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

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Abstract: The taxation of unhealthy food products and the mandatory labeling of key nutrients may help to curve the growth of obesity and related metabolic risk factors. This paper is the first to propose ex ante evaluations of these policy options. To this end, we study the French market for fromages blanc and dessert yogurts, which is characterized by an exogenous variation in legal labeling requirements across products. This is used to identify separately the consumer preferences for fat-content labels and for fat in a structural demand model that is estimated from household scanner panel data. The estimated demand functions are then combined with a structural supply model to evaluate the impact of fat policies on several market outcomes. An ad-valorem tax of 10% on the producer price of full-fat products is shown to result in a 9% fall in fat purchases, whereas the mandatory labeling of fat content produces a 1.5% decrease only. This is explained by the producer price responses, which neutralize up to 96% of the impact of mandatory labeling on consumer demand.

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1 Introduction

The growth of obesity and overweight-related chronic diseases is a major challenge for food companies and policy-makers. According to the World Health Organization (WHO), it has reached epidemic proportions globally, with more than 1 billion adults overweight in 2010. These health trends have been related to the growing share of fat in calories available for human diet. Nowadays, in most OECD countries, fat represents between 40 and 45% of daily calorie intakes, as against 20-30% one century ago (Etilé 2011). The reduction of fat consumption is encouraged by most health professionals and nutritionists. In particular, the WHO (2003) recommends that total fat intake be in the range of 15–30% of total energy intake. In this perspective, two market-based policy options have attracted a great deal of interest from policy-makers and public health advocates: the taxation of unhealthy food products and the mandatory labeling of key nutrients such as fat. This study compares a mandatory fat labeling policy and a fat tax policy, by evaluating *ex ante* their effects in terms of fat purchases, consumer welfare, prices, market shares and producer profits.

Marshall *et al.* (2000) suggests that taxing the fat content of fatty products to raise their price may help people change the nutritional quality of their diet, with sizeable effects in terms of lives saved and health costs. Since then, most studies have emphasized that substitutions between products and ingredient qualities, by consumers and firms, will largely limit the impact of a fat tax (Caraher and Cowburn 2005, Mytton *et al.* 2007, Chouinard *et al.* 2007 and Allais *et al.* 2010). Nevertheless, the tax keeps on attracting the attention of administrations and policy makers in several countries (France, UK, Ireland, Spain, Romania, Norway, Denmark and several U.S. states).[1]

The food industry, which is often blamed for the rise of obesity (Cutler *et al.* 2003), is firmly opposed to a tax. Following the "consumer sovereignty" principle, it argues that consumers would be able to reduce their dietary fat intake by substituting standard food varieties for their reduced-fat counterparts, which are now commercialized for a large number of products. However, this argument is admissible insofar as consumers are perfectly informed about the fat content of food products. Here, assuming that consumers prefer simplified front-of-pack information to their purchase decision (see Grunert and Wills 2007), fat-content labels are likely to play a key signalling role. In this perspective, 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. Evidence on the effectiveness of labeling policies are scarce and mixed. Variyam (2008) find that the U.S. Nutrition labeling and Education

[1] To our knowledge, only Denmark has introduced effectively a tax, which will target ice-creams, chocolate, sweets and soft-drinks. See, for a summary of discussions in France, the following report by the Daily-mail: http://www.dailymail.co.uk/news/worldnews/article-1042142/France-fat-tax-pizzas-crisps-hamburgers.html See also (IGF-IGAS 2008). Each year, there are attempts from a pro-health right-left coalition of the parliement to pass a tax, which is generally presented as a means of fighting the obesity epidemic and levying new resources for financing Social Security.

Act (NLEA) has had little impact on the nutrient intake of those individuals who read the labels prior to the NLEA. Mathios (2000) analyzes the salad dressing market and uncover evidence of a significant decline in the shares of products with the highest fat content. Using scanner data from a field experiment in supermarkets, Teisl *et al.* (2001) also find a positive impact of fat labels on the market share of healthy products for milk and cream cheese.[2]

The current paper adds to this literature in three important ways. First, we exploit an exogenous source of variation in labeling legal requirements in order to identify the causal impact of fat-content labels on consumer choices. Second, the effect of a mandatory labeling or a tax policy depends crucially on the substitutions between products *within* a food category (*i.e.* products with different fat levels) and with the outside option. Existing studies rarely allow for such substitutions.[3] Here, we use disaggregated data at the product and household levels in a market where products are highly differentiated and substitutable. Third, we account for the producers' optimal price response to each policy, and are thus able to assess their impact on the market equilibrium.

We evaluate the fat tax and mandatory labeling policies in the French market for *fromage blanc* and its substitutes.[4] There are three broad product categories in this market: the standard yogurts; the standard *fromages blancs*; and the dessert yogurts, which group products like the strained/greek yogurts and *fromages blancs* or yogurts mixed with cream or other animal fats. It is shown that standard yogurts are not substitutes for *fromages blancs*, while there are significant substitutions between the latter and dessert yogurts. The *fromages blanc* and dessert yogurt market was chosen for three reasons. First, there is a large variety of products in this market, which allows consumers to easily switch from one brand to another. Second, the *fromage blancs* and dessert yogurts account for a quite substantial share of household fat purchases (2.75%). Third, the labeling legislation requires that producers signal the percentage of fat for the standard *fromages blancs* by a fat-content label (like a sticker) displayed on the front of the package, while fat-content labeling is not mandatory for the dessert yogurts. In particular, the producers never put a fat-content label on full-fat dessert yogurts, while they have to do so on full-fat *fromages blancs*. Using these variations in labeling legal requirements and brand labeling strategies, between products with different fat contents and between the dessert yogurts and the *fromages blancs*, we identify separately the consumer preferences for fat and for fat-content labels.

The consumer preferences are estimated using a mixed multinomial logit model of household choices between product varieties. Household-specific demand functions are identified from scanner panel data collected in a representative sample of households in 2007. Then, given the estimated demand functions, the price-cost margins are recovered for each producer and for each product,

[2] Kiesel and Villas-Boas (2010) also uncover empirical evidence from a similar field experiment. They find that implementing low-fat shelf labels for microwave popcorn decreases sales. However, they cannot evaluate the substitutions within this product category. [3] Griffith, *et al.* (2010) is one outstanding exception. [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.

assuming that producers compete *à la Nash* in a Bertrand oligopolistic game. These estimates are used to simulate the impact of the fat tax andthe mandatory fat-content labeling policies on the market equilibrium.

Controlling the endogeneity of the prices and the fat-content labels, we identify the distribution of the Willingness-To-Pay (WTP) for the latter.Although 62% of the households are willing to pay for having this information clearly displayed on the package, this is not the case for the remaining third of the population. Providing a better access to information may not enhance the welfare of all consumers.

Perhaps surprisingly, we find that a mandatory labeling policy would increase the market shares of dessert yogurts, whereas a fat tax policy would increase the market shares of skimmed *fromages blancs* at the expense of full-fat products. The estimated impact of mandatory labeling is explained by large price cuts for dessert yogurts, which are enabled by reductions in margins (less 68% for the full-fat dessert yogurts). Furthermore, both policies would result in a fall of producers' annual profit, which would be considerably larger under the labeling policy (-21.0% *v.s.* -6.1% for the fat tax). The fat tax and the mandatory labeling policies would reduce the annual fat provided to households by this market segment, by 76.5g and 12.5g respectively. While mandatory labeling would increase consumer welfare by 52.9%, the fat tax would decrease it by 2.1%. Hence, from a health policy perspective, the fat tax dominates the mandatory labeling policy, while from a consumer policy perspective, this is the converse.

The rest of the paper is organized as follows. Section 2 hereafter 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.

2 Data

We use household scanner data from a panel maintained by TNS Worldpanel for the calendar year 2007. The advantage of scanner data over experimental or hypothetical choices studies is that the observations are based on actual purchase behavior in a natural shopping environment. Hence, the consumer 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 panel 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. The data do 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 hereafter.[5]

2.1 The relevant market

We restrict the analysis to unflavored products, which represent 43% of the purchases of yogurts and *fromages blancs*. Flavored yogurts and *fromages blancs* contain sugar additives. As such, the 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 the purchases), and we exclude drinking yogurts and yogurts with cereals, which account for less than 1.5% of the purchases. These sample restrictions lead to the exclusion of $1,984$ households.

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 the *fromages blancs* and the standard yogurts are not likely to be substitutes competing on a same market, which is not the case for the *fromages blancs* and the dessert yogurts. To test this point more formally, we analyze the household budget choices between the standard yogurts, the dessert yogurts and the *fromages blancs*, using a demand system approach. The household purchases in 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.

Two additional arguments support this choice. First, we want to evaluate the impact of mandatory labeling. As emphasized in the introduction, the fact that labeling is already mandatory for the *fromages blancs* and not for the dessert yogurts makes it easier to identify separately the consumer preferences for labeling and for fat. Second, the *fromages blancs* and the dessert yogurts have often the same culinary use: they are both served as desserts, frequently added with sugar, marmalade, honey or fruits.

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

[5] Griffith *et al.* (2009) choose to pick up shopping trips at random in the data. 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.

2.2 Product attributes

The data contain information on the fat content of all dessert yogurts and *fromages blancs*, as well as the flavor, 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%). Fat-content labels are mandatory for all *fromage blanc* products.[7] But our data do not provide any information about the presence of fat-content labels on the dessert yogurts. We have 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 also 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), which corresponds to a one-person portion. 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 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*.

[7] See the *décret* 88-1206 in the *Journal Officiel de la République Française*, 31/12/1988.

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).[8] We choose 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 which distribution channels were visited by each household. Its choice set is made up of all products that were available in these distribution channels. The household choice set can therefore vary from one period to another. Two different households have different choice sets if they visited different distribution channels, even if they live at the same place.

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 which one is the most representative of household's preferences. In order to avoid arbitrary choices, we randomly select one of the products, with probabilities of selection that are proportional to the share of each product in the household's purchases over the year.[9] To construct the price of each product in the household choice set, we first calculate the mean unit prices of this product in each distribution channel and for each period. Then, the price faced by the household is the average of the mean unit prices that are observed in the distribution channels that he visited during the period. Hence, the prices vary over time, and between the households according to the distribution channels that were visited.

2.4 Market characteristics

Since the estimation procedure is time-consuming, we reduce somehow the data set by randomly choosing five periods for each household. To avoid having too much noise in the estimation process, we also excludethe products that were purchased less than 10 times in a period. This leaves us with 224 different products. Table 1 presents the summary statistics of the product characteristics, in the universal choice set containing all products and in the union of all household choice sets. Note that there are much less low- and mid-quality products in the latter than in the former because each household choice set varies with the distribution channels that were visited.

[8] 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. [9] For instance, if there are two goods, and the household purchased a quantity $Q1$ of good 1 and a quantity $Q2$ of good 2, then the probability of selecting good 1 in a period where both goods were purchased is $Q1/(Q1 + Q2)$.

[Table 1 about here]

The main characteristics of the market are given in Table 2. While no full-fat dessert yogurts (20 products) had a fat-content label in 2007, 12 out of the 24 half-skimmed had one. The final sample contains $8,985$ observations describing the choices of $1,795$ households over five periods. The *fromages blancs* account for 70.8% of choices, the dessert yogurts for 23.9%, and the outside alternative of consuming none of these products for 5.4%. More than 54% of the purchases of *fromages blancs* were made in the half-skimmed category, about 23% were skimmed, as much were full-fat. By contrast, 72% of dessert yogurts were purchased as full-fat. The price of full-fat products is higher than the price of other products, but there is less variation in the price of dessert yogurts than in the price of *fromages blancs*.[10]

[Table 2 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 3 reports the mean and standard deviation of these variables, among others, in the estimation sample. These household characteristics will be interacted with product attributes in the regression to adjust for the effect of observable characteristics on preferences.

[Table 3 about here]

3 Empirical modeling

3.1 Structural model for the demand side

The 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 and Train 2000). The MMNL model presents three key advantages: first, the household preferences over product characteristics are specified in a flexible manner, as it allows for both observed and unobserved heterogeneity effects on the intercept and the slopes of the utility function; second, the household heterogeneity in the WTP for fat-content labels can be precisely characterized; third, as the choice set varies from one households to another, the 'Independence from Irrelevant Alternatives' constraint imposed by the standard conditional logit model is unlikely to hold.

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

3.1.1 The random utility model

Each household $i = 1, ..., N$ face a set of J_{it} products in a choice situation $t = 1, ..., T$.[11] Each product $j \in J_{it}$ can be described as a bundle of characteristics. As in many other papers, we assume that all product characteristics are known to the consumer and 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

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

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, leading to the endogeneity of the latter (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 the observed prices on the demand then captures both a true price effect and the effect of unobserved marketing efforts. The prices may also be endogenous because some unobserved 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 will have $E(\varepsilon_{ijt} \mid p_{ijt}) \neq 0$.

We will 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

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

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 variation that we consider are those that are 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, the variation in the price faced by a household is the average of these mean unit price variations over the distribution channels that were visited in the corresponding period.

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

Regarding the fat-content labels, the IVs are 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 (see Appendix A.2 for details). This assumption and the resulting exclusion restriction hold if the consumers of *fromage blanc* 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 is the producer to signal it to consumers. In our data set, the 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 implement the procedure to correct for the 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 the price and the 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 problem of endogeneity arises because these unobserved factors are correlated with the price or the fat-content labels. The control function approach takes explicitly into account the effect of μ^p_{ijt} and μ^l_{ijt} on the utility, by introducing proxy measures of these variables in the regressions. These proxy measures are constructed in a first-stage, as the residuals from the regressions of the price and fat-content label variables on all 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 into the regressions solves the endogeneity issue.

3.2.2 Parametrisation 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

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

where

$$v_{ijt} = -\alpha^p_i p_{ijt} + \alpha^l_i l_j + \beta'_i x_j \quad \text{and} \quad c_{ijt} = \lambda^p_{ijt} \hat{\mu}^p_{ijt} + \lambda^l \hat{\mu}^l_{ijt} + \sigma^p \eta^p_{ijt} + \sigma^l \eta^l_{ijt}. \tag{6}$$

The tastes for the observed 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 $\alpha_i = (-\alpha^p_i, \alpha^l_i)$. Then

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

where $\overline{\alpha} = (-\overline{\alpha}^p, \overline{\alpha}^l)$ is the vector of average tastes for the price and the label in the population, and A, B and Σ are respectively two matrices and a symmetric matrix of parameters (specifically, Σ is the Cholesky decomposition of the covariance matrix of ν_i). Under this specification, the elements of $\overline{\alpha} + \Sigma \nu_i$ correspond to the random coefficients for the price and the label variables. The opposite of the random coefficient for the price follows a log-normal distribution, and the random coefficient for the fat-content label has a normal distribution. 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 of 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^p_{ijt} and η^l_{ijt}. Define y_{ijt} as 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.* $\widetilde{\varepsilon}^p_{ijt} = \widetilde{\varepsilon}^l_{ijt} = 0$, 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).[12]

Considering the hypothetical situation where $\widetilde{\varepsilon}^p_{ijt}$, $\widetilde{\varepsilon}^l_{ijt}$ 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

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

where $\eta_{ijt} = \{\eta^p_{ijt}, \eta^l_{ijt}\}$, 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,[13] and the utility derived from the consumption of the outside alternative is normalized to zero. Then, the probability 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 $g(\eta_{ijt}) = \phi(\eta^p_{ijt})\phi(\eta^l_{ijt})$, with $\phi(\bullet)$ the standard normal density function.

[12] Although very attractive because of its extreme tractability, the MNL model restricts substitution patterns in an unreasonable fashion (see, for example, Berry 1994). [13] In order to make the writing lighter, all other conditioning arguments (product and consumer attributes, reduced-form residuals) are omitted here.

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 these instruments, and all product characteristics, including their interactions with household attributes, listed in Table 3, distribution channel and brand fixed effects.[14] Then, these residuals are used as control functions in the above likelihood function. The matrix of variance-covariance is corrected to account for the additional variance induced by the first-stage estimation.

3.2.4 The 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.[15] 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 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, still 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. On cross-section data, however, identification is shown to depend on the variate slope heterogeneity is applied to: for a continuous variable, the mean and variance are still identified without any choice set variation; but for a binary variable, identification requires the set of options to differ across individuals.

[14] A F-test reveals that both instruments are highly significant in the first-stage regressions. [15] 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.* 2009a,b; Berry and Haile 2009a,b; Fox 2009). 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 only.

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.

3.2.5 Household specific parameters

The maximisation of (13) provides unbiased estimates of the structural parameters, θ, describing the distribution of tastes in the population. These estimates 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 1999). 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

$$E(h(\alpha_i) \mid w_i; \theta) = \frac{\sum_{d=1}^{D} E(h(\alpha_i) \mid w_i, \eta_{ijtd}, \nu_{id}, ; \theta) P(w_i \mid \eta_{ijtd}, \nu_{id}; \theta)}{\widetilde{P}(w_i \mid \theta)}, \tag{14}$$

where $\widetilde{P}(w_i \mid \theta)$ is given by (12). Considering $h(\alpha_i) = \alpha_i^l$, relation (14) 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.

3.3 Identification of the structural model for the supply side

The 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 and Bonnet and Réquillart 2010). Simulating the full impact of a labeling or a fat tax policy on the *fromage blanc* and dessert yogurt market, and not only demand, therefore requires a structural model of behaviours on the supply side. In the demand model, two variables are considered as resulting from firms' strategic decisions: price and label.[16] However, it seems reasonable to suppose that the labeling decision is taken when the product is introduced, and that it would hardly be affected

[16] 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.

by a fat tax policy (it becomes strictly exogenous in the case of a mandatory labeling policy).[17] This assumption allows us to focus on price as the sole strategic variable for producers.

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).[18] 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. The profit of producer m, denoted π_m, is given by

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

where p_j and c_j are respectively the price and the (constant) marginal cost of production for product j, and where $s_j(p;\theta) = \sum_{i,t} P(y_{ijt} = 1 \mid \theta)$ is the predicted market share of product j for all $j \in G$, depending on the prices of all products, p, and demand parameters.[19] 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

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

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. Then, the marginal costs are deduced given the observed prices.

Using the equilibria conditions (15), the marginal costs and the other estimated structural parameters, some policy experiments, such as mandatory labeling for dessert yogurts and an ad-valorem fat tax, can be implemented . Implementing a mandatory labeling policy amounts to replace the label variable by a vector of ones, l^*.[20] 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 (9), where v_{ijt} and c_{ijt} are now as follows

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

Here, the terms used to correct for label endogeneity vanish from the control function, the label variable being strictly exogenous once the policy is implemented. The first-order conditions (15)

[17] This is justified by the fact that firms often prefer introducing new food products rather than modifying the characteristics of existing ones. [18] A recent literature enriches this setup, by taking into consideration vertical relationships between the manufacturers and the retailers (see Villas-Boas, 2007, and Bonnet and Dubois, 2010).We leave this for a revision of this paper. [19] 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. [20] We assume that the labelling 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 labelling 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.

are then used to find a new price vector, p_0^*, given $s_j^*(p;\theta)$ and $\partial s_k^*(p;\theta)/\partial p_j$. If p_0^* is close enough to the observed price vector, p, equilibrium prices are unchanged. Otherwise, a new price vector, p_{iter}^*, at the *iter*-th iteration is derived from

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

for all $j \in G_m$ and $m = 1, ..., M$, where market shares are obtained using (9) with

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

where $\hat{\mu}_{j,iter-1}^{p*}$ is the residual obtained from the regression of $p_{j,iter-1}^*$on z_{ijt}. 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 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 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.[21] 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.

[21] 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.

4.1 Utility functions

The Table 4 shows the estimated coefficients of the MMNL model: they can be interpreted directly in terms of marginal utilities. As outlined in the previous section, the marginal utilities of the price and the label 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 under 27, living in a household in the top income quartile. The second column reports the estimated standard deviations of each random component. They are all significant at the 1% level, indicating that the marginal utilities of the price and the label do vary with some unobservable household characteristics. The remaining columns report the coefficients for a number of interactions between the product characteristics, listed in the first column, and the 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 second part of Table 4 provides the estimates of the correction terms for the endogeneity of price and label: the coefficients of the control functions and the variances of the associated error components.

[Table 4 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 increase significantly when the main shopper is risky-overweight (BMI > 27). The random unobserved household attributes are positively correlated, with a coefficient of 2.594. 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 displayed at the bottom of Table 4 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 valuations of some unobserved product characteristics. We imagine well that, in the case of low-fat 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 instead of -1.870).

The households tend to prefer the half-skimmed and full-fat products to the 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 of overweight-related diseases. The literature in sensory research emphasizes that two kind of motives underly consumer preferences for fat in dairy products. For some consumers, the fat content is positively related to taste and immediate hedonic pleasure. For others, the fat content is negatively related to healthiness, and delayed health damages (Grunert et al. 2000). Many risky-overweight individuals are likely to be very concerned by the fat-disease relationship, but they are also likely to exhibit a strong taste for fat. Hence, the polarisation 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 4 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.[22] Last, the bifidus/organic characteristic has no significant effect on utility, while smooth textures are associted to a utility loss, consistent with the fact that non-smooth varieties (especially de 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 the price variation (here in €) that keeps utility unchanged when a fat-content label is displayed on 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 (14), where $h(\alpha_i)$ is the ratio of the marginal utility of a label over the marginal disutility of the price.

[22] 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, p. 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. However, this weight management strategy is partly ineffective, because restrained eaters have self-control problems, especially when they experience a negative emotion. Small package sizes favour lapses of self-control in restrained eaters, because they think that they "are flying under the radar" (Coelho do Vale et al. 2008).

Since the marginal disutility of prices is log-normal, the empirical distribution of the WTP is very asymmetric, with a long left-tail.

Our key result here is that the fat-content labels are not always positively valued by consumers. Mandatory labeling policies may harm their welfare, at least on the short term, which is at odds with the standard predictions from the economics of information:

[Figure 1 about here]

Table 5 reports proportions of households, in the whole sample and in specific subgroups, that fall within different interval ranges of WTP (lower than −2€, between −2€ and −1€, −1€ and 0€, 0€ and 1€, 1€ and 2€). A large majority of households is ready to pay a positive amount to have a fat content label displayed on the front of the package (almost 62%). This proportion is slightly higher in the first income quartile (65%), and slightly lower when the main shopper is risky-overweight (59% for a BMI over 30), indicating that the welfare benefits produced by fat-content labeling are overall positive in the populations targeted by public health policies. Non-risky overweight (25≤BMI<27) is associated to an increase in WTP, with 65% having a positive WTP and almost 49% who are willing to pay more than 1€ for a label. The lowest WTP are observed when the main shopper has a BMI under 25, with a WTP lower than −2€ for more than 20% of this population. .

The results by income groups mirror the estimations of marginal utilities. The WTP for a label is higher in the second income quartile, with a large majority of households (54%) being willing to pay more than 1€. A large majority of households in the first income quartile have a positive WTP, but they are willing to pay more moderate sums of money — between €0 and €1 (only 38% are willing to pay more than €1, 8% less than in the whole sample). This reflects the price effect, as the marginal disutility of price is much higher for these households (see the coefficient in Table 4). The unwillingness to pay for a fat-content label, i.e. the proportion of households with a negative WTP, slightly increases with income. While 16% of households in the first quartile have a WTP lower than −€2, this proportion reaches more than 20% in the fourth income quartile. This income effect suggests that a mandatory labeling policy would not have regressive welfare effects.

The spread of the distribution of the WTP is larger in women than in men. There are more women willing to pay more than €1 (46% as against 35% for men), and also more women with a WTP lower than −€2. Last, the age of the main shopper does not seem to influence the WTP for a fat-content label.

[Table 5 about here]

Since the household position in the distribution of the WTP for fat-content labels is predicted conditionally on the household purchase decisions, there are significant associations between the former and the latter. Table 6 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. Perhaps unsurprisingly, the households who never purchased a dessert yogurt have a positive median WTP, while it is negative for those households who did it at least once. The contrast is maximum for the full-fat dessert yogurts, with a median WTP that falls from €1.13 to −€4.74. On the contrary, a positive median WTP is observed for those who purchase *fromages blancs*, but it slightly decreases with the fat-content of the product (€0.42 for the full-fat *fromages blancs* instead of around €1 for the skimmed and half-skimmed ones). When we compare the households that purchased at least once a full-fat product, there is a clear opposition between the dessert yogurts and the *fromages blancs*, with median WTPs of opposite signs (−€4.74 *v.s.* €0.42).

[Table 6 about here]

The household WTPs were also matched with variables extracted from complementary data collected in the same sample. They describe some aspects of consumer attitudes during shopping as well as their purchase motives. Table 7 reports, for each sentence in the first column, the median value of the WTP depending on whether the household main shopper agrees or not. The last column displays the p-value obtained from the equality of median test. Interestingly, Table 7 highlights that the households whose main shopper declares that diet items are as tasty as normal ones, or believe in the health benefits of diet products have a significantly higher median WTP for fat-content labels (€0.90 *v.s.* €0.47, and €0.76 *v.s.* €0.43, respectively). The median WTP is nevertheless lower when the main shopper reads the list of ingredients during shopping (€0.45 *v.s.* €0.85), and the difference is significative at 5% level. Hence, the presence of a fat-content label would help more the individuals who are interested in diet products, but do not make the effort to read the nutrition panel facts. Being on diet for medical or aesthetic reasons is not associated to significant differences in median WTP, perhaps again because these individuals use to rely on nutrition panel facts rather than on labels. Last, comparing the prices before purchasing is associated to a higher WTP, perhaps because these individuals tend to rely more on information and cognitive efforts than on routines to choose between products.

[Table 7 about here]

The analysis of the empirical distribution of the household WTP suggest that the preferences for fat and fat-content labels broadly fall into three categories. A first group of consumers do love fat but do not want to be informed about it. They are more prone to purchase full-fat dessert yogurts. A second group do not have lower hedonic expectations regarding diet products, and are willing to pay for being informed about the presence of fat. They are attracted by half-skimmed and skimmed *fromages blancs*, and labeled dessert yogurts. A last group may see fat as a positive attribute, and tend to buy full-fat *fromages blancs*.

This segmentation stems from the fact that popular food cultures consider fat as a guarantee of taste, and French eating habits have been traditionally characterized by a taste for rich (*i.e.* fat) and high-quality food (Stearns 2002, pp. 225-228). Over the 20th century, France has also developed a "zeal for slenderness" that is similar to what is observed in other western countries (Stearns 2002, pp. 153-186). Hence, fat is now a dilemma in the modern French diet culture. The fat content will therefore affect a product value along two dimensions, pleasure and health. Wardle and Solomons (1994), and Westcombe and Wardle (1997) show indeed that fat-reduction claims in the packaging can decrease product acceptance in hedonic rating experiments, even when the actual fat content remains constant. Hence, a fat-content label has an impact on hedonic expectations, in addition to its effect on health perceptions. Those consumers who love fat for it is tasty, but dislike it for its health effect are better off at ignoring or making less salient the health dimension.

Economic textbooks see information provision as enhancing consumer welfare, because it favors market segmentation. But here, a non negligible fraction of the population is averse to information. As a consdequence, the absence of information can also favor a product differentation and the market segmentation.

4.3 Price-cost margins

The marginal unit costs are recovered for each variety by inverting the first-order conditions (15), wherein the market shares are obtained by aggregating the corresponding estimated choice probabilities over all households and all periods. The average (and standard deviation) of these marginal costs for each producer, as well as the associated average price-cost margins are not reported in details here for reasons of confidentiality. On average, the marginal cost and the price-cost margin are equal to €1.33 (with a standard deviation of €0.69) and 0.47, respectively. Unsurprisingly, the unit costs are lower for the main retailer brands (between €0.73 and €1.02) than for the main national brands (between €1.23 and €1.69) Nevertheless, the price-cost margins of the former and latter are quite similar. Hence, the difference in production costs is passed to the consumer prices.

5 Ex ante policy evaluation

The methodology described in Section 3.3 is applied to the demand functions estimated above, in order to produce ex ante evaluations 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 the package.[23] We examine their impact on the market shares, the prices and the consumer

[23] 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.

surplus, and we compare them in terms of effectiveness at reducing the amount of fat provided by the market of *fromages blancs* and dessert yogurts.

5.1 Policy impact on the market shares, the prices, and the producer margins and profits

The effect of the policies in terms of market shares, prices and margins are reported in Table 8, for the five big categories of products (skimmed, half-skimmed or full-fat fromages blancs, and half-skimmed or full-fat dessert yogurts). The panel on the top shows the initial situation, while the middle panel displays the variations in shares, prices and margins for the mandatory labeling policy, and the bottom panel does the same for the fat tax policy. For each policy, the first line presents the variations in market shares when only the behavioural response of the households are taken into account. The three remaining lines displays the results obtained when the behavioural response of the producers (their price strategy) is endogeneized.

A first striking result is that the final market equilibrium is totally different according to whether the producer price responses are taken into consideration or not. When producer reactions are ignored, the labeling policy hits the target. The huge decrease in the market share of full-fat dessert yogurts from 17.6% to 5.0% (less 12.6 percentage points) is far from being compensated by the increase in the market share of full-fat fromages blancs (from 15.46% to 19.5%): consumers tend to substitute the former for the latter, as the *fromages blancs* are cheaper, and the dessert yogurts now display fat labels that are a negative attribute for this product category. The mandatory labeling policy appears to be more efficient than the fat tax policy at reducing the consumption of full-fat products.

However, introducing a behavioural response on the supply side changes the result. The labeling policy now leads to a small increase in the market share of dessert yogurts (+1.1 percentage points for the full-fat dessert yogurts), at the expense of the skimmed and half-skimmed *fromages blancs* (−1.8 and −6.4 percentage points respectively). This is due to the large reduction in the prices of dessert yogurts. The producers can use this strategy because the margins on the dessert yogurts are initially quite high: the price-cost margin is 0.67 for the full-fat dessert yogurts, as against 0.41 only for the full-fat *fromages blancs.*.The prices of the half-skimmed and full-fat dessert yogurts is predicted to decrease by about €0.9 and €1.4, respectively, and they would become the cheapest products sold on this market.

[Tables 8 about here]

The fat tax policy would have a small impact on the market shares, and more particularly on the demand for full-fat dessert yogurts, whether or not we endogenize the producer prices. The market share of full-fat fromages blancs would be reduced by 2.3 percentage points, that of full-fat dessert yogurts by 1.4 percentage points. The increase in the share of skimmed *fromage blanc* (+2.83 percentage points) and half-skimmed dessert yogurts (+1.01 points) shows that households would move away from the fatter varieties. The variations in market shares are small because the producers do not fully pass the tax to consumer prices. For instance, for the full-fat dessert yogurts, the final increase in consumer price for a 100% pass-through would be €0.31 euros (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%: the producers are willing to absorb a large part of the intended policy shock on consumer prices.

The Table 9 shows the variations in market shares by demographic group. It is interesting to note that, under mandatory labeling, the consumption of full-fat dessert yogurts would increase more in the households whose main shopper is obese (+4.7 percentage points, as against +1.1 for the whole population). In addition, they would consume less skimmed and half-skimmed *fromages blancs*, as their market shares decrease by 3.04 and 10.2 percentage points 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 the full-fat products to the skimmed and half-skimmed products for the households with obese main shoppers.

The variations in profit and market shares are not reported here in details for reasons of confidentiality. The annual profits are calculated using the predicted market shares, and the observed household purchase frequencies for *fromage blanc* or dessert yogurt 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 the producers, which is larger for the labeling policy (−21.0% *v.s.* −6.1% for the fat tax). The price responses of the producers help them to limit the fall in sales, but they also have to reduce their margins (especially under mandatory labeling). The main national brands would suffer much more from the labeling policy than the retailer brands. The profits of the former would decrease by 34.4% to 76.6%, as against 11.3% to 20.6% for the latter.

5.2 Variations in household fat purchases and welfare

Table 10 reports the changes in average annual household fat purchases, by demographic group, with and without accounting for the producer price reactions. The annual household 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 an household. The fat tax reduces this quantity by 76.5g (−9.1%), whereas the decrease is smaller (less 12.5g or −1.5%) for a mandatory labeling policy. Ignoring the producer price response would result in a large bias, and misleading results, as both policies would then decrease fat purchases by more than 300g. If we aggregate these results over all households and extrapolate them to the entire French population, $2,361$ tons of fat are initially provided by the fromages blancs and dessert yogurts to the households. The fat tax policy leads to a 5.55% decrease and the labeling policy to a smaller figure of 0.9% (not displayed in the table).

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

Table 11 reports the percentage increase in household consumption surplus induced by the two policies, for each demographic group.[24] The fat tax policy reduce the average surplus by 2.1% on average, since the consumer prices increase. The mandatory labeling policy induces an important rise in consumer surplus; It is explained by the large fall in price for the desert yogurts, which more than offsets the disutility of labeling for the consumers.

6 Conclusion

This paper has applied a structural modelling approach to the French market of *fromages blancs* and dessert yogurts, to estimate the distribution of household WTP for fat-content labels, and to evaluate the impact of a mandatory labeling policy and a fat tax on the market equilibrium.

The economic theory predicts that fat-content labels should always be positively valued by consumers, as more information is always better for a rational consumer. It is supposed to favor the emergence of a separating market equilibrium, whereby they can easily buy products that better match their preferences for fat than when the information is unavailable (see Teisl *et al.* 2001).[25] However, we find that about one third of households are willing to pay to avoid fat-content labels: their WTP. The consumers of dessert yogurts, which are generally left unlabeled by the producers, have very negative WTP for the fat content labels. We interpret this in terms of social norms and market segmentation. This market segment attract those individuals who like the taste of fat, but may feel guilty and anxious if they had to learn about the exact fat content of their yogurt. This is reminiscent of the 'aversion to information' argument formalised by Köszegi (2003). He models an individual who faces unprecise risk distributions, and has preferences over these latter. She may learn more about her personal risk, but prefers to ignore the information when she anticipates 'bad news', *i.e.* large and irreversible health damages. As the medical and

[24] The formulas for these welfare calculations are found in Appendix A.3. [25] Whether labeling is beneficial for consumers on the long term remains an open question. Product differentiation may encourage healthy brands to increase their prices and unhealthy brands to lower their prices. The consumption of unhealthy nutrients may then increase for a number of consumers, leading to a worsening of the population health, *i.e.* a decrease in consumer welfare despite a better product-preference matching. In a general equilibrium perspective, the dynamic interactions between consumer behavior and producers' strategies should be explicitly modelled to determine the welfare impact of lablling (Moorman 1998). We have abstracted here from such considerations.

social norms now strongly condemn fat, eating fatty may be associated to such large psychic costs and to some anxiety (Stearns, 2002). It is therefore unsurprising that some people prefer to avoid information : "what I don't see won't hurt me".

We have then combined the demand estimates with a linear pricing supply model to evaluate the consequences of the mandatory fat labeling and the fat tax policies. We find that producers' pricing strategies are crucial to obtaining an accurate picture of the impact of tax and mandatory labeling policy. A fat tax policy results in a fairly large decrease in households' fat purchases : about 9% for a tax of 10% on the producer price of full fat product (and a tax of 5% for half-skimmed products). By contrast, if fat content labeling were mandatory, the households' fat purchases would be reduced by 1.5% only, because the producers of dessert yogurts would accept to cut their margins to retain their customers. This producer reaction entails a large decrease in the price of dessert yogurts, which offset the disutility of having a fat-content label in the packaging. Since the prices are lower, the mandatory labeling policy is likely to increase consumer welfare on the short-term, while the fat tax policy has the opposite impact. However, these welfare calculations do not take into consideration the long-term benefits of reduced fat intake.

Hence, the main conclusion of this paper is that there is no magic bullet to curve fat consumption if one relies only on standard policy tools, because market mechanisms - here, the producers' reactions to policies - tend to neutralise any intervention. One alternative policy, 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 still several limitations to the analysis. First, all the simulation results are based on a supply model where retailers do not exist and producers sell their production directly to consumers. It would be interesting to wheck wehther taking into consideration vertical relationships between producers and retailers has important consequences on the market equilibrium. Second, the set of products is supposed to be fixed, and only pricing strategies are possible for the firms. The 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 long run welfare effect of the policies, and to rank unambiguously the various policy options. 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 Identifying tastes for fat-content labels

Denote s_{jt} the market share of product j in market t and l_j the variable indicating the presence of a fat-content label on the package of j. Consider the following linear model for the market shares:

$$s_{jt} = \alpha l_j + \beta_1 h_j + \beta_2 f_j + \gamma y_j + u_{jt},$$

where h_j equals 1 if j is half-skimmed (and 0 otherwise), f_j equals 1 if j is full-fat (and 0 otherwise), y_j equals 1 if j is a dessert yogurt (and 0 otherwise); u_{jt} is an error term, and α, β_1, β_2 and γ are parameters. In this model, l_j is endogenous if the producer decision to display a fat-content label on j is based (at least partly) on some unobserved determinants of the demand s_{jt}, *i.e.* when $E(u_{jt} \mid l_j = 1) \neq E(u_{jt} \mid l_j = 0)$.

Consider the absence of label ($l_j = 0$) as a treatment. We know that the probability of being treated is zero for the *fromages blancs*, regardless their fat content (since labeling is mandatory), and more or less positive for dessert yogurts, depending on their fat content. Then, we can write

$$\begin{aligned}
E(s_{jt} \mid y_j = 1, f_j = 1) &= \alpha E(l_j \mid y_j = 1, f_j = 1) + \beta_2 + \gamma + E(u_{jt} \mid y_j = 1, f_j = 1), \\
E(s_{jt} \mid y_j = 1, h_j = 1) &= \alpha E(l_j \mid y_j = 1, h_j = 1) + \beta_1 + \gamma + E(u_{jt} \mid y_j = 1, h_j = 1), \\
E(s_{jt} \mid y_j = 0, f_j = 1) &= \beta_2 + E(u_{jt} \mid y_j = 0, f_j = 1), \\
E(s_{jt} \mid y_j = 0, h_j = 1) &= \beta_1 + E(u_{jt} \mid y_j = 0, h_j = 1).
\end{aligned}$$

Applying the difference-in-difference estimator to market shares identifies α as:

$$\alpha = \frac{(E(s_{jt} \mid y_j = 1, f_j = 1) - E(s_{jt} \mid y_j = 1, h_j = 1)) - (E(s_{jt} \mid y_j = 0, f_j = 1) - E(s_{jt} \mid y_j = 0, h_j = 1))}{E(l_j \mid y_j = 1, f_j = 1) - E(l_j \mid y_j = 1, hs_j = 1)}$$

under the assumption that

$$E(u_{jt} \mid y_j = 1, f_j = 1) - E(u_{jt} \mid y_j = 1, h_j = 1) = E(u_{jt} \mid y_j = 0, f_j = 1) - E(u_{jt} \mid y_j = 0, h_j = 1).$$

Hence, assuming that the differences in unobservable factors between full-fat and half-skimmed consumers are the same for *fromages blancs* and dessert yogurts, the taste for the fat-content label is given by the difference between market shares of full-fat and half-skimmed dessert yogurts minus the difference between market shares of full-fat and half-skimmed *fromages blancs*, divided by the difference between the proportions of unlabeled full-fat and half-skimmed dessert yogurts.

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 (14). 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 1: **Mean values of product characteristics**

Product characteristics		In the universal product set	In household choice set
Price (std deviation)		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%

Table 2: **Market characteristics**

	Outside option	Fromages blancs			Dessert yogurts	
		Skimmed	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 price (std deviation) in Euro	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 3: **Household characteristics (N=1785)**

	Mean
Monthly household income in Euro	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 %

Table 4: **Estimated coefficients**

	Mean	Std. dev.	Income			Man	Risky-overweight	Household size	Over 65
			First Quartile	Second Quartile	Third Quartile				
Price	-1.870***	1.995***	-0.232***	-0.148***	-0.013	-0.067	-0.042	0.012	0.263***
	(0.056)	(0.030)	(0.063)	(0.057)	(0.058)	(0.108)	(0.049)	(0.017)	(0.049)
Label	0.592**	3.85***	0.157	0.641**	0.180	-0.239	0.288		-0.447**
	(0.271)	(0.131)	(0.330)	(0.309)	(0.320)	(0.596)	(0.252)		(0.245)
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 2.594***; 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 5: **Distribution of the WTP for a fat content label by demographic groups (in Euros)**

	Proportion of households in percent					
Household	WTP≤-2	-2<WTP≤-1	-1<WTP≤0	0<WTP≤1	1<WTP≤2	Max WTP in Euro
All	18.47	7.73	11.85	16.31	45.64	1.81
Main shopper's body weight						
Normal weight (BMI<25)	20.06	7.25	10.72	17.42	44.55	1.81
Overweight (25≤BMI<27)	19.45	6.68	9.42	15.61	48.84	1.80
Risky-overweight (27≤BMI<30)	16.25	7.99	14.02	14.25	47.49	1.80
Obese (BMI>30)	12.40	10.48	17.93	13.98	45.21	1.78
Income						
First quartile	16.21	9.10	9.27	27.55	37.87	1.81
Second quartile	17.88	6.92	13.99	6.94	54.27	1.80
Third quartile	19.39	6.30	13.45	10.48	50.38	1.78
Fourth quartile	20.46	8.48	10.95	18.49	41.62	1.70
Male	12.19	9.38	15.62	27.90	34.91	1.81
Female	18.75	7.66	11.70	15.60	46.29	1.46
Aged under 65	17.70	8.18	12.82	15.93	45.37	1.78
Aged above 65	18.79	7.73	11.51	16.23	45.74	1.81

Table 6: **Distribution of the WTP for a fat-content label according to the household's product choice**

	Median of the WTP (€)		Equality of median 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 dessert yogurts	1.13	-4.74	0.000

Table 7: **Motives/attitudes and the WTP for a fat-content label**

	Median of WTP (€)		Equality of median test
	If I disagree	If I agree	p-value
I think diet products are as tasty as normal ones	0.47	0.90	0.013
I think diet products have an effective impact on health	0.43	0.76	0.092
I read the list of ingredients before purchasing	0.85	0.45	0.045
I check the sugar or the fat content of the food products I purchase	0.57	0.75	0.216
I am often on diet to stay slim	0.68	0.65	0.868
I am on diet for medical reasons	0.68	0.68	0.953
I always compare the prices before purchasing	-0.09	0.79	0.009

Table 8: **Variations in market shares and prices produced by a fat tax policy and a mandatory fat-content labeling policy, by product category**

		Fromage blanc			Dessert yogurts	
	Outside option	Skimmed/fat-free	Half-skimmed	Full-fat	Half-skimmed	Full-fat
Initial market shares in percent	6.18	15.88	38.09	15.46	6.77	17.62
Initial producer prices in Euro		1.98	1.97	2.95	2.87	3.06
Initial margins in Euro		0.46	0.44	0.41	0.57	0.67
			Mandatory labelling policy			
Share variation with no firm response in pp	4.87	2.03	3.73	4.00	-2.04	-12.59
Share variation with firm response in pp	3.79	-1.88	-8.06	1.88	3.16	1.11
Producer price variations in Euro		0.06	0.06	0.21	-0.95	-1.39
Margin variations in pp		0.01	0.01	0.01	-0.09	-0.22
			Fat tax policy			
Share variation with no firm response in pp	0.86	2.94	0.02	-2.56	1.06	-2.32
Share variation with firm response in pp	0.58	2.98	-0.88	-2.3	1.01	-1.39
Producer price variations in Euro		-0.03	-0.02	-0.07	-0.07	-0.17
Margin variations in pp		-0.01	-0.00	-0.01	-0.01	-0.02

Note: under the mandatory labelling 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. 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 9: **Variations in market shares, by product category and demographic group (in percentage point)**

		Δ Fromage blanc share			Δ Dessert yogurts share	
	Outside option	Skimmed fat free	Half skimmed	Full fat	Half skimmed	Full fat
			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 10: **Variations in the average household annual fat purchases, by demographic group (in gram)**

	Base	Fat tax		Mandatory fat label	
	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 11: **Change in consumer surplus, by demographic group (in percent)**

$\frac{CS_i^{new}-CS_i^{old}}{CS_i^{old}}$	Fat tax	Labeling policy
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.

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