Mandatory labels, taxes and market forces: An empirical evaluation of fat policies

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Abstract

The public-health community views the mandatory labelling and taxation of fat as promising tools to control the growth of food-related chronic disease. This paper is the first to propose an *ex ante* evaluation of these two policy options in an oligopolistic setting with differentiated products and heterogeneous demand. Using household scanner data on *fromages blancs* and dessert yogurts, we separately identify consumer preferences for fat and front-of-pack fat labels by exploiting an exogenous difference in legal labelling requirements between these two product categories. Demand estimates are then combined with a supply model to evaluate both policies. In the absence of any producer price response, making fat labels mandatory reduces the fat supplied to regular consumers in this market by 38%; an ad-valorem tax of 10% (5%) on the producer price of full-fat (half-skimmed) products has a similar impact. Allowing producer price reactions, however, yields much smaller effects: a 9% drop for the fat tax, and a fall of only 1.5% for mandatory labels. Producers thus neutralise up to 96% of the impact of mandatory labelling on demand, via large price cuts on products with large *ex ante* margins. This illustrates how market forces are largely able to defeat the intended effect of market-based public-health interventions.

1 Introduction

What effects do fat taxes and mandatory fat labels have in food markets? In the context of a worldwide rise in overweight and obesity, such market-based policies have attracted a great deal of interest from policy-makers and public-health advocates. We here provide an empirical evaluation of these interventions, comparing their effects on key market indicators and health outcomes, such as equilibrium prices, market shares, producer profits, consumer welfare, and the quantity of fat purchased by households.

Fat in calories available for human diet represents between 40 and 45% of total daily calorie intake in most OECD countries, as against 20-30% one century ago (Popkin and Gordon-Larsen, 2000; James *et al.*, 2004; Oliver, 2006; Etilé, 2011). This trend has been related to the spectacular growth in obesity and overweight, which has reached epidemic proportions globally, with more than 1 billion adults being overweight worldwide in 2010 (OECD, 2010). In this context, the OECD has called for the implementation of tax policies on food items with high calory, fat, or sugar contents (Cecchini *et al.*, 2010).[1] A separate public policy proposed by the European Parliament is the mandatory labelling of the fat-content on fronts-of-packs (FOP): this is easier to use than the back-of-pack nutritional facts panel, which is already mandatory. FOP labels may help consumers to move from high to low fat-content products (Wansink *et al.*, 2004; Grunert and Wills, 2007).[2] To date, FOP nutritional labelling has been voluntary. One key element of this debate is that voluntary FOP labelling does not only play an informational role, it also contributes to differentiation and market segmentation. When labelling is voluntary, producers are more likely to display "low-fat" than "high-fat" labels on the FOP. This has two consequences. First, it is not obvious that making FOP labels mandatory will make consumers better off, as they can currently infer from the absence of any label that the product is high in fat. Second, the producer's decision to introduce a FOP label may depend on unobserved consumer tastes, rendering labelling endogenous in the demand function. Whether fat-content regulation should remain voluntary or become mandatory is an important research question, and comparing the effects (on consumers and firms) of mandatory fat labelling to those of a fat tax policy should help to begin the answer.

Previous research has often used continuous-choice demand models to evaluate the impact of fat taxes (see, for example, Caraher and Cowburn, 2005; Mytton *et al.*, 2007; Chouinard *et al.*, 2007; and Allais *et al.*, 2010).[3] These allow for substitution between food categories, which are more or less aggregated, but ignore any substitution either within food categories or towards an outside good. However, a fat tax is more likely to make consumers of high fat-content exit the market or switch to the nearest low fat-content counterparts in the same food group, rather than substitute one food category for another. In addition, producers' strategic reactions have generally

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[1] In 2009-2010, additional taxes on sugary drinks were proposed in at least 17 US States; Denmark introduced a 25% tax increase on ice cream, chocolate, sweets and soft-drinks in January 2010 (Danish Ministry of Taxation, 2009), and a tax on fat in October 2011; in France, a tax on soft-drinks was introduced in January 2012.   [2] See EUFIC (2012) for an update on nutritional labels in the EU.   [3] Noticeable exceptions are Griffith *et al.* (2010), and Bonnet and Réquillart (2011).

been ignored, except in Griffith *et al.* (2010) and Bonnet and Réquillart (2011). These latter analyse taxes on, respectively, saturated fats in butter and margarine and sugar in soft drinks, and estimate the firms' tax pass-through rate to consumer prices in a differentiated-product oligopoly setting.

The effect of nutritional information on consumer choice has mostly been analysed via hypothetical consumer choices, which can lead to overestimation bias (Cowburn and Stockley, 2005).[4] Empirical econometric evidence on the impact of mandatory food labels on natural shopping behaviour is scarce. The major obstacles are the difficulty of finding exogenous variations in producer label decisions and credible control groups. Nevertheless, some market-level analysis has exploited quasi-natural experiments, such as changes in labelling legislation due to the enactment of the Nutrition Labelling and Education Act (Mathios, 2000; Variyam, 2008) or the lifting of a regulatory ban against the advertising of the health benefits of ready-to-eat cereal (Ippolito and Mathios, 1990). Other work has used field experiments in supermarkets (Teisl *et al.*, 2001; Berning *et al.*, 2010; Kiesel and Villas-Boas, 2010). These have provided mixed results. However, all of these have focused on U.S. back-of-pack or shelf labels, and have not explored any strategic producer reactions to mandatory labelling.

This paper attempts to avoid these pitfalls through the combination of the structural modelling of the market and a quasi-natural experiment. First, we use scanner data, disaggregated at both the household and product levels, to estimate a discrete-choice model of demand allowing for both substitution between products within a same food group and towards an outside option. We model the supply side as an oligopoly proposing differentiated products, in the spirit of Berry *et al.* (1995) and Nevo (2001), to estimate the price-cost margins for each firm, identify strategic price reactions, and determine the new market-price equilibrium implied by each food policy. Second, we exploit an exogenous source of variation in legal labelling requirements in the French market for dessert yogurts and *fromages blancs*[5] to identify the causal impact of fat-content labels on consumer choice. The French labelling legislation requires producers to signal the percentage of fat contained in *fromages blancs* by a fat-content label displayed on the FOP, while fat-content labelling is not mandatory for dessert yogurts. In particular, producers never put FOP fat-content labels on full-fat dessert yogurts, but are required to do so for full-fat *fromages blancs*. Combining these exogenous variations in legal labelling requirements with brand labelling strategies, between products with different fat contents and between dessert yogurts and *fromages blancs*, and controlling for brands, distribution channels and demographics, we are able to identify consumer preferences for fat and fat-content labels separately.

Following the discrete-choice literature, we model consumer preferences using a Mixed Multi-

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[4] See Grunert and Wills (2007) for a detailed survey. [5] The *fromage blanc* is a creamy, soft, fresh, white cheese made with whole, half-skimmed or skimmed milk. In this paper, following the French legislation, we include in the *fromages blancs* category the *faisselles*, which have similar culinary uses. Dessert yogurts include products such as strained/Greek style yogurts and *fromages blancs* or yogurts mixed with cream or other animal fats.

nomial Logit model. In the estimation, we control for the (usual) endogeneity of prices, assuming that the product-specific valuation of the unobserved characteristics is independent from its past variations, but also for the (less classic) case where a characteristic is endogenous. As producers' decisions to place a fat-content label on the packaging of a dessert yogurt may be correlated with unobserved consumer tastes, we also need to control for the endogeneity of fat-content labels. We do so by exploiting the quasi-natural experiment provided by exogenous variation in the labelling requirements for *fromages blancs* and dessert yogurts. Household-specific demand parameters are then identified from panel scanner data collected from a representative sample of households in 2007. These estimates are used to compute producer price-cost margins, assuming that they compete *à la Nash* in a Bertrand oligopolistic game. The new market equilibrium implied by each fat policy can then be simulated.

We show that imposing FOP fat labels reduces the average yearly fat purchases by households by about 38% when the firm response is ignored. This is largely due to an aversion to fat labels by consumers of dessert yogurts, which is interpreted as a desire to have the taste without the guilt of eating unhealthily. When producers can adjust their prices, we find, perhaps surprisingly, that mandatory labelling increases the market share of dessert yogurts. This comes from the large price cuts that producers would effect, via drastic margin reductions (-68% for full-fat dessert yogurts). As labelling becomes mandatory for all products, product differentiation falls, which intensifies price competition. The price response of producers of dessert yogurts is made possible by the sizeable initial margins on dessert yogurts, and high price elasticities just after the policy shock: the fall in margins is offset by the recovery of large market shares. Firms are able to offset 96% of the effect of the policy on consumer demand.

Comparing mandatory labelling to an equivalent fat tax (meaning that tax rates are set such that each policy causes almost the same fall in average yearly fat purchases in the absence of any firm response), we show that when the firm price response is taken into account taxes are somewhat more effective than fat labels in reducing household fat purchases: 9% *vs.* 1.5% respectively. One reason is that the fat tax maintains the market segmentation between *fromages blancs* and dessert yogurts, which avoids intensifying price competition. From a health-policy perspective, we suggest that the fat tax dominates mandatory labelling. From a consumer perspective, however, the opposite pertains: assuming perfect rationality, consumer welfare in this market rises by 53% under mandatory labelling, as a result of the fall in dessert yogurt prices, and falls by 2% with the fat tax. From the firm's perspective, both policies reduce profit, but considerably more so under mandatory labelling (-21%) than under the fat tax (-6%).

The remainder of the paper is organized as follows. Section 2 presents the data and discusses the boundaries of the market. Section 3 outlines the empirical model and the estimation strategy. The estimation results are then discussed in Section 4 and the simulations in Section 5. The last section concludes.

2 Data

We use household panel scanner data from Kantar Worldpanel (KWP) for the 2007 calendar year. The advantage of scanner data over the experimental or hypothetical choice approaches is that observations are based on actual purchases in a natural shopping environment. Consumer preferences can thus be identified in a realistic setting.

There are $13,380$ households in the initial sample, which is nationally representative of the French population. The data record, on a weekly basis, all purchases of yogurts and *fromages blancs* for home consumption by the household over the year. The Universal Product Code (UPC) of each purchase is registered using a handheld scanner, as well as the quantity purchased and the associated expenditure. KWP does not provide UPCs, but a large set of product attributes. We choose to divide the year into 13 periods of four weeks (the time unit t in the next section). We thus focus on representative purchase behaviour in each four-week period, *i.e.* the choices that are the most-frequently observed in a sense that will be defined below.[6]

2.1 The relevant market

There are three broad categories of yogurts and *fromages blancs*: standard yogurts; standard *fromages blancs*; and dessert yogurts. This market was chosen for three reasons. First, it accounts for a quite substantial share of household fat purchases (2.75%). Second, a large variety of products are offered, which allows consumers to easily switch from one brand to another. Last, the fact that labelling is mandatory in France for *fromages blancs* but not for yogurts makes it easier to identify consumer preferences over labelling and fat separately.

We restrict our analysis to plain products, which represent 43% of all purchases of yogurts and *fromages blancs*. Flavored yogurts and *fromages blancs* contain sugar additives. As such, fat-content labels may be less salient for consumers, and less relevant from a nutritional point of view.[7] We also eliminate products that are not made from cows' milk (4.5% of purchases), and drinking yogurts and yogurts with cereals, which account for less than 1.5% of purchases.

In the remaining sample, 46.3% of the households consuming *fromages blancs* over a four-week period also purchased standard yogurts, while only 5.4% purchased dessert yogurts. These statistics suggest that *fromages blancs* and standard yogurts are probably not substitutes competing on the same market, which is the case for *fromages blancs* and dessert yogurts. A formal test comes from analyzing household budget choices between standard yogurts, dessert yogurts and *fromages blancs*, in a classic demand-system setting. Household expenditures on these three categories are aggregated over the year, and local price indices are computed for each category, as in Lecocq

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[6] Griffith *et al.* (2010) choose one unique random shopping trip during the calendar year. In our view, this method has the disadvantage of introducing more noise into the analysis of consumer preferences. [7] In addition, the French yogurt and *fromage blanc* market is characterized by a huge variety of flavors (249 different identified flavors in our dataset), and considering all of these, or even grouping some flavors together, would have rendered the estimation of the model infeasible.

and Robin (2006). An Almost Ideal Demand System is then estimated and the uncompensated cross-price elasticities are derived (Deaton and Mullbauer, 1980). We find only one significant cross-price elasticity, indicating that *fromages blancs* are substitutes for dessert yogurts (the elasticity is +0.398). An increase in the price of dessert yogurts or *fromages blancs* does not significantly impact the consumption of standard yogurts (see the additional results in Appendix A.1). The analysis will hence focus on the relevant market for plain *fromages blancs*, which includes plain dessert yogurts but not standard yogurts.[8]

Last, in order to aid our the identification of consumer preferences, we only retain households which purchased *fromages blancs* or dessert yogurts in more than 10 weeks over the year. Since these households clearly have stable tastes for these products, we do not make inferences from noisy choices. This leaves us with data on 1785 households.

2.2 Product attributes

The data contain information on the fat content of all dessert yogurts and *fromages blancs*, as well as their texture, brand, pack size, type of milk used, whether it is organic or not, and whether probiotics (bifidus) have been added or not. These attributes are used to define the alternatives available on the French market in 2007.

2.2.1 Fat content and fat-content labels

We sort the products into three fat-content categories: full-fat (more than 6% fat), semi-skimmed (between 3% and 6%), and skimmed (less than 3%).[9] Fat-content labels are mandatory for all *fromage blanc* products.[10] However, the data do not provide any information about the presence of fat-content labels for dessert yogurts. We therefore collected additional data from a number of information sources. The main source is Mintel's Global New Products Database (GNPD), which shows high-resolution color images of the packaging of 80% of the products in our dataset, and their changes over time. This information is complemented by an examination of the monthly French publication *Linéaires*, which provides detailed descriptions and pictures of a number of new food products launched in France every month. Last, we also visited the popular website www.flickr.com, which proposes more than 4 billion images, the French consumer network website www.ciao.fr, and, for a small number of products, old TV advertisements from the on-line audiovisual archives available of the *Institut National de l'Audiovisuel*.

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[8] This result is in line with the professional practice in marketing of considering that dessert yogurts and *fromages blancs* compete on the market of *fromages frais*, while yogurts form another market: see for instance the trade publication *Linéaires*, No. 173 (September 2002), p.98, No. 187 (December 2003), p.110, and No. 190 (March 2004), p.74. A last argument supporting this view is that *fromages blancs* and dessert yogurts often have the same culinary use: they are both served as desserts, with sugar, jam, honey or fruit frequently being added. [9] This corresponds closely to the division adopted in food marketing, see for instance the professional review *Linéaires*, No, 187 (December 2003), p. 110. [10] See the *décret* 88-1206 in the *Journal Officiel de la République Française*, 31/12/1988.

2.2.2 Other characteristics

We control for a number of other product characteristics, which were selected because they were significant in preliminary regressions. Differences in hedonic characteristics are captured by a set of discrete attributes indicating whether the product is a *fromage blanc* or a dessert yogurt, and whether its texture is smooth. Health characteristics other than the fat content are captured by a dummy variable indicating whether the product is organic or has probiotics added. Another binary variable shows whether the product is sold in individual portions (200g or less). Last, there are 15 dummy variables that control for brand heterogeneity. These include the main national producers (Yoplait, Danone, Triballat, etc.) and retailer brands (Carrefour, Leclerc, Intermarché, etc.). The small national brands are grouped together, along with the small retailer brands. We also control for three levels of brand quality (low-, medium- and high-quality brands). The low-quality category includes hard-discount and first-price retailer brands. The national and high-quality retailer brands form the high-quality category. These attributes together define 279 distinct varieties of dessert yogurts and *fromages blancs*.

2.3 Household choice set, choice and prices

These 279 products discussed above are distributed through a number of stores, supermarkets and hypermarkets. To simplify the analysis, we define 14 homogenous categories of distribution channels, according to criteria such as the company name (for supermarkets and hypermarkets) and the store format (hard-discount, hyper and supermarkets, grocery stores).[11] We retain these two criteria because they are significant determinants of quality positioning and pricing strategies. For each distribution channel, we assume that the set of products observed in the yearly purchase data is that which was available in each period.

We know the distribution channels that were visited by each household in each period. We define each household choice set as the set of all products available in these channels. Choice sets therefore vary both from one period to another for the same households, and across households (even living in the same place) in the same period, if they visited different distribution channels.

There are two situations regarding household choice in each period. If the household did not make any purchases or purchased a single product, then defining choice is not a problem. However, when more than one product was purchased, we have to choose that which is the most representative of household preferences. In order to avoid arbitrary choices, we select this at random with the selection probabilities being proportional to the share of each product in the household's annual

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[11] The 14 distribution channels are: independent hard discount such as Lidl and Aldi; hard discount Ed; hard discount Leader Price-Franprix; hyper and supermarket Intermarché; hypermarket Carrefour; hypermarket Casino; hypermarket and supermarket Cora; hypermarket Auchan; hypermarket Leclerc; hypermarket and supermarket U; supermarket Carrefour (Stock, Shopi, and Proxi); supermarket Casino (Monoprix, EcoService, PetitCasino, Spar, and Maxicoop); supermarket Auchan (Atac, and Maximarché); and other distribution channels such as cheesemongers, and grocery stores.

purchases.[12] The price of each product in the household-choice set is constructed in two steps. We first calculate the mean unit price for this product by distribution channel and period; we then average these mean unit prices over the distribution channels that were visited by the household during the period. Prices thus vary over time and between households according to the distribution channels visited.

2.4   Market characteristics

Given that the estimation procedure is time-consuming, we reduce the dataset to an extent by randomly selecting five periods for each household. To avoid having too much noise in the estimation process, we also exclude products that were purchased less than 10 times in a period. This leaves us with 224 different products. Table 1 presents the summary statistics of the product characteristics, in the universal choice set containing all products and in the union of all household choice sets. Note that there are far fewer low- and medium-quality products in the latter than in the former, simply because many of these are private labels that can be found in only one distribution channel.

[Table 1 about here]

The main market characteristics are described in Table 2. The final sample contains $8,975$ observations on the choices of $1,795$ households over five periods. First note that 12 out of the 24 semi-skimmed dessert yogurts have fat-content labels, while none of the full-fat dessert yogurts (20 products) do. *Fromages blancs* account for 70.8% of choices, dessert yogurts 23.9%, and the outside alternative of consuming none of these products over a four-week period for 5.4%. More than 54% of the *fromages blancs* purchased are semi-skimmed, about 23% are skimmed, and as many are full-fat. By way of contrast, 72% of the dessert yogurts purchased are full-fat. On average, full-fat products are more expensive than the others, with smaller variations in prices for dessert yogurts than for *fromages blancs*.[13]

[Table 2 about here]

2.5   Household characteristics

Our empirical specification also includes household characteristics: income quartiles, household size, and three dummy variables indicating whether the head of the household is aged over 65, whether the main shopper is classified as being risky overweight (BMI>27), and whether the main shopper is a man. Table 3 shows the mean and standard deviation of these variables, amongst others, in the estimation sample. These variables are interacted with product attributes in the estimation to account for the effect of observable characteristics on preferences.

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[12] For instance, if there are two goods, and the household purchased a quantity $Q1$ of good 1 and a quantity $Q2$ of good 2 *over the year*, then the probability of selecting good 1 in a *four-week period* where both goods were purchased is $Q1/(Q1 + Q2)$.   [13] The *fromage blanc* is a traditional food product. As such, some product varieties are prestigious and expensive.

3 Empirical modeling

Following the empirical industrial organization literature , market equilibrium is modeled combining a flexible discrete-choice model of demand with a linear-pricing model of supply. This section describes this analytical framework, together with the estimation strategy and the simulation of each policy option.

3.1 Structural model for the demand side

Consumer preferences are modeled in a random-utility framework, via a Mixed Multinomial Logit model (MMNL) (Berry *et al.*, 1995, McFadden and Train, 2000). Preferences over product characteristics are specified in a flexible manner, as this allows for both observed and unobserved heterogeneity in the intercept and slopes of the utility function. Household heterogeneity in the Willingness-To-Pay (WTP) for fat-content labels can thus be more precisely estimated. The MMNL also relaxes the "Independence of Irrelevant Alternatives" constraint imposed by the standard Conditional (or Multinomial) Logit model, which is unlikely to hold at the aggregate level as the choice set varies from one household to another.

3.1.1 The random utility model

Each household $i = 1, ..., N$ faces a set of J_{it} products in a choice situation $t = 1, ..., T$.[14] Each product $j \in J_{it}$ is described as a bundle of characteristics. As in many other papers, we assume that all product characteristics are observable (or can be observed by careful inspection) by consumers but some are unobserved by the econometrician. Examples of the observable characteristics are package size, brand, nutritional facts, etc; the unobserved characteristics include the position of the product within the range of products sold under the same brand or the way it is displayed and advertised in a particular distribution channel.

Formally, denote by p_{ijt} the price of good j faced by household i in period t, and l_j the binary variable indicating whether a fat-content label is displayed on the packaging of j. Further, let x_j denote the vector of observed exogenous attributes of j and let $j = 0$ be the outside (or no purchase) option, whose characteristics are all set to zero. Considering that each household buys only one product at a time, the utility that household i obtains from the consumption of one unit of good j in period t can be written as

$$u_{ijt} = v_{ijt} + \varepsilon_{ijt} = v_i(p_{ijt}, l_j, x_j; \alpha_i^p, \alpha_i^l, \beta_i) + \varepsilon_{ijt}, \tag{1}$$

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[14] In the empirical section below, a choice situation is defined as a four-week period; the set of products is indexed by i as households visit different distribution channels and therefore face different choice sets (see Section 2).

where v_{ijt} is the deterministic part of utility, depending on the observed attributes of j, α_i^p, α_i^l and β_i are parameters representing the preferences of household i over p_{ijt}, l_j and x_j, respectively, and ε_{ijt} is unobserved utility. The latter captures consumer valuation of the unobserved product characteristics.

3.1.2 Endogenous prices and fat-content labels

There is empirical evidence that some of the observed and unobserved characteristics are correlated, producing endogeneity problems (Berry, 1994). For instance, promoted products are often moved to the front of the shelf, advertised and sold at a lower price at the same time. The estimated impact of observed prices on demand will then capture both a true price effect and the effect of unobserved marketing. Prices may also be endogenous if some unobserved characteristics are positively valued by consumers, who thus are ready to pay a premium for them. This may be taken into account by producers in determining their prices. In both cases, we have $\mathbb{E}(\varepsilon_{ijt} \mid p_{ijt}) \neq 0$.

We instrument the current price by its lagged changes. The identifying assumption is that, controlling for brands, distribution channels, and demographics, the individual valuation of the product-specific unobserved characteristics, ε_{ijt}, is independent of its own past changes. Given this assumption, the valuation of a particular product will be independent of the price changes for that same product in the same distribution channel.[15] At the same time, common production and/or distribution costs imply that the price of a product within a distribution channel will be correlated with its past changes, which can therefore be used as valid instrumental variables (IVs). The price changes that we consider are those observed between the current and the last period. They are constructed in the same way as the price levels: for each product, the mean unit price and its change are first calculated for each distribution channel and period; these mean unit price changes are then averaged over the distribution channels that were visited by the household in the corresponding period.

Most papers dealing with endogeneity in MMNL models have focussed on price endogeneity, assuming the exogeneity of all other observed characteristics. We here relax this assumption for the fat-content label, as the producer's decision to put a fat-content label on the packaging of a dessert yogurt may be correlated with some unobserved consumer tastes. In this case, $\mathbb{E}(\varepsilon_{ijt} \mid l_j = 1) \neq \mathbb{E}(\varepsilon_{ijt} \mid l_j = 0)$.

An IV for fat-content labels can be constructed by exploiting the "quasi-natural experiment" from the exogenous variation in labelling rules between *fromages blancs* and dessert yogurts. Considering the absence of label as a treatment, we know that the probability of being treated is zero for *fromages blancs*, regardless of their fat content (since labelling is mandatory), and more or less positive for dessert yogurts, depending on their fat content. The marginal value of a fat-

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[15] This is similar to Villas-Boas and Winer (1999), except that they instrument current prices by past price levels. This choice is valid only if ε_{ijt} is uncorrelated over time. Here, we rather consider that ε_{ijt} is likely to be stable through time, because it essentially relates to time-invariant attributes such as the colour and the shape of the packaging and the product name.

content label is then identified from the empirical market shares, using a difference-in-difference estimator, assuming that the differences in unobservable factors between consumers of full-fat and semi-skimmed products are the same for *fromages blancs* and dessert yogurts. This assumption and the resulting exclusion restriction hold if the consumers of *fromages blancs* are not more sensitive to a fat increase than the consumers of dessert yogurts. In addition, it seems reasonable to consider that the decision to label a dessert yogurt is taken once and for all when introducing the product on the market. Changes in unobserved factors over time, in customer services or the perception of the product for example, have little to do with this (Ackerberg *et al.*, 2005). Last, the interaction between the dessert yogurt and the semi-skimmed (or full-fat) dummy variables is a good predictor of the producer's labelling decision: the fatter the dessert yogurt, the less likely the producer is to signal this to consumers. In our data set, full-fat dessert yogurts are indeed never labeled.

3.2 Empirical estimation of the demand functions

3.2.1 A control function approach to endogeneity

To correct for price and fat-content label endogeneity, decompose ε_{ijt} as

$$\varepsilon_{ijt} = \widetilde{\varepsilon}_{ijt}^{p} + \widetilde{\varepsilon}_{ijt}^{l} + \widetilde{\varepsilon}_{ijt}, \tag{2}$$

where $\widetilde{\varepsilon}_{ijt}^{p}$ is the error component related to the price, $\widetilde{\varepsilon}_{ijt}^{l}$ the error component related to the presence of a label, and $\widetilde{\varepsilon}_{ijt}$ is an iid extreme-value term.

We then apply a control function approach, as proposed by Petrin and Train (2009) for discrete-choice models. Consider the following orthogonal decompositions for $\widetilde{\varepsilon}_{ijt}^{p}$ and $\widetilde{\varepsilon}_{ijt}^{l}$

$$\widetilde{\varepsilon}_{ijt}^{p} = \lambda^{p}\mu_{ijt}^{p} + \sigma^{p}\eta_{ijt}^{p} \quad \text{and} \quad \widetilde{\varepsilon}_{ijt}^{l} = \lambda^{l}\mu_{ijt}^{l} + \sigma^{l}\eta_{ijt}^{l}, \tag{3}$$

where μ_{ijt}^{p} and μ_{ijt}^{l} are jointly normal, and η_{ijt}^{p} and η_{ijt}^{l} are iid standard normal (whose standard deviations σ^{p} and σ^{l} are estimated). In this equation, μ_{ijt}^{p} and μ_{ijt}^{l} represent the variations in prices and fat-content labels that are explained neither by the other observed variables nor by the instruments, and which may affect utility (if λ^{p} or $\lambda^{l} \neq 0$). There is endogeneity as these unobserved factors are correlated with prices or fat-content labels. The control-function approach explicitly takes into account the effect of μ_{ijt}^{p} and μ_{ijt}^{l} on utility, by introducing proxy measures of these variables into the estimations. These proxy measures are constructed in a first stage, as the residuals from the regressions of the price and fat-content label variables on all of the exogenous variables and the instruments, z_{ijt}

$$p_{ijt} = \delta^{p}z_{ijt} + \mu_{ijt}^{p} \quad \text{and} \quad l_{j} = \delta^{l}z_{ijt} + \mu_{ijt}^{l}, \tag{4}$$

where δ^{p} and δ^{l} are vectors of parameters. The estimated residuals, $\hat{\mu}_{ijt}^{p}$ and $\hat{\mu}_{ijt}^{l}$, are called the control functions. Their introduction, as additional explanatory variables, in the regressions solves the endogeneity problem.

3.2.2 Parameterisation of the utility function

Combining (1) to (3), and assuming a linear specification for the deterministic part of the utility function $v_i(\bullet)$, we have

$$u_{ijt} = v_{ijt} + \varphi_{ijt} + \widetilde{\varepsilon}_{ijt}, \tag{5}$$

where

$$v_{ijt} = -\alpha_i^p p_{ijt} + \alpha_i^l l_j + \beta_i' x_j \quad \text{and} \quad \varphi_{ijt} = \lambda^p \hat{\mu}_{ijt}^p + \lambda^l \hat{\mu}_{ijt}^l + \sigma^p \eta_{ijt}^p + \sigma^l \eta_{ijt}^l. \tag{6}$$

The tastes for observed product characteristics, α_i^p, α_i^l and β_i, are modeled as a function of observable household characteristics. As we are primarily interested in the heterogeneity of consumer preferences for fat-content labels, we further allow α_i^p and α_i^l to depend on unobservable household characteristics. Formally, denote respectively s_i and ν_i as the vectors of observed and unobserved attributes of household i, and let $\alpha_i = (-\alpha_i^p, \alpha_i^l)$. Then

$$\alpha_i = \overline{\alpha} + \Sigma \nu_i + A s_i \quad \text{and} \quad \beta_i = \overline{\beta} + B s_i, \tag{7}$$

where $\overline{\alpha} = (-\overline{\alpha}^p, \overline{\alpha}^l)$ is the vector of average tastes for the price and the label in the population, and A, B and Σ are respectively two matrices and a symmetric matrix of parameters (specifically, Σ is the Cholesky decomposition of the covariance matrix of ν_i). Under this specification, the elements of $\overline{\alpha} + \Sigma \nu_i$ correspond to the random coefficients for the price and label variables; we assume that α_i^p follows a log-normal distribution and α_i^l a normal distribution.[16] The two distributions are correlated (the off-diagonal element of Σ is non-zero). We hence end up with a MMNL model with mixing over the error components and random coefficients for the endogenous variables.

3.2.3 Likelihood and estimation procedure

The choice probabilities can be obtained by summing the choices implied by the utility model over the distribution of the unobserved attributes of households in the population of interest, ν_i and $\widetilde{\varepsilon}_{ijt}$, as well as over the distribution of the error components, η_{ijt}^p and η_{ijt}^l. Define y_{ijt} as an indicator variable which equals 1 if household i purchases good j in period t, and 0 otherwise. Each household is supposed to choose the utility-maximizing option, and assuming that ties occur with probability zero, the choice criterion is

$$
\begin{aligned}
y_{ijt} \quad &= \quad 1 \text{ if } u_{ijt} > u_{ikt} \quad \forall j \neq k, \\
&= \quad 0 \text{ otherwise.}
\end{aligned}
\tag{8}
$$

Under the additional assumptions that there is no error component, $i.e.$ $\widetilde{\varepsilon}_{ijt}^p = \widetilde{\varepsilon}_{ijt}^l = 0$, and that household heterogeneity enters the utility function only through the additive error term $\widetilde{\varepsilon}_{ijt}$, $i.e.$ $s_i = \nu_i = 0$, the model reduces to the standard Multinomial Logit model (MNL).[17]

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[16] The estimation does not converge when assuming a log-normal distribution for both coefficients. [17] Although very attractive because of its extreme tractability, the MNL model unreasonably restricts substitution patterns (see, for example, Berry, 1994).

In the hypothetical situation where $\widetilde{\varepsilon}^p_{ijt}$, $\widetilde{\varepsilon}^l_{ijt}$ and ν_i are observed and are different from zero, the above model corresponds to a MNL formulation where the observed product characteristics and household attributes are interacted, with choice probabilities given by[18]

$$P(y_{ijt} = 1 \mid \eta_{ijt}, \nu_i; \theta) = \frac{\exp(v_{ijt}(\nu_i) + \varphi(\eta_{ijt}))}{1 + \sum_{k \in J_{it}, k \neq 0} \exp(v_{ikt}(\nu_i) + \varphi(\eta_{ikt}))}, \tag{9}$$

where $\eta_{ijt} = \{\eta^p_{ijt}, \eta^l_{ijt}\}$, θ is the full parameter set, $P(y_{ijt} = 1 \mid \eta_{ijt}, \nu_i; \theta)$ is the probability that alternative j is purchased by household i at time t conditional on η_{ijt} and ν_i, and the utility derived from the consumption of the outside alternative is normalized to zero. The probability of observing the sequence of choices made by household i in periods $t = 1, ..., T$, denoted $w_i = \{y_{ijt} = 1\}^T_{t=1}$, is then

$$P(w_i \mid \eta_{ijt}, \nu_i; \theta) = \prod_{t=1}^{T} \sum_{j \in J_{it}} y_{ijt} P(y_{ijt} = 1 \mid \eta_{ijt}, \nu_i; \theta). \tag{10}$$

However, since η_{ijt} and ν_i are not actually observed, the relevant probability has to be unconditional, as follows

$$P(w_i \mid \theta) = \int P(w_i \mid \eta_{ijt}, \nu_i; \theta) g(\eta_{ijt}) f(\nu_i) d\nu_i d\eta_{ijt}, \tag{11}$$

where $f(\nu_i)$ is the joint density function of ν_i and $g(\eta_{ijt}) = \phi(\eta^p_{ijt})\phi(\eta^l_{ijt})$, with $\phi(\bullet)$ being the standard normal density function.

Given that each component of η_{ijt} and ν_i adds a dimension to the integral, it is not possible to solve (11) analytically by integrating out over η_{ijt} and ν_i. The most common solution is to replace the choice probability by the following unbiased, smooth and tractable simulator

$$\widetilde{P}(w_i \mid \theta) = \frac{1}{D} \sum_{d=1}^{D} P(w_i \mid \eta_{ijtd}, \nu_{id}; \theta), \tag{12}$$

where η_{ijtd} and ν_{id} denote the d-th draw from the distributions of η_{ijt} and ν_i, and D is the number of draws. The simulated log-likelihood function can then be written as

$$\widetilde{L}(\theta) = \sum_{i=1}^{N} \ln \widetilde{P}(w_i \mid \theta). \tag{13}$$

The estimation procedure consists of two steps. First, the residuals $\hat{\mu}^p_{ijt}$ and $\hat{\mu}^l_j$ are predicted by regressing the price and label variables on the instruments, all product characteristics, including their interactions with household attributes, as listed in Table 3, and the distribution channel and brand fixed effects.[19] These residuals are then used as control functions in the above likelihood function. The variance-covariance matrix is corrected to account for the additional variance introduced by the first-stage estimation.

---

[18] In order to make the presentation simpler here, all of the other conditioning arguments (product and consumer attributes, reduced-form residuals) are omitted. [19] The identifying instrument for label is significant at the 1% level in both first-stage regressions; the IV for price is significant at the 1% level in the label regression and at the 10% level in the label regression.

3.2.4 Empirical identification of the distribution of consumer tastes

The empirical identification of MMNL models is known to depend on the richness of the data in terms of variation in the explanatory variables.[20] Cherchi and Ortúzar (2008) investigate the effect of data richness on the empirical identification of the binomial version of the MMNL. Using Monte Carlo simulations, and assuming that choice sets differ across observations, they find that data richness does indeed matter and, in particular, that identification problems arise when slope heterogeneity is applied to a characteristic that has little variability between alternatives. They also show that the observation of more than one choice per individual (*e.g.* panel data) makes empirical identification easier and sharply reduces the effect of sample size. Their analysis, however, focusses on continuous characteristics. The identification of slope heterogeneity in both continuous *and* discrete variables, and the impact of choice-set variation (across individuals and/or markets) on identification are addressed in Lecocq (2010). Monte Carlo results show that MMNL models are empirically identified when they are estimated on panel data, regardless of the type of variable, even when the set of alternatives is the same for all observations. Variation in the choice set strengthens identification for discrete characteristics.

By construction, we here retain as much information and variability as possible: five choices are observed per households and the choice set of available products varies from one choice situation to another and across households (via the distribution channels). This guarantees the empirical identification of slope heterogeneity for any type of variable.

3.3 Structural model for the supply side

Producers are likely to adjust to exogenous shocks, and ignoring their strategic behaviour may lead to biased estimates of the effect of public policies (Griffith *et al.*, 2010; Bonnet and Réquillart, 2011). The simulation of policy effects on market equilibrium therefore requires a structural model of the supply side. In the demand model, two variables result from firms' strategic decisions: price and label.[21] However, it seems reasonable to suppose that the labelling decision is taken when the product is introduced, and is not affected by a fat tax (it becomes strictly exogenous in the case of mandatory labelling).[22] We thus focus on price as the firm's only strategic variable.

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[20] Proofs of the theoretical identification of MMNL models have recently been provided, under the assumption that the set of alternatives differs across observations (see Bajari *et al.*, 2012; Berry and Haile, 2009, 2010; Fox *et al.*, 2011). Even when a model is shown to be *theoretically* identified, it may not be *empirically* identified, because the data do not support it. We here discuss empirical identification. [21] While the explicit modeling of the firm's pricing strategy is now common in the literature, modeling the firm's choice of characteristics is both rarer and complicated: see Crawford and Shum (2001), who model the firm's choice of quality but only deal with monopoly situations with one observed characteristic; another approach mentioned by Ackerberg *et al.* (2007) is similar to Olley and Pakes (1996) and requires dynamic modeling. [22] This is justified by the fact that firms often prefer to introduce new food products rather than modify the characteristics of existing ones.

3.3.1 The linear-pricing model

We assume that firms compete *à la* Nash-Bertrand, *i.e.* by setting prices in order to maximise their profit conditional on the demand parameters and other firms' prices, as in Berry *et al.* (1995) and Nevo (2001).[23] Suppose that there are M producers on the market, each producing a subset G_m of G, the total number of products on the market. Denoting by p_j and c_j the price and (constant) marginal cost of production of product j, respectively, the profit of producer m, π_m, can be written as

$$\pi_m = \sum_{j \in G_m} (p_j - c_j) s_j(p; \theta),$$

where $s_j(p; \theta)$ is the predicted market share of product j for all $j \in G$, depending on the prices of all products, p, and demand parameters.[24] Market share is calculated as $s_j(p; \theta) = \sum_{i,t} P(y_{ijt} = 1 \mid \theta)$, where

$$P(y_{ijt} = 1 \mid \theta) = \int P(y_{ijt} = 1 \mid \eta_{ijt}, \nu_i; \theta) g(\eta_{ijt}) f(\nu_i) d\nu_i d\eta_{ijt}, \tag{14}$$

which can be approximated by simulation, with $P(y_{ijt} = 1 \mid \eta_{ijt}, \nu_i; \theta)$ given by (9). Assuming a pure-strategy Nash equilibrium in prices, the price of good j produced and sold by producer m must satisfy the following first-order conditions

$$s_j(p; \theta) + \sum_{k \in G_m} (p_k - c_k) \frac{\partial s_k(p; \theta)}{\partial p_j} = 0, \tag{15}$$

for all $j \in G_m$ and $m = 1, ..., M$. Solving (15) provides the price-cost margins for each product, as a function of the estimated demand parameters. Given the observed prices, the marginal costs are identified. Assuming that the marginal costs and demand parameters are fixed, the equilibrium condition (15) can then be used to identify the impact of public policies on the market equilibrium (equilibrium prices and market shares). We analyze the mandatory labelling of all dessert yogurts on the one hand, and a fat tax proportional to the fat content on the other.

3.3.2 Simulation algorithm

The implementation of mandatory labelling implies the replacement of the label variable by a vector of ones, l^*.[25] We recalculate, for each producer m and each item in G_m, the new market shares, $s_j^*(p; \theta)$, and all of the corresponding derivatives, $\partial s_k^*(p; \theta)/\partial p_j$, using the new label variable, l^*, the estimated demand parameters and probability (14), where v_{ijt} and c_{ijt} are now as follows

$$v_{ijt} = v_{ij} = -\alpha_i^p p_j + \alpha_i^l l_j^* + \beta_i' x_j \quad \text{and} \quad \varphi_{ijt} = \lambda^p \hat{\mu}_j^p + \sigma^p \eta_{ijt}^p.$$

---

[23] A recent literature enriches this setup, by taking vertical relationships between manufacturers and retailers into consideration (see Villas-Boas, 2007; Bonnet and Dubois, 2010; Bonnet *et al.*, 2012). The hypothesis of capacity constraints is maintained, which means that our results will pertain to the short-term equilibrium effects of policies.

[24] For each product, there is now one single price which is the average, over periods and distribution channels, of the mean unit prices computed in Section 2.3. This therefore no longer depends on the i and t subscripts. [25] We assume that the labeling cost is zero or negligible for two reasons: first, as the fat-content is listed in the nutrient facts displayed on the packaging of all products, its determination for dessert yogurts is costless; second, as mandatory labeling simply consists in sticking a fat-content label on the front of the packaging, marketing and associated costs should be small relative to the product's total cost.

The terms used to correct for label endogeneity here vanish from the φ_{ijt} expression since the label variable is strictly exogenous once the policy is implemented. The first-order conditions (15) are then used to find a new price vector, p_0^*, given $s_j^*(p;\theta)$ and $\partial s_k^*(p;\theta)/\partial p_j$. If p_0^* is close enough to the observed price vector, p, equilibrium prices are unchanged. Otherwise, a new price vector, p_{iter}^*, at the $iter$-th iteration is derived from

$$s_j^*(p_{iter-1}^*;\theta) + \sum_{k \in G_m} (p_{k,iter}^* - c_k) \frac{\partial s_k^*(p_{iter-1}^*;\theta)}{\partial p_{j,iter-1}^*} = 0,$$

for all $j \in G_m$ and $m = 1,...,M$. The market shares are obtained using (14) with

$$v_{ijt} = v_{ij} = -\alpha_i^p p_{j,iter-1}^* + \alpha_i^l l_j^* + \beta_i' x_j \quad \text{and} \quad \varphi_{ijt} = \lambda^p \hat{\mu}_{j,iter-1}^{p*} + \sigma^p \eta_{ijt}^p,$$

where $\hat{\mu}_{j,iter-1}^{p*}$ is the residual from the regression of $p_{j,iter-1}^*$ on z_{ijt} and all **exogenous** variables. We iterate over p_{iter}^* until convergence is reached, that is when $\max_j |p_{j,iter}^* - p_{j,iter-1}^*| < 10^{-5}$.

We assume that the fat tax is ad valorem, proportional to the fat content, such that the *consumer* price for product j is

$$p_j^\tau = (1 + \tau_{cat,j})p_j$$

where p_j denotes the producer price for product j and $\tau_{cat,j}$ the tax rate assigned to product j in the fat-content category cat. Below, $\tau_{cat,j}$ is set equal to 0, 0.05 or 0.10 when j is a skimmed, semi-skimmed or full-fat product, respectively. In the same way as for the algorithm described to calculate equilibrium prices under mandatory labelling, we obtain a new vector of *producer* prices, p_{iter}^*, at the $iter$-th iteration solving

$$s_j(p^{\tau*};\theta) + \sum_{k \in G_m} (p_{k,iter}^* - c_k) \frac{\partial s_k(p^{\tau*};\theta)}{\partial p_j^{\tau*}} (1 + \tau_{cat,j}) = 0,$$

for all $j \in G_m$ and $m = 1,...,M$, where $p^{\tau*}$ represents the new consumer price vector whose j-th element $p_j^{\tau*}$ is given by $p_j^{\tau*} = (1 + \tau_{cat,j})p_{j,iter-1}^*$. As above, we iterate over the producer price vector until $\max_j |p_{j,iter}^* - p_{j,iter-1}^*| < 10^{-5}$.

4 Estimation results

This section presents the MMNL estimates obtained using the control function approach described in Section 3 to correct for the endogeneity of price and label variables. All of the estimations below are carried out using 500 Halton draws.[26] The variances of the estimators are corrected by standard formulae for two-step estimators (Murphy and Topel, 1985), given the additional variation due to the introduction of the residuals from the first-step instrumental regressions.

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[26] One difficulty with MMNL models is that the simulated log-likelihood functions are not as well-behaved as standard log-likelihood functions. In particular, using too few draws in the simulator (12) may mask identification issues (see Chiou and Walker, 2007). These can be revealed by the instability of parameter and standard error estimates as the number of draws increases. We estimated the model for $D = 100, 200, 300, 500$ and 1000 draws, and obtained stable estimates from $D = 300$ onwards. These results are available upon request from the authors.

4.1 Utility functions

Table 4 shows the estimated coefficients of the MMNL model: these can be interpreted directly in terms of marginal utilities. As outlined in the previous section, price and label marginal utilities have both deterministic and random components. The first column shows the mean marginal utility of the product characteristics for a reference main shopper who is a woman aged under 65, with BMI under 27, living in a household in the top income quartile. The second column shows the estimated standard deviations of each random component. All are significant at the 1% level, indicating that the marginal utilities of price and label do vary with unobservable household characteristics. The remaining columns list the coefficients for a number of interactions between the product characteristics, listed in the first column, and the household characteristics, in the first row (household income quartiles, household size, the main shopper being risky overweight, a man, and aged over 65). For instance, the difference in the mean marginal utility of price between the reference shopper and one in the first income quartile (first line, fourth column) is -0.232 utility units. The bottom part of Table 4 provides the estimates of the price and label control functions and the variances of the associated error components.

[Table 4 about here]

As expected, the probability of choosing an alternative falls with its price. The marginal utility of price is the inverse of the marginal utility of income. Its mean is negative (-1.870), and larger for households below median income, which is consistent with poorer households having a higher marginal utility of income. The standard deviation of the random effect on price is fairly high (1.995), implying that the marginal utility of income is very heterogeneous, beyond the effect of the observed socio-demographic attributes.

Fat-content labels have, on average, a positive value (0.592 for the reference individual), but once again the standard deviation is large relative to the mean effect (3.850): there considerable unobserved heterogeneity in household preferences over these labels. The elderly tend to dislike fat-content labels, while there is a hump-shaped income effect peaking in the second income quartile. The marginal utility of labels is not significantly higher when the main shopper is risky overweight (BMI>27). The random unobserved household attributes are negatively correlated, with a coefficient of -0.77. A strong taste for labels is likely associated with a greater marginal disutility of price, which limits the willingness-to-pay for labels.

The coefficients on the control functions, at the bottom of Table 4, are both positive and significant. Ignoring label endogeneity leads to over-estimates of the marginal utility of labels, with an estimated mean base coefficient of 1.710 (instead of 0.592). This suggests that, when labelling is not mandatory, firms display labels according to the consumer valuation of some unobserved product characteristics. It is easy to imagine that, in the case of semi-skimmed dessert yogurts, the label is just one component of the whole packaging, which can also generate hedonic and

health expectations through the use of specific colors, shapes, etc. (see *inter alia* Ares and Deliza, 2010). Likewise, the marginal disutility of price is slightly underestimated when the presence of unobserved product characteristics is ignored (-1.763 *vs.* -1.870).

Households tend to prefer semi-skimmed and full-fat products to skimmed ones. This taste for fat is more developed in low-income households, and when the main shopper is a man or elderly. Valli and Traill (2005) have previously found that the French dislike low-fat yogurts, as compared to the British, Dutch, Spanish and Portuguese. It is worth noting that risky-overweight shoppers prefer either low-fat or full-fat products to semi-skimmed ones. This may suggest two different types of consumers among those at risk for overweight-related diseases. The literature in sensory research emphasises that two kind of motives underlie consumer preferences for fat in dairy products. The fat content is positively related to taste and immediate hedonic pleasure (Wardle and Solomons, 1994; Westcombe and Wardle, 1997), but may also be negatively related to healthiness via delayed health damage (Grunert *et al.*, 2000). Risky-overweight individuals are more likely to be concerned by the fat-disease relationship, but also to exhibit a strong taste for fat. The polarization of their preferences between low- and full-fat products then likely reflects opposite hierarchies of purchase motives: for some health matters more than taste, while the reverse holds for others.

Table 4 also reveals that low- and medium-quality products are much less popular than high-quality ones for high-income households, while they have more success in low-income and large households. Male main shoppers are less likely to like products sold in small portions.[27] Last, the bifidus/organic characteristic has no significant effect on utility, while smooth textures are associated with a utility loss, consistent with the fact that non-smooth varieties (especially *faisselles* and *fromages blancs de campagne*) are considered as luxuries and part of French culinary culture.

4.2   The Willingness-To-Pay for a fat-content label

The Willingness-To-Pay (WTP) for a label is defined as the change in price (here expressed in €) that keeps utility unchanged when a fat-content label is added to the front and sides of the packaging. A household-specific WTP can be calculated from the estimates, conditional on household-specific information (observed choices, product and household characteristics), from equation (**??**) in Appendix A.2.

Our key finding is that a non negligible fraction of households (38%) have WTPs less than or equal to zero (see Table A.2 in the Appendix).[28] This proportion varies by demographic group, but not very much: in particular, it is the same whether the main shopper in the household is risky overweight or not, and only slightly higher (41%) when the shopper is obese; moreover, it is only

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[27] This gender effect is consistent with previous findings in the nutrition literature. In France, as in many countries, body standards are "imposed far more vociferously on women than on men" (Stearns, 2002, p.189). As a result, women are more prone to restrict their consumption in order to control their weight. Small-portion packs are seen as an effective means of controlling consumption (Stroebele *et al.*, 2009). It is thus unsurprising that women have a greater taste for small portions.   [28] Note that, when we constrain the marginal utility of information to be positive, the estimates do not converge, showing that such this restriction is rejected by the data.

a little lower in the first income quartile (35% *vs.* 39-40% in the upper quartiles), which suggests that labelling policies may not have regressive welfare effects.

Fat-content labels are thus not positively valued by all consumers, and mandatory labelling may then reduce their welfare, at least in the short run. This result is at odds with the standard predictions from the economics of information, where information provision is considered to always enhance consumer welfare as it favors market segmentation, which leads to a better match between consumer preferences and product characteristics. Here, it seems that it is the *absence* of information that favors product differentiation and market segmentation. As noted above, fat is a vector of immediate hedonic pleasure, but also produces unpleasant health consequences. When consumers are in conflict between the short-term pleasure of eating and the long-term goal of health preservation, informing them of the nutritional value of the choice options is likely to increase the anticipated guilt and psychic costs associated with less-healthy products. The fall in utility is larger for consumers who have a strong hedonic taste for fat (Wansink and Chandon, 2006, Kivetz and Keinan, 2006, Okada, 2005). They may thus prefer not to deal with information, in order to peacefully enjoy the pleasure of eating a product that they enjoy.[29] Nevertheless, it remains the case that a large majority of households are ready to pay positive amounts to have fat-content labels displayed on the front-of-pack. This is also true for those in the first income quartile and with a risky-overweight/obese main shopper, which suggests that the welfare benefits produced by fat-content labels are likely to be positive in the populations usually targeted by public-health policies.

One last remark is in order. Caplin and Leahy (2001) propose a theoretical framework that can be used to rationalize preferences for ignorance. The basic idea is that individuals may be subject to anticipatory feelings of anxiety in their current utility when the distribution of choice outcomes is uncertain. This can induce aversion to information, as the worst distribution can emerge from the resolution of uncertainty (see Köszegi, 2003, for an application to medical check-ups). Although this type of preference departs from traditional utility specifications, it does not require that we abandon the principle of revealed preferences. As such, we can use the estimated utility functions for welfare analysis.

4.3   Price-cost margins

Marginal costs are recovered for each product by inverting the first-order conditions in (15). Their mean (and standard deviation), as well as the associated average price-cost margins, are then computed for each producer. These cannot however be listed in detail here for confidentiality

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[29] Marketing research has shown that anticipation of guilt feelings plays an important role in food choices (Baumeister, 2002; Dhar and Simonson, 1999; Shiv and Fedorikhin, 1999; Wertenbroch, 1998; King *et al.*, 1987). The trade publication *Linéaires*, covering the launch of a new dessert yogurt in its issue of April 2001 (p. 50), reports that the producer explicitly wanted to avoid feelings of guilt among consumers. This was made through the choice of packaging colors and words reminiscent of "lightness" (a light blue colour scheme, the words "pearl" or "foam" etc.).

reasons. On average, the marginal costs and price-cost margins are equal to €1.33 (with a standard deviation of €0.69) and 47%, respectively. Unsurprisingly, unit costs are lower for the main retailer brands (between €0.73 and €1.02) than for the main national brands (between €1.23 and €1.69) Nevertheless, the price-cost margins for both types of brands are quite similar, so that differences in production costs are passed onto consumer prices. The top panel of Table 7 shows the initial market shares, producer prices and margins for five categories of products (skimmed, semi-skimmed and full-fat *fromages blancs*, and semi-skimmed and full-fat dessert yogurts). The margins are between 60% and 70% for the dessert yogurts, and around 45% for the *fromages blancs.*

5   Ex ante policy evaluation

The methodology described in Section 3.3 is applied to the above-estimated demand functions, to *ex ante* evaluate two fat policies: (*i*) mandatory labelling requiring all products to label fat-content on the front-of-pack; and (*ii*) an ad-valorem fat tax. Tax rates are set so as to produce a meaningful comparison between the two policies. As one key comparison criterion is household fat purchased, we choose the tax rates for semi-skimmed and full-fat products so as to yield approximately the same reduction in total fat purchases as mandatory labelling, in the absence of any firm response. Increasing producer prices by 10% and by 5% for full-fat and semi-skimmed products respectively produces this result (see the first line of Table 5).[30]

The policies are simulated both with and without a producer price response, to compare their effectiveness in reducing the quantity of fat purchased, and their impact on market shares, prices and consumer surplus. We first present the results in terms of health (fat purchases) and welfare. We then explore in detail the market mechanisms behind these results.

5.1   The change in household fat purchases and welfare

Table 5 lists the change in household annual fat purchases, by demographic group, with and without producer price reactions. Household annual fat purchases are calculated by multiplying the predicted choice probabilities by first the fat content of each product and then the 2007 purchase frequency. Pre-policy, 844g of fat were purchased on average per year by households participating in this market. Ignoring producer price responses, the policies produce large falls in fat purchases: of $300 - 325$g (around -38%) After accounting for the producer price response, this figure is 76.5g (-9.1%) for the fat tax and -12.5g (-1.5%) for labelling. If we aggregate these results over all households and extrapolate them to the entire French population, $2,361$ tons of fat are initially purchased by households via *fromage blanc* and dessert yogurt. Fat tax and mandatory labelling lead to falls of 5.55% and 0.9% (not shown in the table).

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[30] In all of the simulations we assume that the set of products is fixed and that pricing is the only strategy available to firms: product entry is excluded.

The fat tax affects all demographic groups similarly (between -8% and -10%), except households where the main shopper is a man (-6.4%). The effects of mandatory labelling show more variation, with a tiny increase in fat purchases in households whose main shopper is obese ($+0.2\%$), and a large fall for households in the first income quartile (-4.4%).

[Table 5 about here]

Table 6 shows the change in household consumer surplus by demographic group, when producer price responses are taken into account.[31] A fat tax reduces surplus by 2.1% on average, as consumer prices rise. Conversely, mandatory labelling yields a large rise in average surplus (52.5%). Differences by demographic group are only small.

[Table 6 about here]

Why does mandatory labelling have such an effect on consumer surplus? We now show that this is generated by the large fall in the price of dessert yogurts, which more than offsets any disutility from labels which is mainly found for consumers of dessert yogurts.

5.2   Impact on market equilibrium, producer margins and profits

The effects of both policies on market shares, prices and margins are summarized in Table 7. The middle and bottom panels present changes in shares, prices and margins following mandatory labelling and a fat tax, respectively, while the top panel describes the initial situation. For each policy, the first line represents the change in market share, in percentage points (pp), when only household responses are taken into account; the three remaining lines show the changes in shares (pp), prices (€) and margins (pp) after producer price responses.

[Table 7 about here]

A first striking result is that the simulated market equilibrium changes sharply when we allow for producer price responses. When we ignore them, shown above by the changes in fat purchases, both policies hit the target, although in different ways. Overall, mandatory labelling appears more efficient than the fat tax in reducing the demand for full-fat products (-8.6 pp *vs.* -4.9 pp). The fall in the market share of full-fat dessert yogurts, from 17.6% to 5.0% (-12.6 pp), following the introduction of a label is far from offset by the rise in the market share of (cheaper) full-fat *fromages blancs* ($+4$ pp). All *fromage blanc* categories (as well as the outside option) benefit from this fall. The explanation is that, apart from their taste for fat, most dessert yogurt consumers are fat lovers who do not want to be informed about the fat they eat. Their WTP for fat-content labels is indeed low, and often negative: for instance, the median WTP amongst households who

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[31]   The formulae for these welfare calculations appear in Appendix A.3. These are of course short-term welfare effects, since the welfare impact of health changes are not included.

purchased a full-fat dessert yogurt at least once is $-€4.74$. By way of comparison, the figure for households who purchased a full-fat *fromage blanc* at least once is €0.42 (see Table A.3 in Appendix A.2). Dessert yogurt consumers may move not only to full-fat *fromages blancs* because they are cheaper, but also to lighter categories of *fromages blancs* to attenuate the psychic costs of eating fatty products; they may stop consuming as well.

Allowing for supply-side price responses completely changes this picture. Labelling then leads to a small rise in the market share of dessert yogurts ($+1.1$ pp for full-fat dessert yogurts), at the expense of skimmed and semi-skimmed *fromages blancs* (-1.9 pp and -8.1 pp, respectively). This can be explained by the large fall in the price of dessert yogurts: semi-skimmed and full-fat dessert yogurts exhibit price falls of about €0.95 and €1.39, respectively, hence becoming the cheapest products on this market. In spite of this fall in prices, the margins remain positive for all products.[32]

In the absence of a strategic price response, the fat-tax impact on market shares is smaller than that of mandatory labelling, especially for full-fat dessert yogurts. This however reverses with producer price responses. The market share is reduced by 2.3 pp for full-fat *fromages blancs*, and by 1.4 pp for full-fat dessert yogurts. The corresponding increase in the share of skimmed *fromage blancs* ($+2.8$ pp) and semi-skimmed dessert yogurts ($+1$ pp) shows that households move away from the fatter varieties. The changes in market share are smaller as producers do not fully pass the tax on to consumer prices. For instance, for full-fat dessert yogurts, the final increase in consumer price with 100% pass-through would be €0.31 (3.06 times the tax of 10%), whereas it is only €0.12 (i.e. $(3.06 - 0.17) \times 110\%$ minus 3.06) with a price response. This means that the pass-through rate is under 40%: producers are willing to absorb a large part of the intended policy shock on consumer prices.

Table 8 shows the changes in market share by demographic group after firm price responses. Under mandatory labelling, the consumption of full-fat dessert yogurts increases more in households whose main shopper is obese ($+4.7$ pp, compared to $+1.1$ pp for the whole population). In addition, this group consumes less skimmed and semi-skimmed *fromage blanc*, with the market shares falling by 3.0 pp and 10.1 pp, respectively. Labelling thus fails to achieve the objective of changing the choices of those who would really need to switch from full- to lower-fat products. Again, the fat tax seems to be a better policy, as it induces substitution from full-fat to skimmed and semi-skimmed products for households with obese main shoppers.

[Table 8 about here]

The changes in profits and market share are not shown here in detail for confidentiality reasons. Annual profits are calculated using predicted market share and observed household purchase

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[32] To obtain the new price equilibrium, two full-fat and one semi-skimmed dessert yogurts have to be dropped from the universal set of products (the algorithm does not converge otherwise). The households who chose these products are then considered as having selected the "no purchase" option. This covers only 35 out of 8975 possible decisions.

frequencies for *fromages blancs* and dessert yogurts over the year, extrapolated to the French population using the sampling weights provided by Kantar WorldPanel. Both policies reduce producers' annual profits, with a larger effect from labelling (−21.0%) than from the fat tax (−6.1%). Producer price responses help them to limit the fall in sales, but require them to reduce their margins (especially under mandatory labelling). The main national brands suffer more from labelling than do retailer brands, with the fall in profits ranging from 34.4% to 76.6% for the former, and 11.3% to 20.6% for the latter.

The producer price response aims to minimise the fall in profits. This can be explained by three factors: initial margins; the elasticity and concavity of demand curves; and the competition between producers and, for each producer, between products in its portfolio.

In the case of mandatory labelling for dessert yogurts, producers can afford large price cuts on these products as margins are initially substantial: the initial price-cost margin is 67% for full-fat dessert yogurts, as opposed to only 41% for full-fat *fromages blancs*. In addition, the estimated own-price elasticity of demand for full-fat dessert yogurts is −5.1 in the absence of a price response. Producers can hence expect to win back market share via price cuts. This strategy is constrained by two factors. First, demand becomes less and less elastic as price falls: the elasticity of full-fat dessert yogurts is −2.4 after the price response. Profit maximisation entails a trade-off between lower margins and a larger market share, which is partly determined by the concavity of the demand function, i.e. the change in elasticity (see Stern, 1987, and Delipalla and Keen, 1992 for the case of taxation under imperfect competition). Second, each producer faces the price response of all of the other producers and must in addition optimise its own response over its portfolio of products. For instance, the demand elasticity for full-fat *fromages blancs* is −4.8 in the absence of price response. The producers of these full-fat products have the means of countering the lower price of dessert yogurts, although they are constrained by their lower initial margins. Mandatory labelling actually increases competition on the market, by making products more similar. The Herfindahl-Hirschman Index (HHI) of market shares is initially 921; this would fall to 770 without any price response. For the tax policy, and without any price response, the HHI only changes little (906 instead of 921).

6 Conclusion

This paper has developed an *ex ante* evaluation of the impacts of a fat tax and mandatory labelling on market equilibrium. This evaluation requires the separate identification of consumer preferences for fat-content labels and fat. This is made possible by an exogenous change in legal fat-content labelling requirements in the French *fromage blanc* and dessert yogurt market. Following the recent literature in empirical industrial organization, we combine a flexible discrete-choice model of demand, estimated on scanner data (disaggregated at both the household and product levels), with a linear-pricing supply model to recover price-cost margins for each manufacturer and to

determine the food-policy impact on market outcomes.

In the absence of a producer price response, making fat labels mandatory reduces household fat purchases by about 38%. To obtain a similar effect, and thus compare mandatory labelling to the fat tax, we set ad valorem taxes of 10% and 5% on the producer price of full-fat and semi-skimmed products, respectively. Taking into account producer price responses is shown to dramatically change the policy evaluation. Fat taxes then result in a more modest reduction in fat purchases of about 9%. However, mandatory labelling reduces household fat purchases by only 1.5%, as dessert yogurt producers cut their margins to retain customers. This producer reaction entails a large fall in the price of dessert yogurts, offsetting 96% of the impact of front-of-pack fat-content labels. As prices are lower, mandatory labelling likely increases consumer welfare in the short run, while the fat tax has the opposite effect. Although these welfare calculations do not take into account the long-run benefits of reduced fat intake, the estimated changes in the latter are only small, so that the health effects will arguably be so as well.

The key policy message of our research here is thus that there is no magic bullet to reduce fat consumption when we rely only on standard policy tools, as market mechanisms — here the firms' response to policies — can neutralise any intervention. Firm reactions will depend on the market under consideration and, specifically, on the margins. For example, Griffith *et al.* (2010) find higher pass-through rates and effects of a tax on saturated fat in the British butter and margarine market, where the margins are estimated to be smaller (0.38–0.49 v.s. 0.52–0.69 for dessert yogurts). One alternative policy option, currently being considered by the French public-health authorities in association with producers, is to promote voluntary limits on the fat (and sugar) content of products.

While this paper is, to the best of our knowledge, the first to encompass structurally the question of prices and labels, there are three limitations to our analysis. First, all of the simulation results are based on a supply model without explicit modelling of the vertical relationships between retailers and producers. Although the results are very similar when we model them as a two-part tariff contract with resale price maintenance (where wholesale prices are such that the retailer's price-cost margins are zero), it would be interesting to check whether other types of vertical relationships have significant consequences for the market equilibrium. Second, the set of products is supposed to be fixed, so that firms can only use pricing strategies. However, firms may change their products too; new products may enter the market, and other products may exit. Last, the demand model does not take into account, in a structural way, the health effects of fat consumption. As such, it is difficult to evaluate the long-run welfare effects of each policy, and to rank the various options according to health. While the short- and long-run welfare effects are probably only little different for a single product, this would certainly not be the case for policies which target a large range of products. We leave these questions for future research.

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7 Tables

Table 1: **Mean values of product characteristics**

		In the universal product set	In the household choice set
Price (std. dev.)		2.44 (1.09)	2.71 (1.22)
Products with a label	Label	85%	81%
Skimmed		24%	22%
Semi-skimmed		38%	35%
Full-fat		37%	43%
Fromage Blanc		80%	78%
Texture	Smooth	75%	73%
Small pack size	Portion < 200g	54%	59%
Organic or bifidus products	Organic/Bifidus	4%	8%
Low-quality retailer and hard-discount brands	Low quality	20%	9%
Medium-quality retailer brands	Medium quality	39%	23%
High-quality retailer and national brands	Reference	40%	68%

Note: Column 1 refers to the means over 224 products, and column 2 to the means over 8497 observed purchases.

Table 2: **Market characteristics**

	Outside option	Fromages blancs			Dessert yogurts	
		Skimmed/fat-free	Semi-skimmed	Full-fat	Semi-skimmed	Full-fat
Number of products (number with a label)		54 (54)	63 (63)	63 (63)	24 (12)	20 (0)
Mean prices (std. dev.) in Euros	0	1.99 (0.88)	1.98 (0.78)	2.95 (1.14)	2.88 (1.36)	3.09 (0.39)
Market shares inc. the outside option	5.4%	16.2%	38.9%	15.7%	6.7%	17.2%
Market shares exc. the outside option		17.1%	41.1%	16.6%	7.1%	18.2%

Note: The mean prices are calculated over the universal product set; using the household choice set yields fairly similar results.

Table 3: **Household characteristics (N=1785)**

	Mean
Monthly household income (€)	2696 (1435)
Household size	2.6 (1.33)
Male main shopper	4%
Single household	8%
Couple without children	23%
Couple with children	39%
Aged over 65	31%
Body Mass Index (BMI)	24.77 (4.23)
Main shopper overweight: BMI≥25	40%
Main shopper risky-overweight: BMI≥27	26%
Main shopper obese: BMI≥30	12%
Education = Primary	25%
Education = High school	33 %
Education = Baccalaureat	26 %
Education > Baccalaureat	16 %

Notes: Mean over the 1785 households in our sample; Main shopper's body mass index (BMI) is based on self-reported measures of height and weight.

Table 4: **Estimated coefficients**

	Mean	Std. Dev.	Income			Male	Risky-overweight	Household size	Over 65
			First Quartile	Second Quartile	Third Quartile				
Price	-1.870***	1.995***	-0.232***	-0.148***	-0.013	-0.067	-0.042	0.012	0.263***
	(0.056)	(0.030)	(0.063)	(0.057)	(0.058)	(0.108)	(0.049)	(0.017)	(0.049)
Label	0.592**	3.85***	0.157	0.641**	0.180	-0.239	0.288		-0.447**
	(0.271)	(0.131)	(0.330)	(0.309)	(0.320)	(0.596)	(0.252)		(0.245)
Semi-skimmed	0.283***		0.664***	0.400***	0.360***	0.766***	-0.201***		0.189***
	(0.065)		(0.085)	(0.083)	(0.089)	(0.176)	(0.070)		(0.070)
Full-fat	0.250***		0.384***	0.142	0.229**	0.995***	0.010		0.226***
	(0.082)		(0.106)	(0.102)	(0.106)	(0.207)	(0.086)		(0.084)
Fromage blanc	1.447***		-0.009	-0.767***	-0.669***	0.303	-0.262*		-0.123
	(0.162)		(0.198)	(0.173)	(0.183)	(0.378)	(0.136)		(0.134)
Low-quality	-1.608***		0.367***	0.204*	0.221*			0.169***	
	(0.184)		(0.121)	(0.112)	(0.119)			(0.032)	
Medium-quality	-0.490***		0.364***	0.452*	0.447***			0.069***	
	(0.158)		(0.085)	(0.077)	(0.079)			(0.023)	
Below 200g	1.290***					-0.411***			
	(0.053)					(0.151)			
Smooth	-0.651***								
	(0.068)								
Terms to correct for endogeneity									
Residuals, price	0.585***								
	(0.056)								
Residuals, label	0.898***								
	(0.129)								
Err. compnt, price	-0.246***								
	(0.087)								
Err. compnt, label	0.004								
	(0.098)								

Notes: standard errors are in parentheses; ***, **, and * denote significance at the 1%, 5% and 10% levels respectively; the column "Std. Dev." shows the standard deviation of the random coefficients; the random coefficients are distributed according to the opposite of a lognormal law for price, and to a normal law for the label; their coefficient of correlation is -0.77***; the other control variables are the fixed effects for the 14 distribution channels and the 15 brands or groups of brands (results available from the authors on request); these results are obtained with $D = 500$ draws; the reference individual is a female main shopper in the top income quartile, aged under 65, whose BMI is under 27.

Table 5: **Changes in average household annual fat purchases, by demographic group (in grams)**

	Base Fat	Fat tax		Mandatory labeling	
		No producer response	Producer response	No producer response	Producer response
All	844.28	-305.47	-76.51	-325.90	-12.51
Income					
First quartile	855.58	-305.23	-85.26	-318.96	-37.76
Second quartile	845.63	-315.66	-76.08	-330.28	1.33
Third quartile	849.07	-300.44	-71.48	-325.22	-2.03
Fourth quartile	830.06	-300.52	-73.40	-328.36	-11.57
Main shopper BMI					
BMI<25	835.62	-303.88	-77.13	-324.15	-18.02
25≤BMI<30	851.18	-303.42	-75.62	-324.82	-6.97
BMI≥30	871.11	-318.43	-75.52	-337.32	1.83
Male	990.50	-370.44	-63.04	-393.50	-9.29
Female	837.82	-302.60	-77.10	-322.92	-12.65
Aged under 65	808.00	-296.84	-77.55	-313.18	-12.46
Aged above 65	926.85	-325.11	-74.15	-354.86	-12.60

Notes: Annual fat purchases are calculated using the predicted choice probabilities and household purchase frequency in 2007; under mandatory labeling all products have a fat-content label; under the fat tax, there is an ad valorem tax of 10% for full-fat and 5% for semi-skimmed products.

Table 6: **Change in consumer surplus, by demographic group (in percent)**

	Fat tax	Label
All	-2.15	52.85
Income		
First quartile	-2.35	55.35
Second quartile	-2.19	53.26
Third quartile	-2.07	48.34
Fourth quartile	-2.01	53.82
Main shopper BMI		
BMI<25	-2.14	52.08
25≤BMI<30	-2.17	54.20
BMI≥30	-2.14	53.44
Male	-2.63	53.57
Female	-2.13	52.82
Aged under 65	-2.23	56.50
Aged above 65	-1.95	44.55

Notes: Under mandatory labeling all products have a fat-content label; under the fat tax, there is an ad valorem tax of 10% for full-fat and 5% for semi-skimmed products; all results include the producers' price responses.

Table 7: **Changes in market shares and prices produced by a fat tax and mandatory labeling, by product category**

	Outside option	Fromages blancs			Dessert yogurts	
		Skimmed/fat-free	Semi-skimmed	Full-fat	Semi-skimmed	Full-fat
Initial market shares (%)	6.18	15.88	38.09	15.46	6.77	17.62
Initial producer prices (€)		1.98	1.97	2.95	2.87	3.06
Initial margins (%)		46.05	44.29	41.15	56.88	66.63
Mandatory labeling						
Share change with no firm response (pp)	4.87	2.03	3.73	4.00	-2.04	-12.59
Share change with firm response (pp)	3.79	-1.88	-8.06	1.88	3.16	1.11
Producer price change (€)		0.06	0.06	0.21	-0.95	-1.39
Margin change (pp)		0.66	1.45	1.40	-9.44	-21.93
Fat tax						
Share change with no firm response (pp)	0.86	2.94	0.02	-2.56	1.06	-2.32
Share change with firm response (pp)	0.58	2.98	-0.88	-2.3	1.01	-1.39
Producer price change (€)		-0.03	-0.02	-0.07	-0.07	-0.17
Margin change (pp)		-1.01	-0.77	-1.16	-1.74	-2.33

Notes: Mandatory labeling requires all products to display a fat-content label; the fat tax increases the producer prices of full-fat and semi-skimmed products by 10% and 5% respectively; the abbreviation pp stands for percentage point; price and margin changes are averages by product category, weighted by product market share; margins are given by $(price-mc)/price$, where mc denotes the marginal cost; price and margin changes include firms' strategic pricing responses.

Table 8: **Changes in market shares, by product category and demographic group (in percentage points)**

		Fromages blancs			Dessert yogurts	
	Outside option	Skimmed/fat-free	Semi-skimmed	Full-fat	Semi-skimmed	Full-fat
Mandatory labeling						
First income quartile	4.07	-0.93	-7.05	1.92	3.25	-1.26
Second income quartile	3.66	-3.36	-11.36	-0.01	4.96	6.11
Third income quartile	3.79	-2.39	-8.83	1.74	3.49	2.20
Fourth income quartile	3.70	-1.00	-5.41	3.60	1.25	-2.14
Main shopper BMI<25	3.85	-1.52	-7.38	2.14	3.00	-0.09
Main shopper 25≤BMI<30	3.72	-2.16	-8.60	1.79	3.15	2.10
Main shopper BMI≥30	3.71	-3.04	-10.17	0.78	4.01	4.71
Male	4.05	-0.71	-6.79	3.38	1.30	-1.23
Female	3.80	-1.94	-8.12	1.81	3.24	1.21
Aged under 65	4.01	-2.11	-8.31	1.16	3.47	1.78
Aged above 65	3.34	-1.37	-7.50	3.50	2.45	-0.42
Fat tax						
First income quartile	0.56	2.99	-1.09	-2.28	1.40	-1.58
Second income quartile	0.57	3.06	-0.94	-2.15	0.93	-1.47
Third income quartile	0.59	2.71	-0.63	-2.23	1.05	-1.49
Fourth income quartile	0.62	3.09	-0.83	-2.51	0.73	-1.10
Main shopper BMI<25	0.57	2.98	-0.91	-2.30	1.10	-1.44
Main shopper 25≤BMI<30	0.61	2.92	-0.78	-2.28	0.89	-1.36
Main shopper BMI≥30	0.59	3.11	-0.93	-2.37	0.83	-1.23
Male	0.71	2.04	0.24	-3.04	0.74	-0.69
Female	0.58	3.02	-0.93	-2.27	1.02	-1.42
Aged under 65	0.57	3.23	-1.06	-2.34	1.00	-1.40
Aged above 65	0.60	2.40	-0.46	-2.21	1.04	-1.37

Notes: Under the labeling policy, all products have a fat-content label; under the fat tax there is an ad valorem tax of 10% on full-fat and 5% on semi-skimmed products; all of the results include the producers' price responses.

A Appendix

A.1 Defining the relevant market

We here want to exploit the difference in labelling rules between *fromages blancs* and yogurts, so the set of alternatives must necessarily include all of the *fromages blancs*. We thus have to determine whether both standard *and* dessert yogurts should be included in the definition of the relevant market for *fromages blancs*. The purpose of any relevant market test is to measure the degree of competition exerted over a given product from the other products. In its guidelines for the assessment of relevant markets, the European Commission (1997) defines the three main factors determining competition: substitution on the demand side, substitution on the supply side generated by the strategic responses of competitors to the producer's decision, and the entry of new competitors on the market. We here check only for demand substitution, which represents the most immediate competitive constraint for producers. With each decision regarding a product's ingredients and marketing-mix, producers must bear in mind that customers can switch from one variety to another.

Demand substitutions is analyzed via the estimation of an Almost Ideal Demand System (Deaton and Mullbauer, 1980). This relates the yearly budget share s_{ij} of products $j = 1, .., J$ for household $i = 1, ..., N$ to log total expenditure x_i for unflavored yogurts and *fromages blancs*, and the log price J-vector p_i, through the following equation

$$s_{ij} = \alpha_j x_i + \gamma_j p_i + \beta_j (x_i - a(p_i, \theta)) + u_{ij},$$

where $a(p_i, \theta)$ is a nonlinear price aggregator that can be approximated by a Stone price index. Here x_i is a set of socio-demographic variables (number of household members, position in the lifecycle, socio-economic status, gender and education of the main shopper, whether the main shopper has a body mass index over 27, and the region and type of residential area). Following Lecocq and Robin (2006), product-level prices are computed as the average price of all purchases made in the same region and area, and we control for the endogeneity of total expenditure via a control function approach with household income as an instrument.

The first row of Table A.1 presents the conditional (on total expenditure) uncompensated elasticities for *fromages blancs* with respect to the price of *fromages blancs*, dessert yogurts and standard yogurts. The second and third rows display the same elasticities for dessert and standard yogurts respectively. We can see that there is a significant increase in purchases of *fromages blancs* as the price of dessert yogurts increases. A similar but *insignificant* effect is found for the price of standard yogurts. This shows that dessert yogurts should be included in the relevant market for *fromages blancs*, but not standard yogurts. The other cross-price elasticities are insignificant.

Table A.1: **Uncompensated price elasticities**

	Fromages Blancs	Dessert Yogurts	Standard Yogurts
Fromages Blancs	-0.982^{***}	0.393^{*}	0.200
	(0.218)	(0.208)	(0.221)
Dessert Yogurts	-0.275	-1.187^{**}	-0.381
	(0.517)	(0.492)	(0.523)
Standard Yogurts	0.094	-0.265	-1.021^{***}
	(0.182)	(0.173)	(0.184)

Note: ***, ** and * represent significance at the 1, 5 and 10 percent levels respectively.

A.2 Distribution of household WTP conditional on observed choices

The estimates resulting from the maximisation of (13), can be used to determine the distribution of tastes over the sampled households, $\{\alpha_i, \beta_i\}$, as well as functions of these, conditional on the household's observed choices and population parameters (Revelt and Train, 2000). Formally, if $h(\alpha_i)$ is such a function, its conditional expectation is given by

$$E(h(\alpha_i) \mid w_i; \theta) = \int E(h(\alpha_i) \mid w_i, \eta_{ijt}, \nu_i; \theta) g(\eta_{ijt} \mid w_i) f(\nu_i \mid w_i) d\nu_i d\eta_{ijt},$$

where $g(\eta_{ijt} \mid w_i)$ and $f(\nu_i \mid w_i)$ are the densities of η_{ijt} and ν_i conditional on the household's observed sequence of choices. From Bayes' rule, we have

$$E(h(\alpha_i) \mid w_i; \theta) = \frac{\int E(h(\alpha_i) \mid w_i, \eta_{ijt}, \nu_i; \theta) P(w_i \mid \eta_{ijt}, \nu_i; \theta) g(\eta_{ijt}) f(\nu_i) d\nu_i d\eta_{ijt}}{P(w_i \mid \theta)}.$$

Similarly to (11), and still denoting by η_{ijtd} and ν_{id} the d-th draws from the distribution of η_{ijt} and ν_i, this expectation can be approximated through simulation by

$$E(h(\alpha_i) \mid w_i; \theta) = \frac{\sum_{d=1}^{D} E(h(\alpha_i) \mid w_i, \eta_{ijtd}, \nu_{id}, ; \theta) P(w_i \mid \eta_{ijtd}, \nu_{id}; \theta)}{\widetilde{P}(w_i \mid \theta)}, \tag{16}$$

where $\widetilde{P}(w_i \mid \theta)$ is given by (12). With $h(\alpha_i) = \alpha_i^l$, (16) shows the household's expected taste for fat-content labels; if $h(\alpha_i) = \alpha_i^l / \alpha_i^p$, then it describes the household's expected willingness-to-pay for labels.

Table A.2: **Descriptive statistics of the WTP for fat-content labels**

	WTP≤0 (%)*	Median (€)
All	38.05	0.65
Main shopper's body weight		
Normal weight (BMI<25)	38.03	0.65
Overweight (25≤BMI<27)	35.55	0.73
Risky-overweight (27≤BMI<30)	38.26	0.71
Obese (BMI>30)	40.81	0.47
Income quartile		
First	34.58	0.65
Second	38.79	1.22
Third	39.14	0.90
Fourth	39.89	0.35
Male	37.19	0.17
Female	38.11	0.68
Aged under 65	38.70	0.62
Aged over 65	38.03	0.86

Note: *Percentage of households with negative WTP.

Table A.3 below shows median WTP according to whether the household never chose or chose at least once the options listed in the first column. The final column shows the p-value for the hypothesis that the two medians are equal.

Table A.3: **Households' product choice and WTP for a fat-content label**

	Median WTP (€)		Equality test
	Never	At least once	p-value
Outside option	1.07	-0.40	0.000
Skimmed/fat-free *fromages blancs*	0.33	1.05	0.000
Semi-skimmed *fromages blancs*	-0.45	1.01	0.000
Full-fat *fromages blancs*	0.80	0.42	0.040
Semi-skimmed dessert yogurts	0.88	-1.71	0.000
Full-fat dessert yogurts	1.13	-4.74	0.000

A.3   Household consumer surplus

The consumer surplus $CS_i(p_t, l_t)$ for household i in period t is calculated using the log-sum formula proposed by Small and Rosen (1981)

$$CS_i(p_t, l_t) = \frac{\mathbb{E}(\max_j u_{ijt}(p_t, l_t))}{|\alpha_i^p|} = \frac{1}{|\alpha_i^p|} \ln \left[\sum_{j=0}^{J_{it}} \exp(u_{ijt}(p_t, l_t)) \right],$$

where $|\alpha_i^p|$ is the estimated marginal disutility of price for consumer i. Consumer surplus is calculated given the household-specific taste parameters, using the formula in equation (16). The change in surplus from mandatory fat-content labels, implying new equilibrium prices p^* and label variable l^*, is given by $CS_i(p_t^*, l_t^*) - CS_i(p_t, l_t)$. With a fat tax, only equilibrium prices vary, and l_t is unchanged. Note that consumer surplus depends on the utility obtained from all alternatives, including the outside option. It therefore varies across households not only through price sensitivity, but also from the utility of each alternative, which allows us to take into account the changes in household utility produced by substitutions between the alternatives.