 | | | | | 0.00 | 0.82 |
| Brand 5 | | | 0.00 | 0.18 | 0.01 | -1.36 | | | -0.01 | -0.19 |
| **Firm 2** | | | | | | | | | | |
| Brand 6 | | | 0.00 | -1.63 | 0.15 | -27.49 | 0.01 | 1.51 | 0.00 | -0.37 |
| **Firm 3** | | | | | | | | | | |
| Brand 7 | | | 0.01 | -0.82 | 0.00 | 0.64 | 0.00 | 1.66 | 0.01 | 0.03 |
| Brand 8 | | | 0.00 | -3.94 | | | | | 0.00 | -3.94 |
| Brand 9 | | | 0.00 | -2.71 | | | | | 0.00 | -2.71 |
| **Firm 4** | | | | | | | | | | |
| Brand 10 | 0.00 | -2.45 | -0.05 | -5.46 | 0.00 | 1.03 | 0.00 | 1.71 | 0.01 | -1.34 |
| **Firm 5** | | | | | | | | | | |
| Brand 11 | 0.00 | -0.63 | | | | | 0.00 | 1.60 | 0.01 | -0.06 |
| **Firm 6** | | | | | | | | | | |
| Brand 12 | | | 0.00 | 1.14 | 0.00 | 1.13 | 0.01 | 1.79 | 0.01 | 1.55 |
| Brand 13 | | | 0.00 | 0.38 | | | 0.00 | 1.41 | 0.00 | 0.90 |
| **Pls** | 0.00 | -0.79 | -0.03 | -2.65 | -0.02 | -1.94 | 0.00 | 1.63 | -0.01 | -0.81 |
| **All** | 0.00 | -1.01 | -0.02 | -2.24 | -0.03 | -2.53 | 0.00 | 1.63 | -0.01 | -0.86 |

*Notes*: The reported change in price of a brand and a category is the weighted average (using market shares as weights) of the change in price of all products from this brand in this category. FBPS and ODD stand for fromage blanc and petit suisse, and other dairy dessert, respectively.

Table F.2: **Taxation without product reformulation: Share of taxed products and tax level (€/kg) by brand and product category**

| | Compote | | Yogurt | | FBPS | | ODD | |
|---|---|---|---|---|---|---|---|---|
| | Share | Tax | Share | Tax | Share | Tax | Share | Tax |
| **Firm 1** | | | | | | | | |
| Brand 1 | | | 57% | 0.27 | 50% | 0.30 | 100% | 0.40 |
| Brand 2 | | | 0% | | 0% | | 100% | 0.22 |
| Brand 3 | | | 0% | | | | | |
| Brand 4 | | | 50% | 0.22 | | | | |
| Brand 5 | | | 50% | 0.26 | 50% | 0.26 | | |
| **Firm 2** | | | | | | | | |
| Brand 6 | | | 40% | 0.27 | 63% | 0.43 | 100% | 0.33 |
| **Firm 3** | | | | | | | | |
| Brand 7 | | | 75% | 0.25 | 20% | 0.29 | 100% | 0.34 |
| Brand 8 | | | 67% | 0.28 | | | | |
| Brand 9 | | | 100% | 0.24 | | | | |
| **Firm 4** | | | | | | | | |
| Brand 10 | 67% | 0.32 | 100% | 0.28 | 0% | | 100% | 0.32 |
| **Firm 5** | | | | | | | | |
| Brand 11 | 67% | 0.33 | | | | | 100% | 0.28 |
| **Firm 6** | | | | | | | | |
| Brand 12 | | | 0% | | 0% | | 100% | 0.35 |
| Brand 13 | | | 50% | 0.21 | | | 100% | 0.24 |
| **PLs** | 67% | 0.32 | 57% | 0.27 | 50% | 0.26 | 100% | 0.33 |
| **All** | 67% | 0.32 | 50% | 0.27 | 37% | 0.28 | 100% | 0.34 |

*Notes*: A proportional tax of €0.20 per 100g of sugar per kilo of product is implemented when product sugar content is above 12g for compote and 10g for other product categories. The reported share of taxed products for a brand is computed as the ratio, in percent, of the market share of taxed products and the total market share of the brand. The reported amount of the tax is a weighted average tax of taxed products, using market shares as weights. FBPS and ODD stand for fromage blanc and petit suisse, and other dairy dessert, respectively.

Table F.3: **Taxation with product reformulation: Share of taxed products and tax level (€/kg) by brand and product category**

| | Compote | | Yogurt | | FBPS | | ODD | |
|---|---|---|---|---|---|---|---|---|
| | Share | Tax | Share | Tax | Share | Tax | Share | Tax |
| **Firm 1** | | | | | | | | |
| Brand 1 | | | 29% | 0.22 | 50% | 0.24 | 100% | 0.40 |
| Brand 2 | | | 0% | | 0% | | 100% | 0.22 |
| Brand 3 | | | 0% | | | | | |
| Brand 4 | | | 25% | 0.21 | | | | |
| Brand 5 | | | 50% | 0.24 | 50% | 0.22 | | |
| **Firm 2** | | | | | | | | |
| Brand 6 | | | 20% | 0.26 | 63% | 0.31 | 100% | 0.33 |
| **Firm 3** | | | | | | | | |
| Brand 7 | | | 75% | 0.23 | 20% | 0.27 | 100% | 0.34 |
| Brand 8 | | | 33% | 0.25 | | | | |
| Brand 9 | | | 0% | | | | | |
| **Firm 4** | | | | | | | | |
| Brand 10 | 33% | 0.27 | 100% | 0.23 | 0% | | 100% | 0.32 |
| **Firm 5** | | | | | | | | |
| Brand 11 | 67% | 0.28 | | | | | 100% | 0.28 |
| **Firm 6** | | | | | | | | |
| Brand 12 | | | 0% | | 0% | | 100% | 0.35 |
| Brand 13 | | | 0% | | | | 100% | 0.24 |
| **PLs** | 67% | 0.26 | 50% | 0.23 | 30% | 0.24 | 100% | 0.33 |
| **All** | 56% | 0.27 | 35% | 0.23 | 30% | 0.24 | 100% | 0.34 |

*Notes*: A proportional tax of €0.20 per 100g of sugar per kilo of product is implemented when product sugar content is above 12g for compote and 10g for other product categories. The reported share of taxed products for a brand is computed as the ratio, in percent, of the market share of taxed products and the total market share of the brand. The reported amount of the tax is a weighted average tax of taxed products, using market shares as weights. FBPS and ODD stand for fromage blanc and petit suisse, and other dairy dessert, respectively.

Table F.4: **Taxation with and without product reformulation: Average pass-through rates across brands and product categories**

| | Product categories | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Compote | | Yogurt | | Fromage blanc, petit suisse | | Other dairy dessert | |
| | with | without | with | without | with | without | with | without |
| **Firm 1** | | | | | | | | |
| Brand 1 | | | 1.22 | 1.22 | 1.23 | 1.19 | 1.22 | 1.21 |
| Brand 2 | | | | | | | 1.19 | 1.19 |
| Brand 3 | | | | | | | | |
| Brand 4 | | | 1.21 | 1.20 | | | | |
| Brand 5 | | | 1.22 | 1.22 | 1.21 | 1.19 | | |
| **Firm 2** | | | | | | | | |
| Brand 6 | | | 1.20 | 1.21 | 1.19 | 1.14 | 1.18 | 1.17 |
| **Firm 3** | | | | | | | | |
| Brand 7 | | | 1.24 | 1.24 | 1.21 | 1.19 | 1.18 | 1.17 |
| Brand 8 | | | 1.22 | 1.22 | | | | |
| Brand 9 | | | | 1.22 | | | | |
| **Firm 4** | | | | | | | | |
| Brand 10 | 1.18 | 1.19 | 1.19 | 1.21 | | | 1.16 | 1.15 |
| **Firm 5** | | | | | | | | |
| Brand 11 | 1.19 | 1.19 | | | | | 1.17 | 1.15 |
| **Firm 6** | | | | | | | | |
| Brand 12 | | | | | | | 1.14 | 1.13 |
| Brand 13 | | | | 1.16 | | | 1.19 | 1.18 |
| **PLs** | 1.16 | 1.18 | 1.15 | 1.18 | 1.15 | 1.14 | 1.18 | 1.17 |
| **All** | 1.17 | 1.19 | 1.19 | 1.20 | 1.19 | 1.16 | 1.18 | 1.18 |

*Notes*: A proportional tax of € 0.20 per 100g of sugar is implemented when sugar content is above 12g for compote and 10g for other product categories. The average pass-trough of a brand for a product category is computed by taking the average of the pass-trough of the taxed products of the brand and category. Hence a brand with no product or taxed products has a blank display.

Table F.5: **Taxation without product reformulation: Changes in average price (€/kg) and market share (%) across brands and product categories**

| | Compote | | Yogurt | | FBPS | | ODD | | All | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Price | MS | Price | MS | Price | MS | Price | MS | Price | MS |
| **Firm 1** | | | | | | | | | | |
| Brand 1 | | | 0.11 | -4.77 | 0.08 | -1.58 | 0.51 | -27.11 | 0.23 | -13.11 |
| Brand 2 | | | 0.00 | 10.75 | 0.00 | 11.59 | 0.28 | -9.31 | 0.01 | 5.33 |
| Brand 3 | | | 0.00 | 12.14 | | | | | 0.00 | 12.14 |
| Brand 4 | | | 0.13 | 0.47 | | | | | 0.13 | 0.47 |
| Brand 5 | | | 0.14 | -3.36 | 0.16 | -0.41 | | | 0.15 | -2.66 |
| **Firm 2** | | | | | | | | | | |
| Brand 6 | | | 0.15 | -3.08 | 0.51 | -15.07 | 0.42 | -18.28 | 0.27 | -13.14 |
| **Firm 3** | | | | | | | | | | |
| Brand 7 | | | 0.36 | -16.54 | 0.03 | 5.95 | 0.42 | -18.54 | 0.23 | -7.31 |
| Brand 8 | | | 0.22 | -11.26 | | | | | 0.22 | -11.26 |
| Brand 9 | | | 0.31 | -17.11 | | | | | 0.31 | -17.11 |
| **Firm 4** | | | | | | | | | | |
| Brand 10 | 0.31 | -10.90 | 0.41 | -18.96 | 0.00 | 10.70 | 0.38 | -14.08 | 0.33 | -12.94 |
| **Firm 5** | | | | | | | | | | |
| Brand 11 | 0.29 | -10.40 | | | | | 0.43 | -13.01 | 0.32 | -11.06 |
| **Firm 6** | | | | | | | | | | |
| Brand 12 | | | 0.01 | 10.92 | 0.00 | 11.24 | 0.40 | -13.98 | 0.05 | -4.79 |
| Brand 13 | | | 0.06 | 1.64 | | | 0.30 | -11.33 | 0.17 | -4.91 |
| **Pls** | 0.29 | -13.09 | 0.12 | -6.10 | 0.04 | 1.57 | 0.49 | -23.31 | 0.21 | -11.75 |
| **All** | 0.30 | -12.39 | 0.15 | -5.45 | 0.05 | 1.64 | 0.50 | -21.45 | 0.22 | -10.43 |

*Notes*: A proportional tax of € 0.20 per 100g of sugar is implemented when the sugar content is above 12g for compote and 10g for other product category. The reported change in price of a brand and a category is the weighted average (using market shares as weights) of the change in price of all products from this brand in this category. FBPS and ODD stand for fromage blanc and petit suisse, and other dairy dessert, respectively.

Table F.6: **Change in firm market shares in the two tax scenarios (in %)**

| | Product category | | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Compote | | Yogurt | | FBPS | | ODD | | | |
| Reformulation | Without | With | Without | With | Without | With | Without | With | Without | With |
| Firm 1 | | | -1.43 | -1.44 | 0.72 | -1.99 | -24.56 | -24.62 | -6.78 | -7.40 |
| Firm 2 | | | -3.08 | 1.08 | -15.07 | -33.52 | -18.28 | -18.47 | -13.14 | -12.41 |
| Firm 3 | | | -14.03 | -6.14 | 5.95 | 4.99 | -18.54 | -18.79 | -10.20 | -4.48 |
| Firm 4 | -10.90 | -0.81 | -18.96 | -21.43 | 10.70 | 9.93 | -14.08 | -14.22 | -12.94 | -10.22 |
| Firm 5 | -10.40 | -10.05 | | | | | -13.01 | -13.15 | -11.06 | -10.84 |
| Firm 6 | | | 6.44 | 10.09 | 11.24 | 10.59 | -13.22 | -13.28 | -4.83 | -3.65 |
| PL provider | -13.09 | -11.63 | -6.10 | -4.81 | 1.57 | 3.41 | -23.31 | -23.63 | -11.75 | -10.90 |
| All | -12.39 | -9.82 | -5.45 | -3.57 | 1.64 | 1.26 | -21.45 | -21.68 | -10.43 | -9.53 |

Note: A proportional tax of € 0.20 per 100g of sugar per kilo of product is implemented when sugar content is above 12g for compote and 10g for other product categories. Columns 'without' indicate the change in market share's when firms do not reformulate their products, and columns 'with' when firms do reformulate their products. Firm 1 owns brands 1 to 5; firm 2 owns brand 6; firm 3 owns brands 7 to 9; firm 4 owns brand 10; firm 5 owns brand 11; and firm 6 owns brands 12 and 13. FBPS and ODD stand for fromage blanc and petits suisse, and other dairy dessert, respectively.

Table F.7: **Change in firm price in the two tax scenarios (in %)**

| | Product category | | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Compote | | Yogurt | | FBPS | | ODD | | | |
| Reformulation | Without | With | Without | With | Without | With | Without | With | Without | With |
| Firm 1 | | | 4.02 | 2.73 | 2.42 | 1.26 | 15.43 | 15.47 | 5.73 | 4.69 |
| Firm 2 | | | 6.04 | 2.87 | 9.28 | 9.09 | 10.98 | 11.13 | 7.82 | 6.13 |
| Firm 3 | | | 13.16 | 6.78 | 1.09 | 1.08 | 10.77 | 10.89 | 10.30 | 5.56 |
| Firm 4 | 9.30 | 2.56 | 15.01 | 12.02 | 0.16 | 0.24 | 7.70 | 7.78 | 8.77 | 5.88 |
| Firm 5 | 8.71 | 7.78 | | | | | 9.21 | 9.32 | 8.65 | 8.01 |
| Firm 6 | | | 0.40 | 0.19 | 0.09 | 0.16 | 6.55 | 6.72 | 1.94 | 1.60 |
| PL provider | 12.72 | 10.61 | 6.88 | 2.81 | 1.69 | -0.43 | 17.95 | 18.16 | 9.33 | 7.31 |
| All | 11.58 | 9.06 | 6.83 | 3.75 | 1.79 | -0.32 | 15.02 | 15.20 | 8.05 | 6.18 |

*Notes*: A proportional tax of € 0.20 per 100g of sugar per kilo of product is implemented when sugar content is above 12g for compote and 10g for other product categories. Columns 'without' indicate the change in price when firms do not reformulate their products, and columns 'with' when firms do reformulate their products. Firm 1 owns brands 1 to 5; firm 2 owns brand 6; firm 3 owns brands 7 to 9; firm 4 owns brand 10; firm 5 owns brand 11; and firm 6 owns brands 12 and 13. FBPS and ODD stand for fromage blanc and petit suisse, and other dairy desserts, respectively.

Table F.8: **Taxation without product reformulation: Percent change in calories, fat, and sugar intakes by household type**

| Household | | Children | | Social class | | | Adults obese | | |
|---|---|---|---|---|---|---|---|---|---|
| | **All** | **With** | **Without** | **Rich** | **Medium** | **Poor** | **None** | **One** | **All** |
| Sugar | -16.45 | -16.47 | -16.45 | -16.26 | -16.45 | -16.70 | -16.33 | -16.46 | -16.64 |
| | (-649) | (-410) | (-823) | (-789) | (-664) | (-492) | (-646) | (-585) | (-773) |
| Lipid | -12.92 | -12.17 | -13.27 | -12.99 | -12.91 | -12.85 | -12.86 | -12.86 | -13.09 |
| | (-144) | (-92) | (-181) | (-174) | (-147) | (-109) | (-143) | (-130) | (-170) |
| Calorie | -13.98 | -13.55 | -14.17 | -13.93 | -13.98 | -14.05 | -13.89 | -13.95 | -14.16 |
| | (-4620) | (-2941) | (-5843) | (-5612) | (-4725) | (-3512) | (-4594) | (-4168) | (-5495) |

The percentage change in nutrient intakes is calculated over the initial nutrient intakes from dessert consumption.

## G Additional tables and figures for Section 7

Table G.1: **Reformulation: Percentage change in nutrient intakes**

| | Constant market shares | Constant prices | Endogenous prices |
|---|---|---|---|
| Δ sugar | -6.7% | -7.5% | -7.4% |
| Δ lipid | +0.9% | -0.5% | -0.5% |
| Δ calorie | -2.8% | -3.7% | -3.8% |

*Notes*: The percentage changes in nutrient intake are calculated using the initial intake from dessert consumption as a baseline.

Table G.2: **Impact of alternative modelling assumptions on the nutrient intakes from the four product categories**

| | Passive pricing No reformulation | Strategic pricing no reformulation | Strategic pricing reformulation |
|---|---|---|---|
| Δ sugar | -13.5% | -16.4% | -21.1% |
| Δ lipid | -10.8% | -12.9% | -12.4% |
| Δ calorie | -11.7% | -14.1% | -15.9% |

Table G.3: **Taxation with product reformulation: Changes in calorie, fat, and sugar intake (%) and outside option market share (pp) by household type**

| **Household** | | **Children** | | **Social class** | | | **Adults obese** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **All** | **With** | **Without** | **Rich** | **Medium** | **Poor** | **None** | **One** | **All** |
| Outside option* | **3.80pp** | **2.75pp** | **4.43pp** | **4.18pp** | **3.81pp** | **3.42pp** | **3.83pp** | **3.76pp** | **3.83pp** |
| Sugar | -8.73 | -7.16 | -9.57 | -9.29 | -8.73 | -8.13 | -8.80 | -8.67 | -8.73 |
| Lipid | 1.52 | 0.95 | 1.88 | 1.72 | 1.52 | 1.33 | 1.54 | 1.48 | 1.56 |
| Calorie | -1.75 | -1.47 | -1.92 | -1.89 | -1.75 | -1.61 | -1.77 | -1.75 | -1.72 |

*Notes*: The percentage changes in nutrient intake are calculated using the initial intake from dessert and the outside option consumption as a baseline. * Outside option market share. **pp** stands for percentage point.