Mandatory labeling *vs.* fat tax: An empirical evaluation of fat policies in the French *fromage blanc* and yogurt market

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Abstract

The taxation or the mandatory labeling of unhealthy nutrients may help to curve the growth of food-related chronic diseases, such as obesity. This paper is the first to propose an *ex ante* evaluation of the impact of these two policy options in an oligopolistic setting with differentiated products and heterogeneous demand. Using scanner data on *fromages blancs* and yogurts purchased by French households, consumers preferences for fat-content labels and for fat are separately identified by relying on a discontinuity in fat-content labeling legal requirements that is specific to this market. The demand estimates are then used to compute the price-cost margins of producers, and evaluate the impact of the fat tax and madatory labeling policies without and with strategic price response. An ad-valorem tax of 10% on producer prices of full-fat products would lead to a 9% fall in yearly fat purchases, whereas the mandatory labeling of fat content would yield a 1.5% decrease only. This is explained by producers response, which neutralizes up to 96% of the impact of mandatory labeling on consumer demand through large price cuts.

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1 Introduction

Dietary fat is an important issue in public health policy since more than forty years now. In 1977, an American Senate Select Committee on Nutrition proposed new "Dietary Goals for the United States", which for the first time called on Americans to reduce their consumption of red meat and dairy products, in order to prevent a host of health conditions such as heart disease, certain cancers, stroke, high blood pressure, obesity, diabetes, and arteriosclerosis. In most developed countries, official reports started to promote similar nutritional advices in the late Seventies and the Eighties. More recently, the spectacular growth of obesity and overweight, which has reached epidemic proportions globally, with more than 1 billion adults overweight worldwide in 2010, has become a major concern for policy-makers (OECD, 2010). Not without controversies, these trends have been related to the growing share of fat in calories available for human diet (Popkin and Gordon-Larsen, 2000; James et al., 2004; Oliver, 2006). Nowadays, in most OECD countries, fat represents between 40 and 45% of total daily calorie intakes, as against 20-30% one century ago (Etilé, 2011). In this context, two market-based food policy options have attracted a great deal of interest from policy-makers and public health advocates: the taxation of fat or fatty food products and the mandatory labeling of key nutrients such as fat.[1] This paper examines these two policy options, comparing *ex ante* their effects on market outcomes (quantity of fat purchased by households, consumer welfare, prices, market shares and producer profits).

Previous research usually used continuous choice demand models to evaluate the impact of fat tax.[2] This approach allows for substitutions between food categories, more or less aggregated, but ignores substitutions either within food categories or towards an outside good. Yet, it is more credible to consider that a fat tax will make consumers of high fat-content items exiting the market or switching to the nearest low fat-content counterparts in the same food group, rather than substituting from one food category to another. In addition, the strategic reactions of producers are generally ignored, except in Griffith et al. (2010) and Bonnet and Réquillart (2011). These authors analyse taxes on respectively saturated fats in butter and margarine and sugar in soft drinks, and they estimate firms'pass-through rate of the tax to consumer prices in a differentiated product oligopoly setting.

The effect of nutritional information on consumer choices has mostly been investigated through consumer responses to hypothetical choices, which can lead to overestimation biases (Cowburn

[1] OECD has called for the implementation of tax policies as a means of fighting the obesity epidemic (Cecchini *et al.*, 2010); in 2009-2010, additional taxes on sugary drinks were proposed in at least 17 US States; Denmark introduced a 25% tax increase on ice-creams, 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. Regarding mandatory labeling policies, the European parliament voted for a draft proposal in favor of mandatory labeling on the front-of-packages in June 2010. The content in seven key nutrients, including fat, should soon be displayed in a visible way on all food products to help consumers moving from high fat-content products to low fat-content products. See EUFIC (2012) for an update on nutrition labelling in EU. [2] See for example Caraher and Cowburn (2005), Mytton *et al.* (2007), Chouinard *et al.* (2007) and Allais *et al.* (2010); a noticeable exception is Griffith *et al.* (2010).

and Stockley, 2005).[3] Empirical econometric evidence on the impact of mandatory food labels on purchase behavior in a natural shopping environment is quite scarce. Difficulties to find exogenous variations in producers' labeling decisions and credible control groups are major obstacles to identification. Some studies have however been able to use quasi-natural experiments, such as changes in labeling legislation caused by the enactment of Nutrition Labelling and Education Act (Mathios, 2000) or the lift of regulatory ban against advertising on ready-to-eat cereal health benefits (Ippolito and Mathios, 1990). Other studies have exploited field experiments in supermarkets (Teisl *et al.*, 2001; Kiesel and Villas-Boas, 2010). To the best or our knowledge, the strategic reactions of the supply to mandatory labeling have never been explored.

This paper attempts to avoid these these pitfalls of policy evaluation through the combination of a quasi-natural experiment and a structural modelling of the market. First, we use scanner data, disaggregated at both household and product levels,to estimate a discrete choice model of demand, which allows both for substitutions between products within a same food group and for an outside option. Second, 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 manufacturer, to identify the strategic price reactions of firms, and to determine the new market price equilibrium implied by each food policy.

Last, we exploit an exogenous source of variation in labeling legal requirements in the French market for dessert yogurts and *fromages blancs*[4] to identify the causal impact of fat-content labels on consumer choices. The French labeling legislation requires producers to signal the percentage of fat contained in *fromages blancs* by a fat-content label displayed on front-of-pack, while fat-content labeling is not mandatory for dessert yogurts. In particular, producers never put front-of-pack fat-content labels on full-fat dessert yogurts, but they have to on full-fat *fromages blancs*. Combining these exogenous variations in labeling legal requirements with brand labeling 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 the consumer preferences for fat and for fat-content labels separately. Beyond this unusual but quasi-natural discontinuity in labeling rules, this market is interesting because the fromage blancs and dessert yogurts compete on a highly differentiated market, and they account for a quite substantial share of household fat purchases (2.75%, with a high proportion of saturated fats)..

Following the discrete choice literature, we model consumer preferences using a Mixed Multinomial 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 not only. As producers' decisions to place a fat-content label on the package of

[3] See Grunert and Wills (2007) for a detailed survey. [4] 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 gather together products like the strained/greek style yogurts and fromages blancs or yogurts mixed with cream or other animal fats.

a dessert yogurt may be correlated to some unobserved consumer tastes, we also need to control for the endogeneity of fat-content labels. We do so exploiting the "quasi-natural experiment" provided by the exogenous variation in the labeling rules between *fromages blancs* and dessert yogurts. Household-specific demand parameters are then identified from scanner panel data collected in a representative sample of households in 2007. These estimates are used to compute price-cost margins for manufacturers assuming that producers compete *à la Nash* in a Bertrand oligopolistic game and the new market price equilibrium implied by the implementation of each food policies is computed.

We find that a fat tax would increase the market shares of skimmed *fromages blancs* at the expense of all full-fat products, as expected. Conversely, and a priori more surprisingly, a mandatory labeling policy would increase the market shares of dessert yogurts. This result can be explained by the important price cuts that would be operated by producers for dessert yogurts, through drastic reductions in margins (−68% for full-fat dessert yogurts) that were initially very large. Firms would then offset 96% of the effect produced by the policy on consumers' demand. Both policies would result in a fall of producers' annual profit, which would be considerably larger under the mandatory labeling policy (−21.0%) than under the fat tax (−6.1%). The fat tax and mandatory labeling policies would reduce the annual fat provided to households on this market segment, by 76.5g and 12.5g respectively. Hence, from a health policy perspective, our results suggest that the fat tax dominates the mandatory labeling policy. From a consumer policy perspective, however, they suggest the opposite: consumer welfare would increase by 52.9% with the mandatory labeling, as a result of the fall in prices, and decrease by 2.1% with the fat tax.

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. Estimation results are discussed in Section 4 and simulations in Section 5. The last section concludes.

2 Data

We use household scanner data from a panel maintained by Kantar Worldpanel (KWP) for the calendar year 2007. The advantage of scanner data over experimental or hypothetical choices studies is that observations are based on actual purchase behavior in a natural shopping environment. Hence, consumers' preferences are identified in a realistic setting.

There are 13,380 households in the starting sample, which is nationally representative of the French population. The data record, on a weekly basis, all purchases of yogurts and *fromages blancs* made for home consumption by the households throughout the year. The Universal Product Code (UPC) of each purchase is registered through the use of a handheld scanner, as well as the quantity purchased and the associated expenditures. KWP does not provide UPCs, but a large set of product attributes. We choose to divide the year into 13 periods (or time units t) of four weeks.

We thus focus on representative purchase behaviors in each four-week period, *i.e.* the choices that are the most frequently observed in a sense that will be defined below.[5]

2.1 The relevant market

There are three broad categories of yogurts and *fromages blancs*: the standard yogurts; the standard *fromages blancs*; and the 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 in France labeling is mandatory for the *fromages blancs* and not for the dessert yogurts makes it easier to identify the consumer preferences for labeling and for fat separately.

We restrict the analysis to unflavored 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 are likely to be less salient for consumers, and less relevant from a nutritional point of view.[6] We also eliminate products that are not made from milk cow (4.5% of all purchases), and we exclude drinking yogurts and yogurts with cereals, which account for less than 1.5% of all purchases.

In the remaining sample, 46.3% of those households who consumed *fromages blancs* in 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 a same market, which is the case for *fromages blancs* and dessert yogurts. A formal test of this can be obtained by 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 and Robin (2006). An Almost Ideal Demand System is then estimated and the uncompensated cross-price elasticities are derived (Deaton and Mullbauer, 1980). We only find one significant cross-price elasticity, indicating that the *fromages blancs* are substitutes to the 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). Hence, the analysis will focus on the relevant market for the unflavored fromages blancs,which includes the unflavored dessert yogurts but not the standard yogurts.[7]

Eventually, in order to strengthen the identification of consumer preferences, we only keep the

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[5] Griffith *et al.* (2010) choose a unique random shopping trip during the calendar year. In our view, this method has the disadvantage of introducing more noise in the analysis of consumer preferences. [6] In addition, the French yogurt and *fromage blanc* market is characterized by a huge variety of flavors (more than 249 different flavors in our dataset), and considering all, or even grouping some flavors together, would have rendered the estimation of the model infeasible. [7] This result is in line with the professional practice in marketing of considering that the dessert yogurts and the *fromages blancs* compete on the market of textitFromages Frais, while the yogurts form another market: see for instance the professional review *Linéaires*, n¡173, September 2002, p. 98, or n¡187, December 2003, p. 110, or n¡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, frequently added with sugar, marmalade, honey or fruits.

households who purchased *fromages blancs* or dessert yogurts more than 10 weeks in the year. Since they clearly exhibit a stable taste for these products, this avoids making inference from noisy choices. This leaves us with 1785 households.

2.2 Product attributes

The data contain information on the fat content of all dessert yogurts and *fromages blancs*, as well as the 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 that were available on the French market in 2007.

2.2.1 Fat content and fat-content labels

Using the fat content, we sort the products into three categories: full-fat (more than 6% of fat), half-skimmed (between 3% and 6%), or skimmed (less than 3%).[8] Fat-content labels are mandatory for all *fromage blanc* products.[9] But our data do not provide any information about the *presence* of fat-content labels on the dessert yogurts. We therefore collected additional data from several sources of information. The main source is the online Mintel's Global New Products Database (GNPD), which shows for 80% of the products in the dataset high-resolution color images of the package, and its evolution through time. This information was completed by an examination of the monthly French review *Linéaires*, which provides a detailed description and a picture of a number of new food products launched in France every month. Last, we also visited the popular website www.flickr, which proposes more than 4 billion images; the French website of consumer network www.ciao.fr; and for a small number of products, we used old TV advertisements from audiovisual archives available on line from the *Institut National de l'Audiovisuel*.

2.2.2 Other characteristics

We control for a number of other product characteristics, which have been ultimately selected because they were significant in preliminary regressions. Differences in hedonic characteristics are captured by a set of discrete attributes that indicate whether the product is a *fromage blanc* or a dessert yogurt, and whether its texture is smooth or not. Differences in health characteristics other than the fat content are captured by a dummy variable that indicates whether the product is organic or has been supplemented with probiotics. 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. There are the main national producers (Yoplait, Danone, Triballat, etc.) and the main retailer brands (Carrefour, Leclerc, Intermarché, etc.). The small national brands are grouped together, as well as the small retailer brands. We also control for brand quality, in

[8] Note that this corresponds closely to the division adopted in food marketing, see for instance the professional review *Linéaires*, n¡187, December 2003, p. 110 [9] See the *décret* 88-1206 in the *Journal Officiel de la République Française*, 31/12/1988.

three levels (low-, mid- and high-quality brand). The lowest level includes the hard-discount and the first-price retailer brand. The national brands and the high-quality retailer brands form the highest level. These attributes define 279 distinct varieties of dessert yogurts and *fromages blancs*.

2.3 Household choice set, choice and prices

These 279 products 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 retailer company (for supermarkets and hypermarkets) and the store format (hard-discount, hyper and supermarkets, grocery stores).[10] We retain these two criteria because they are strong determinants of quality positioning and pricing strategies. For each distribution channel, we assume that the set of products that are observed in the yearly purchase data is the set of products that were available at each period.

For each period, we know the distribution channels that were visited by each household. We define each household choice set as the set of all products available in these channels. Choice sets therefore vary 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.

Regarding the household choice in each period, there are two situations. If the household did not make any purchase or did purchase a single product, then defining its choice is not a problem. However, when more than one product were purchased, we have to choose the one that is the most representative of household's preferences. In order to avoid arbitrary choices, we select it at random with probabilities of selection being proportional to the share of each product in the household's annual purchases.[11] The price of each product in the household choice set is constructed in two steps. First, we calculate the mean unit prices of this product in each distribution channel and each period; then, we average these mean unit prices over the distribution channels that were visited by the household during the period. Hence, the prices vary over time and between the households according to the visited distribution channels.

2.4 Market characteristics

Given that the estimation procedure is time-consuming, we reduce somehow the data set 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

[10] The 14 distribution channels are: independent hard discount such as Lidl and Aldi; hard discount Ed; hard discount Leader Price-Franprix; hyper and supermarket Intermarche; 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 cheese stores, and grocery stores. [11] 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 $Q1/(Q1 + Q2)$.

us with 224 different products. Table 2 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 much less low- and mid-quality products in the latter than in the former, simply because many of them are private labels that can be found in only one distribution channel.

[Table 2 about here]

The main characteristics of the market are given in Table 3. The final sample contains 8,985 observations describing the choices of 1,795 households over five periods. First note that 12 out of the 24 half-skimmed dessert yogurts have a fat-content label, while none of the full-fat dessert yogurts (20 products) are labelled. *Fromages blancs* account for 70.8% of choices, dessert yogurts for 23.9%, and the outside alternative of consuming none of these products in a 4-weeks period for 5.4%. More than 54% of the *fromages blancs* purchased are half-skimmed, about 23% are skimmed, and as much are full-fat. By contrast, 72% of the dessert yogurts purchased are full-fat. On average, full-fat products are more expensive than others, with smaller variations in prices for dessert yogurts than for *fromages blancs*.[12]

[Table 3 about here]

2.5 Household characteristics

The 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 risky overweight (BMI>27), and whether the main shopper is a man. Table 4 reports the mean and standard deviation of these variables, among others, in the estimation sample. These variables are interacted with product attributes in the estimation to adjust for the effect of observable characteristics on preferences.

[Table 4 about here]

3 Empirical modeling

Following the literature in empirical industrial organization, 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 strategy retained for its estimation and for simulation of each policy option.

3.1 Structural model for the demand side

Consumer preferences for *fromages blancs* and dessert yogurts are modeled in the random utility framework, through a Mixed Multinomial Logit model (MMNL) (Berry et al., 1995, McFadden

[12] The *fromage blanc* is a traditional food product. As such, some product varieties are very prestigious and very expensive.

and Train, 2000). The preferences over product characteristics are specified in a flexible manner, as it allows for both observed and unobserved heterogeneity effects on the intercept and slopes of the utility function. As such, the household heterogeneity in the Willingness-To-Pay (WTP) for fat-content labels can be precisely characterized. The MMNL also relaxes the "Independence from Irrelevant Alternatives" constraint imposed by the standard Conditional (or Multinomial) Logit model, which is unlikely to hold at an aggregate level as the choice set varies from one household to another; third,

3.1.1 The random utility model

Each household $i = 1, ..., N$ faces a set of J_{it} products in a choice situation $t = 1, ..., T$.[13] 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 known to consumers and we allow some of them to be unobserved by the econometrician. Examples of observed characteristics are fat content, package size, brand, 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 specific distribution channel.

Formally, denote 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 or not on the package of j. Further denote x_j 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

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

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 tastes of household i for p_{ijt}, l_j and x_j, respectively, and ε_{ijt} is the unobserved utility. The latter captures the consumer valuation of the unobserved product characteristics.

3.1.2 Endogenous prices and fat-content labels

There are empirical evidence that some unobserved characteristics may be correlated to the observed ones, then leading to an endogeneity issue (Berry, 1994). For instance, promoted products are often moved to the front of the shelf, advertised and sold at a reduced price at the same time. The estimated impact of observed prices on demand then captures both a true price effect and the effect of unobserved marketing efforts. Prices may also be endogenous because some unobserved

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

characteristics are positively valued by consumers, who thus are ready to pay for, which may be accounted for by producers in determining their prices. In both cases, we have $E(\varepsilon_{ijt} \mid p_{ijt}) \neq 0$.

We instrument the current price by its past variations, as in Villas-Boas and Winer (1999). The identifying assumption is that, controlling for brands, distribution channels, and demographics, the product-specific valuation of the unobserved characteristics, ε_{ijt}, is independent from its past variations. Given this assumption, the valuation of a particular product will be independent of the price variations of that same product in the same distribution channel. Conversely, common production and/or distribution costs imply that the price of a product within a distribution channel will be correlated with its past variations, which therefore can be used as valid instrumental variables (IVs). The price variations that we consider are those observed between the current and the last period. They are constructed in the same way as the prices in level: for each product, the mean unit price and its variation are first computed in each distribution channel and period; then, these mean unit price variations are averaged over the distribution channels that were visited by the household in the corresponding period.

Most papers dealing with endogeneity issues in MMNL models have focussed on price endogeneity, assuming the exogeneity of all other observed characteristics. Here, we relax that assumption for the fat-content label characteristic, as producers' decisions to place a fat-content label on the package of a dessert yogurt may be correlated to some unobserved consumer tastes. In this case, $E(\varepsilon_{ijt} \mid l_j = 1) \neq E(\varepsilon_{ijt} \mid l_j = 0)$.

An IV for fat-content labels can be constructed by exploiting the "quasi-natural experiment" provided by the exogenous variation in the labeling rules between the *fromages blancs* and the dessert yogurts. Considering the absence of label as a treatment, we know that the probability of being treated is zero for *fromages blancs*, regardless their fat content (since labeling is mandatory), and more or less positive for dessert yogurts, depending on their fat content. Then, the marginal value of a fat-content label is identified from the empirical market shares, using a difference-in-difference estimator, under the assumption that the differences in unobservable factors between full-fat and half-skimmed consumers are the same for *fromages blancs* and dessert yogurts. This assumption and the resulting exclusion restriction hold if the consumers of *fromage blancs* are not more sensitive to a fat increase than the consumers of dessert yogurts. In addition, it might be reasonable to argue 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 in the perception of the product for example, have little to do with it (Ackerberg *et al.*, 2005). Last, the interaction of the dessert yogurt and half-skimmed (or full-fat) variables is a good predictor of the producer's labeling decision: the fatter the dessert yogurt, the less likely the producer to signal it 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

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

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

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

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

where μ^{p}_{ijt} and μ^{l}_{ijt} are jointly normal, η^{p}_{ijt} and η^{l}_{ijt} are iid standard normal (whose standard deviations σ^{p} and σ^{l} are estimated). In this equation, μ^{p}_{ijt} and μ^{l}_{ijt} represent the variations in prices and fat-content labels that are explained neither by the other observed variables neither by the instruments, and that may have an impact on utility (if λ^{p} or $\lambda^{l} \neq 0$). The endogeneity issue arises because these unobserved factors are correlated with prices or fat-content labels. The control function approach takes explicitly into account the effect of μ^{p}_{ijt} and μ^{l}_{ijt} on utility, by introducing proxy measures of these variables in the estimations. These proxy measures are constructed in a first-stage, as the residuals from the regressions of price and fat-content label variables on all exogenous variables and instruments, z_{ijt}

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

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

3.2.2 Parametrization 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

$$v_{ijt} = -\alpha^{p}_{i} p_{ijt} + \alpha^{l}_{i} l_{j} + \beta'_{i} x_{j} \quad \text{and} \quad \varphi_{ijt} = \lambda^{p}\hat{\mu}^{p}_{ijt} + \lambda^{l}\hat{\mu}^{l}_{ijt} + \sigma^{p}\eta^{p}_{ijt} + \sigma^{l}\eta^{l}_{ijt}. \tag{6}$$

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

$$\alpha_i = \overline{\alpha} + \Sigma\nu_i + As_i \quad \text{and} \quad \beta_i = \overline{\beta} + Bs_i, \tag{7}$$

where $\overline{\alpha} = (-\overline{\alpha}^p, \overline{\alpha}^l)$ is the vector of average tastes for price and 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.[14] The two distributions are correlated (the off-diagonal element of Σ is non-zero). Hence, we end up with a MMNL model with mixing over the error components and random coefficients for the endogenous variates.

3.2.3 Likelihood and estimation procedure

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

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

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 $\widetilde{\varepsilon}_{ijt}$, that is $s_i = \nu_i = 0$, the model reduces to the standard Multinomial Logit model (MNL).[15]

Considering the hypothetical situation where $\widetilde{\varepsilon}_{ijt}^p$, $\widetilde{\varepsilon}_{ijt}^l$ and ν_i would be different from zero but observed, the above model would then simply correspond to a MNL formulation, where the observed product characteristics and the observed household attributes are interacted, and with choice probabilities given by[16]

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

where $\eta_{ijt} = \{\eta_{ijt}^p, \eta_{ijt}^l\}$, θ is the full set of parameters, $P(y_{ijt} = 1 \mid \eta_{ijt}, \nu_i; \theta)$ 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. Then, the probability

[14] The estimation does not converge when assuming a log-normal distribution for both coefficients. [15] Although very attractive because of its extreme tractability, the MNL model restricts substitution patterns in an unreasonable fashion (see, for example, Berry, 1994). [16] In order to make the writing lighter, all other conditioning arguments (product and consumer attributes, reduced-form residuals) are omitted here.

of observing the sequence of choices made by household i in periods $t = 1, ..., T$, denoted $w_i = \{y_{ijt} = 1\}_{t=1}^{T}$, would be

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

However, since η_{ijt} and ν_i are actually not 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 $g(\eta_{ijt}) = \phi(\eta_{ijt}^p)\phi(\eta_{ijt}^l)$, with $\phi(\bullet)$ 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) by integrating out over η_{ijt} and ν_i analytically. 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 takes two steps. First, the residuals $\hat{\mu}_{ijt}^p$ and $\hat{\mu}_j^l$ are predicted by regressing the price and label variables against the instruments, and all product characteristics, including their interactions with household attributes, listed in Table 4, distribution channel and brand fixed effects.[17] Then, these residuals are used as control functions in the above likelihood function. The variance-covariance matrix is corrected to account for the additional variance induced by the first-stage estimation.

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 variations in the explanatory variables.[18] Cherchi and Ortúzar (2008) investigate the effect of data information richness on empirical identification of the binomial version of the MMNL. Using Monte Carlo simulations, and assuming that choice sets differ across observations, they find that the richness of the data does matter and, in particular, that identification problems arise when slope heterogeneity is applied to a characteristic that has a low variability between alternatives. They

[17] A F-test reveals that both instruments are highly significant in the first-stage regressions ; F statistic for each equation is higher than 1000. [18] Proofs of theoretical identification applying to 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 (through a mathematical result), it may not be *empirically* identified (because the data do not support it). We here discuss the empirical identification.

also show that observing more than one choice per individual (*e.g.* panel data) makes empirical identification easier and strongly reduces the effect of sample size. Their analysis, however, focusses on continuous characteristics. The identification of slope heterogeneity applied to continuous *and* discrete variates, and the impact of choice set variations (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 the type of variate, even in the case where the set of alternatives is the same for all observations.[19] Variation in the choice set strengthens the identification for discrete characteristics.

By construction, we have here kept 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 (through distribution channels). This guarantees empirical identification of slope heterogeneity on any type of variates.

3.3 Structural model for the supply side

Producers are likely to adjust to exogenous shocks and ignoring their strategic behavior may lead to under or over-estimate the impact of public policies (Griffith *et al.*, 2010; Bonnet and Réquillart, 2011). Simulating policy effects on the market equilibrium therefore requires a structural model of behaviors for the supply side In the demand model, two variables are considered as resulting from firms' strategic decisions: price and label.[20] However, it seems reasonable to suppose that the labeling decision is taken when the product is introduced, and that it would hardly be affected by a fat tax policy (it becomes strictly exogenous in the case of a mandatory labeling policy).[21] We thus assume a fixed set of products and focus on price as the sole strategic variable for producers.

3.3.1 The linear pricing model

We assume that firms compete *à la* Nash-Bertrand, *i.e.* by setting prices in order to maximize their profit conditional on demand parameters and other firms' prices, as in Berry *et al.* (1995) or Nevo (2001).[22] 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 p_j and c_j the price and the (constant) marginal cost of production for product j, respectively, the profit of producer m, π_m,

[19] With many repeated observations for each household, it is theoretically possible to estimate one logit model per household, and therefore household-specific tastes, provided that there is enough variations in observed choices. The parametrisation of taste heterogeneity is then a convenient means of reducing the curse of dimensionality. [20] If explicit modeling of the firm's pricing strategy is now common in the literature, modeling the firm's choice of characteristics is rare and complex: see Crawford and Shum (2001) who model the firm's choice of quality, but can 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. [21] This is justified by the fact that firms often prefer introducing new food products rather than modifying the characteristics of existing ones. [22] A recent literature enriches this setup, by taking into consideration vertical relationships between manufacturers and retailers (see Villas-Boas, 2007; Bonnet and Dubois, 2010; Bonnet et al., 2012).

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.[23] The market share is computed 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 the system of equations (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. Then, assuming that the marginal costs are fixed, the equilibria conditions (15) can be used to identify the impact of opublic policies on the market equilibrium (equilibrium prices and market shares). We analyze the mandatory labeling of all dessert yogurts on the one hand, and a fat tax proportional to the fat content on the other hand.

3.3.2 Simulation algorithm

Implementing a mandatory labeling policy amounts to replace the label variable by a vector of ones, l^*.[24] We recalculate, for each producer m and each item belonging to G_m, the new market shares, $s_j^*(p;\theta)$, and all 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

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

Here, the terms used to correct for label endogeneity 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

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

[23] 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. Therefore, it does not depend on i and t subscripts anymore.

[24] We assume that the labeling cost is null or negligible for two reasons: first, the fat-content being 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 package, marketing and associated costs should be small relative to the whole cost of the product.

for all $j \in G_m$ and $m = 1, ..., M$, where 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 obtained from the regression of $p_{j,iter-1}^*$ on z_{ijt} and all exogeneous variables. We iterate over p_{iter}^* until convergence, that is when $\max_j |p_{j,iter}^* - p_{j,iter-1}^*| < 10^{-5}$.

Regarding the fat tax policy, we assume an ad-valorem tax, 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 belonging to the fat-content category *cat*. Below, $\tau_{cat,j}$ equals 0, 0.05 or 0.10 when j is a skimmed, half-skimmed or full-fat product, respectively. As for the algorithm described to get the equilibrium prices in the mandatory labeling case, 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 estimations and results below are performed with 500 Halton draws.[25] The variances of the estimators are corrected by standard formulas for two-step estimators (Murphy and Topel, 1985), given the extra source of variations caused by the introduction of the residuals of first step instrumental regressions.

4.1 Utility functions

Table 5 shows the estimated coefficients of the MMNL model: they can be interpreted directly in terms of marginal utilities. As outlined in the previous section, price and label marginal utilities have deterministic and random components. The first column reports the mean marginal utility of product characteristics for a reference main shopper who is a female aged under 65, with BMI

[25] A difficulty with MMNL models is that 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 $D = 300$. The results are available upon request from the authors.

under 27, living in a household in the top income quartile. The second column reports 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 some unobservable household characteristics. The remaining columns report the coefficients for a number of interactions between product characteristics, listed in the first column, and household characteristics, which appear in the first row (household income quartiles, household size, the main shopper is risky overweight, is a man, is aged over 65). For instance, the difference in the mean marginal utility of price between the reference shopper and a shopper in the first income quartile (first line, fourth column) is -0.232 units of utility. The lower part of Table 5 provides the estimates of the price and label control functions and the variances of the associated error components.

[Table 5 about here]

As expected, the probability of choosing an alternative decreases on average with its price. The mean marginal utility of price is negative (-1.870), and higher in magnitude for households under the median income or when the main shopper is aged over 65. The standard deviation of the random effect on price is quite high (1.995), which implies that the marginal disutility of price is very heterogeneous, beyond discrepancies captured by 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 high relative to the mean base effect (3.850): there is a strong unobserved heterogeneity in household preferences for these labels. The elderly tend to dislike fat-content labels, while there is a concave positive income effect which peaks in the second income quartile. The marginal utility of labels does not significantly increase when the main shopper is risky overweight (BMI>27). The random unobserved household attributes are positively correlated, with a correlation of 0.77. A strong taste for labels is likely to be associated to a higher marginal disutility of price, which limits the willingness-to-pay for a label.

The coefficients of the control functions, at the bottom of Table 5, are both significant and positive. Ignoring label endogeneity would lead to over-estimate the marginal utility of labels, with an estimated mean base coefficient of 1.710 (instead of 0.592). This suggests that, when labeling is not mandatory, firms decide to display a label according to the consumer positive valuation of some unobserved product characteristics. We imagine well that, in the case of half-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 would have been slightly underestimated had the presence of unobserved product characteristics been ignored (-1.763 *vs.* -1.870).

Households tend to prefer half-skimmed and full-fat products to skimmed ones. This taste for fat is even more developed in low-income households or when the main shopper is a male or an elderly. Valli and Traill (2005) already noted 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 half-skimmed ones. This finding may be explained by the existence of two very different types of consumers among those who are at risk for overweight-related diseases. The literature in sensory research emphasizes that two kind of motives underly 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 it may also be negatively related to healthiness, and delayed health damages (Grunert *et al.*, 2000). The risky-overweight individuals are more likely to be very concerned by the fat-disease relationship, but they are also likely to exhibit a strong taste for fat. Hence, the polarization of their preferences between low-fat and full-fat products is likely to reflect opposite hierarchies of purchase motives in this population: for the ones, health matters more than taste and the converse for the others.

Table 5 also reveals that low- and mid-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.[26] Last, the bifidus/organic characteristic has no significant effect on utility, while smooth textures are associated to a utility loss, consistent with the fact that non-smooth varieties (especially *faisselles and fromages blancs de campagne*) are considered as luxury and patrimonial in the 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 price variation (here expressed in €) needed to maintain utility unchanged when a fat-content label is added to the front and the sides of the package. A household-specific WTP can be computed from the estimates, conditionally on household-specific information (observed choices, product and household characteristics), by using equation (16) in Appendix A.2., where $h(\alpha_i)$ is the ratio of the marginal utility of a label over the marginal disutility of price.

Our key finding is that a non negligible fraction of households (38%) have WTPs lower than or equal to zero (see Table A.2. in Appendix). This proportion shows some variations across demographic groups, but not so much: in particular, it is about the same when the main shopper in the household is risky overweight and it is only slightly higher (41%) when she is obese; it is slightly lower in the first income quartile (35% *vs.* 39-40% in the upper quartiles), which is noteworthy as it suggests that labeling policies may not have regressive welfare effects.

Hence, fat-content labels are not positively valued by all consumers, and a mandatory labeling policy may then harm their welfare, at least on the short term. This result is at odds with the standard predictions from the economics of information, where information provision is considered as always enhancing consumer welfare. It favors market segmentation which lead to a better match

[26] This gender effect is consistent with findings from nutrition studies. In France, as in many countries, the body standards are "imposed far more vociferously on women than on men" (Stearns, 2002: 189). As a consequence, individuals who are more prone to restrict their consumption in order to control their weight are more frequently women. Small portion packs are seen as an effective means of controlling one's consumption (Stroebele *et al.*, 2009). Hence, it is then unsurprising to find a higher taste for small portions among women.

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 it is also associated with unpleasant health consequences. When consumers have a conflict between the short-term pleasure of eating and the long-term goal of health preservation, informing them about the nutritional value of the choice options is likely to increase the anticipated guilt and the psychic costs associated to the less healthy products. The decrease in utility is more important for the consumers who have a strong hedonic taste for fat (Wansink and Chandon, 2006, Kivetz and Keinan, 2006, Okada, 2005). They may thus prefer to avoid information, in order to peacefully enjoy the pleasure of eating a tasty product.[27]

Nevertheless, it remains that a large majority of households are ready to pay a positive amount to have a fat-content label 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 labeling is likely to be positive in the populations targeted by public health policies.

4.3 Price-cost margins

Marginal costs are recovered for each product by inverting the first-order conditions (15). Their average (and standard deviation), as well as the associated average price-cost margins, are then computed for each producer. These, however, cannot be reported in details here for confidentiality reasons. On average, marginal costs and price-cost margins are equal to €1.33 (with a standard deviation of €0.69) and 0.47, 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, price-cost margins for both types of brands are quite similar. Hence, the difference in production costs is passed on consumer prices. The upper panel of Table 6 reports the initial market shares, producer prices and margins for five categories of products (skimmed, half-skimmed or full-fat *fromages blancs*, and half-skimmed or full-fat dessert yogurts). The margins are between

[27] The 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 marketing review for professionals *Linéaires*, covering the launching of a new dessert yogurt in its issue of April 2001 (p. 50), reports that the producer explicitly wanted to avoid feelings of guiltiness 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.). In economics, a theoretical decision-making framework has been proposed by Caplin and Leahy (2001) to rationalize such anticipatory feelings effects. Köszegi (2003) uses it to show how feelings of anxiety about results from medical check-ups can induce aversion to health information.

60% and 70% for the dessert yogurts, and around 45% for the *fromages blancs*.[28]

5 Ex ante policy evaluation

The methodology described in Section 3.3 is applied to the demand functions estimated above, in order to produce an *ex ante* evaluation of two fat policies: (*i*) an ad-valorem fat tax that increases the producer price by 10% for all full-fat products and by 5% for all half-skimmed products; (*ii*) a mandatory labeling policy that requires all products to exhibit a fat-content label on the front-of-pack.[29] We examine their impact on market shares, prices and consumer surplus, and we compare their effectiveness at reducing the quantity of fat provided by the market.

5.1 Impact on market equilibrium, producer margins and profits

The effects of both policies on market shares, prices and margins are summarized in Table 6. The middle and bottom panels report the variations in shares, prices and margins implied by the mandatory labeling and fat tax policies, respectively,while the top panel describes the initial situation. For each policy, the first line presents the variations in market shares, in percentage points (pp), when households' responses only are taken into account. The three remaining lines show the variations in shares (pp), prices (in euros) and margins (pp) when producers' price responses are made possible.

[Table 6 about here]

A first striking result is that the final market equilibrium is totally different whether producers' price responses are taken into consideration or not. Ignoring them, both policies hit the target. Overall, the mandatory labeling appears more efficient than the fat tax at 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% (−12.6 pp), induced by the addition of a label is far from being compensated by the increase in the market share of the (cheaper) full-fat *fromages blancs* (+4 pp). All *fromage blanc* categories (the outside option as well as) take the advantage of this fall. The explanation is that, beyond their strong taste for fat, most consumers of dessert yogurts are primarily fat lovers who do not want to be informed about the fat they eat. And indeed, their WTP for fat-content labels is very low, often negative: for instance, the median WTP among the households who purchased

[28] To judge whether these are realistic figures, one can consider rough estimates from available aggregate data (as in Nevo, 2001). Unfortunately, the information is rather scarce. The 2011 report of the *Observatoire de la formation des prix et des mares des produits alimentaires*, a governmental agency that monitor the price transmission in the food sector, conclude that the price spread along the food chain for nature yogurts is respectively 50% for the producers, and 30% for the retailers. This would lead to a total raw margin of 80%, from which one should deduce the transformation and retailing costs to obtain a price-cost margin. For instance, the *Observatoire* estimates that the producer added value is about 14%, and the annual report of Danone for 2010 reports an operating profit margin of 14.5% for the fresh dairy products (13.8% in 2009). Overall, the estimated price-cost margins looks realistic. The estimated margins are higher for the dessert yogurts because the market is less mature. [29] All simulations assume that the set of products is fixed and that pricing strategies are the only possible response for firms: the entry or exit of products is excluded.

at least once a full-fat dessert yogurt is −€4.74. In comparison, the households who purchased at least once a full-fat *fromage blanc* is €0.42 (see Table A.3 in Appendix A.2). As a consequence, the consumers of dessert yogurts 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 price responses on the supply side, however, completely changes the results. The labeling policy then leads to a small increase in the market share of dessert yogurts (+1.1 pp for full-fat dessert yogurts), at the expense of skimmed and half-skimmed *fromages blancs* (−1.9 pp and −8.1 pp, respectively). This can be explained by the large reduction in the prices of dessert yogurts: the half-skimmed and full-fat dessert yogurts show a decrease in prices of about €0.95 and €1.39, respectively, hence becoming the cheapest products sold on this market. In spite of this fall in prices, the margins remain positive for all products.[30]

In the absence of strategic price response, the impact of the fat tax on market shares is smaller than that of mandatory labeling, especially for full-fat dessert yogurts. However, it does reverse with producers' 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 half-skimmed dessert yogurts (+1 pp) shows that households move away from the fatter varieties. Variations in market shares are small because producers do not fully pass the tax on consumer prices. For instance, for full-fat dessert yogurts, the final increase in consumer price for a 100% pass-through would be €0.31 (3.06 times the tax of 10%). It is only €0.12 (i.e. $(3.06 - 0.17) \times 110\%$ minus 3.06), which means that the pass-through rate is lower than 40%: producers are willing to absorb a large part of the intended policy shock on consumer prices.

Table 7 shows the variations in market shares by demographic group when firms' strategic pricing response is integrated. It is interesting to note that, under mandatory labeling, 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, they consume less skimmed and half-skimmed *fromages blancs*, with market shares decreasing by 3.0 pp and 10.1 pp, respectively. Hence, the labeling policy fails at achieving the objective of changing the choices of those who would really need to switch from full-fat to less fat products. Once again, the fat tax policy seems to be the better option, as it induces a substitution from full-fat products to skimmed and half-skimmed products for households with obese main shoppers.

[Table 7 about here]

Variations in profits and market shares are not reported here in details for reasons of confidentiality. Annual profits are calculated using predicted market shares, and observed household

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

purchase frequencies for *fromage blancs* or dessert yogurts over the year, and extrapolated to the entire French population using the sampling weights provided by Kantar WorldPanel. Both policies result in a fall of the annual profit of producers, which is larger for the labeling policy (−21% *vs.* −6.1% for the fat tax). The price responses of producers help them limit the fall in sales, but require them to reduce their margins (especially under mandatory labeling). The main national brands suffer much more from the labeling policy than retailer brands, the decrease in profits ranging between 34.4% and 76.6% for the former, and between 11.3% and 20.6% for the latter.

The strategic price response of producers aims at minimising profit losses. It can be explained by three factors: the initial margins; the competition between producers and, for each producer, between products in its portfolio; the elasticity and the concavity of the demand curves.

In the case of the mandatory labeling of dessert yogurts, the producers can afford large price cuts on these products because the margins are initially quite high: the initial price-cost margin is 0.67% for full-fat dessert yogurts, as against 0.41% only for full-fat *fromages blancs*. In addition, the estimated own price elasticity of the market share of full-fat dessert yogurts would be −5.079 in the absence of price response. Hence, the producer can expect to win back market shares through price cuts. This strategy is constrained by two factors. First, the demand becomes less and less elastic as the price decreases: the elasticity of full-fat dessert yogurts is −2.372 after the price response. Profit maximization entails a trade-off between lower margins and larger market shares, which is partly determined by the concavity of the demand function (see Stern, 1987, and Delipalla and Keen, 1992 for the case of taxation under impeerfect competition). Second, each producer face the price response of all other producers and must in addition optimise its own response over its portfolio of products. For instance, the demand elasticity of full-fat *fromage blancs* would be −4.778 in the absence of price response. The producers of these products has the means of countering the price drop of dessert yogurts, although they are constrained by lower initial margins. The mandatory labeling policy actually increases the competition on the market, by making the products more similar. The Herfindahl-Hirschman Index (HHI) computed from the market shares is initially at 921. It would fall at 770 without the price response. For the tax policy, and without price response, the HHI displays little variation (906 instead of 921).

5.2 Variations in household fat purchases and welfare

Table 8 reports the changes in households' annual fat purchases, by demographic group, with and without producers' price reactions. Households' annual fat purchases are calculated by multiplying the predicted choice probabilities by the fat content of each product, times the purchase frequency observed in 2007. Before the implementation of the policy, 844g of fat are purchased on average by a household. The fat tax reduces this quantity by 76.5g (−9.1%), whereas the decrease is smaller (−12.5g or −1.5%) for the labeling policy.[31] If we aggregate these results over all households

[31] Note that ignoring producers' price responses would result in a large bias, and misleading results, as both policies would then decrease fat purchases by more than 300g.

and extrapolate them to the entire French population, 2,361 tons of fat are initially provided to households through fromage blanc and dessert yogurt consumption. The fat tax leads to a 5.55% decrease, and the mandatory labeling to a smaller figure of 0.9% (not shown in the table).

The impact of the fat tax policy shows little variation across demographic groups (between −8% and −10% for all), except for households where the main shopper is a male (−6.4%). The effects of mandatory labeling are more differentiated, with a tiny increase in fat purchases among households whose main shopper is obese (+0.2%), and a large decrease for households in the first income quartile (−4.4%).

[Table 8 about here]

Eventually, Table 9 presents the percentage increase in household consumption surplus induced by the two policies, for each demographic group.[32] The fat tax policy reduces the average surplus by 2.1% on average, since consumer prices increase. Conversely, the mandatory labeling policy induces an important rise in the average surplus, 52.5, explained by the large fall in the prices of dessert yogurts, which more than offsets the disutility for labels mainly found among consumers of dessert yogurts. The variations across demographic groups are insignificant.

[Table 9 about here]

6 Conclusion

This paper proposes an *ex ante* evaluation of the impacts of fat tax and mandatory labeling policies on market equilibrium. This evaluation requires that consumer preferences for fat-content labels and for fat be separately identified. This is made possible by an exogenous source of variation in fat-content labeling legal 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 household and product levels), with a linear pricing model of supply to recover the price-cost margins for each manufacturer and to determine the impact of each food policy on market outcomes. Taking into account the producer price response to public policies is shown to have a dramtic impact on the evaluation.

A fat tax policy would result in a fairly large decrease in household fat purchases: about 9% for an ad valorem tax of 10% and 5% on the producer price of full-fat and half-skimmed products respectively. By contrast, if fat-content labels were mandatory, household fat purchases would be reduced by 1.5% only, because the producers of dessert yogurts would accept to cut their margins to retain customers. This producer reaction entails a large decrease in the price of dessert yogurts, which offsets 96% of the disutility of having a fat-content label on the packaging. Since the prices are lower, the mandatory labeling policy is likely to increase consumer welfare on the short term,

[32] The formulas for these welfare calculations can be found in Appendix A.4.

while the fat tax policy has the opposite effect. Although these welfare calculations do not take into consideration the long-run benefits of reduced fat intake, taking into account the differential in health effects would hardly change the picture, as the estimated variations in fat intake are very small.

Hence, the key policy message of this research is that there is no magic bullet to curve fat consumption if one relies only on standard policy tools, because market mechanisms — here, producer reactions to policies — tend to neutralize any intervention. One alternative option, that is currently considered by the French public health authorities in agreement with the producers, is to promote voluntary limitations in the fat (and sugar) content of products. Whether nutrient-content regulations should remain voluntary or become mandatory is an important research question.

While this paper is, to our knowledge, the first to encompass in a structural approach the question of prices and that of labels, they are two limitations to the analysis. Second, the set of products is supposed to be fixed, and only pricing strategies are possible for firms. But firms may reformulate their product as well; new products may enter the market, other products may exit. Last, the demand model does not take into account, in a structural manner, the health effect of fat consumption. As such, it is difficult to evaluate the long-run welfare effect of each policy, and to rank the various options in this health perspective. While the short- and long-term welfare effects would probably display little differences for a single product, this would certainly not be the case for policies targeting large ranges of products. We leave these questions for future research.

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A Appendix

A.1 Defining the relevant market

As we want to exploit the variations in labeling rules between the *fromages blancs* and the yogurts, the set of alternatives must necessarily include all *fromages blancs*. Hence, the question boils down to determine whether both standard *and* dessert yogurts must be included in the definition of the relevant market for the *fromages blancs*. The purpose of any relevant market test is to measure the strength of competition exerted over a given product by the other products. In its guidelines to the assessment of relevant markets, the European Commission (1997) defines the three main factors that determine competition: substitutions on the demand side, substitutions 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 substitutions, which are the most immediate competitive constraints for producers. At each decision regarding the formulation and the marketing-mix of a product, they must bear in mind that customers can switch from one variety to another relatively easily and quickly.

The demand substitutions are analyzed through the estimation of an Almost Ideal Demand System (Deaton and Mullbauer, 1980). It relates the yearly budget share s_{ij} of products $j = 1, .., J$ for household $i = 1, ..., N$ to the log total expenditure x_i for the 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 (namely, 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 or not, and the region and type of residential area). Following Lecocq and Robin (2006), the product-level prices are computed as the average price of all purchases made in a same region and a same area, and we control for the endogeneity of total expenditure, by using a control function approach and the household income as an instrument.

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

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 * significant at the 1, 5 and 10 percent levels.

A.2 Distribution of the household WTP conditional on observed choices

The estimates, that results from the maximisation of (13), can be used to determine the distribution of tastes of each sampled household, $\{\alpha_i, \beta_i\}$, as well as functions of them, 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 household's observed sequence of choices. By 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), still denoting η_{ijtd} and ν_{id} the d-th draw from the distribution of η_{ijt} and ν_i, this expectation can be approximated through simulation by

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

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

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

Table 1: Table A.2: **Descriptive statistics of the WTP for a fat content label**

	WTP≤0[a]	Median	Max WTP (€)
All	38.05	0.65	1.81
Main shopper's body weight			
Normal weight (BMI<25)	38.03	0.65	10.72
Overweight (25≤BMI<27)	35.55	0.73	9.42
Risky-overweight (27≤BMI<30)	38.26	0.71	14.02
Obese (BMI>30)	40.81	0.47	17.93
Income			
First quartile	34.58	0.65	1.81
Second quartile	38.79	1.22	13.99
Third quartile	39.14	0.90	13.45
Fourth quartile	39.89	0.35	10.95
Male	37.19	0.17	15.62
Female	38.11	0.68	11.70
Aged under 65	38.70	0.62	12.82
Aged above 65	38.03	0.86	11.51

[a] Proportions of households with negative WTP

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
Half-skimmed fromages blancs	-0.45	1.01	0.000
Full-fat fromages blancs	0.80	0.42	0.040
Half-skimmed dessert yogurts	0.88	-1.71	0.000
Full-fat dessertyogurts	1.13	-4.74	0.000

A.3 Household consumer surplus

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

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

where $|\alpha_i^p|$ is the estimated marginal disutility of the price for consumer i. The consumer surplus is computed given the household specific taste parameters, by using the formula in equation (16). The change in surpluses produced by the mandatory fat-content labeling policy, which implies new equilibrium prices p^* and label variable l^*, is given by $CS_i(p_t^*, l_t^*) - CS_i(p_t, l_t)$. In the case of the fat tax policy, only the equilibrium prices vary, and l_t is kept unchanged. Note that the consumer surplus depends on the utility obtained from all alternatives, including the outside option. Therefore, it varies across households not only through price sensitivity, but also through the utility of each alternative, which allows to account for changes in household utility produced by switches between the alternatives.

Table 2: **Mean values of product characteristics**

		In the universal product set	In household choice set
Price (std. dev.)		2.44 (1.09)	2.71 (1.22)
Products with a label	Label	85%	81%
Skimmed		24%	22%
Half-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%
Mid-quality retailer brands	Mid quality	39%	23%
High-quality retailer and national brands	Reference	40%	68%

Note: Mean over 8497 observed purchases

Table 3: **Market characteristics**

		Fromages blancs			Dessert yogurts	
	Outside option	Skimmed/fat-free	Half-skimmed	Full-fat	Half-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: Mean prices are computed in the universal product set; Results in household choice sets are quite similar.

Table 4: **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 older than 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 %

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

Table 5: **Estimated coefficients**

	Mean	Std. dev.	Income: First Quartile	Income: Second Quartile	Income: Third Quartile	Man	Risky-overweight	Household size	Over 65
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)
Half-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)	
Mid-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)								

Note: Standard errors are in parentheses; ***, ** and * Significant at the 1%, 5% and 10% levels; The column "Std. dev." reports the standard deviation of the random coefficients; The random coefficients are distributed according to the opposite of a lognormal law for price, and according to a normal law for label; Their coefficient of correlation is 0.77***; Other control variables are fixed effects for the 14 distribution channels and 15 brands or groups of brands (results available from the authors on request); 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 6: **Variations in market shares and prices produced by a fat tax policy and a mandatory fat-content labeling policy, by product category**

		Fromages blancs			Dessert yogurts	
	Outside option	Skimmed/fat-free	Half-skimmed	Full-fat	Half-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 (%)		0.46	0.44	0.41	0.57	0.67
			Mandatory labeling policy			
Share variation with no firm response (pp)	4.87	2.03	3.73	4.00	-2.04	-12.59
Share variation with firm response (pp)	3.79	-1.88	-8.06	1.88	3.16	1.11
Producer price variations (€)		0.06	0.06	0.21	-0.95	-1.39
Margin variations (pp)		0.01	0.01	0.01	-0.09	-0.22
			Fat tax policy			
Share variation with no firm response (pp)	0.86	2.94	0.02	-2.56	1.06	-2.32
Share variation with firm response (pp)	0.58	2.98	-0.88	-2.3	1.01	-1.39
Producer price variations (€)		-0.03	-0.02	-0.07	-0.07	-0.17
Margin variations (pp)		-0.01	-0.00	-0.01	-0.01	-0.02

Note: The mandatory labeling policy requires all products to display a fat-content label; The fat tax policy increases the producer prices of all full-fat and all half-skimmed products by 10% and by 5% respectively. The abbreviation pp stands for percentage point. Price and margin variations are averages by product category, weighted by product market share; Margins are given by $(price\text{-}mc)/price$, where mc denotes marginal cost. Price and margin variations integrate firms' strategic pricing response.

Table 7: **Variations in market shares, by product category and demographic group (in percentage points)**

		Fromages blancs			Dessert yogurts	
	Outside option	Skimmed/fat-free	Half-skimmed	Full-fat	Half-skimmed	Full-fat
		Mandatory labeling policy				
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 policy				
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

Note: Under the labeling policy, all products have a fat-content label; Under the fat tax policy, the producer prices increase by 10% for all full-fat products and by 5% for all half-skimmed products; All results integrate firms' strategic pricing response.

Table 8: **Variations in the average household annual fat purchases, by demographic group (in grams)**

		Fat tax		Mandatory labeling	
	Base Fat	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

Note: The annual fat purchases are calculated by using the predicted choice probabilities and the household purchase frequency observed in 2007; Under the mandatory labeling policy, all products have a fat-content label; Under the fat tax, the producer prices increase by 10% for all full-fat products and by 5% for all half-skimmed products.

Table 9: **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
Meal 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

Note: Under the mandatory labeling policy, all products have a fat-content label; under the fat tax, the producer prices increase by 10% for all full-fat products and by 5% for all half-skimmed products; all results integrate the producer responses in price.