HEDG
HEALTH, ECONOMETRICS AND DATA GROUP
THE UNIVERSITY of York

WP 12/14

Mandatory labelling, nutritional taxes and market forces: An empirical evaluation of fat policies in the French fromage blanc and yogurt market

Olivier Allais; Fabrice Etile & Sebastien Lecocq

September 2012

york.ac.uk/res/herc/hedgwp

Mandatory labelling, nutritional taxes and market forces: An empirical evaluation of fat policies in the French *fromage blanc* and yogurt market

Olivier Allais[a] Fabrice Etilé[a,b]*

Sébastien Lecocq[a]

[a]INRA, UR1303 ALISS, F-94200 Ivry-sur-Seine, France

[b]Paris School of Economics, F-75600 Paris

July 2012

Abstract

This paper evaluates and compares two popular options of nutritional policy: mandatory front-of-pack labelling and the fat tax. Using household scanner data on *fromages blancs* and dessert yogurts, the distribution of consumer preferences for fat and for front-of-pack fat labels are separately identified by exploiting an exogenous difference in labelling requirements between the two product categories. The demand estimates are then used to calibrate an oligopolistic supply model, and to evaluate the impact of public policies. In the absence of producer price response, making fat labels mandatory would reduce by 38% the fat supplied by this market to regular consuming households. An ad-valorem tax of 10% (5%) on the producer price of full-fat (half-skimmed) products has a similar impact. However, after accounting for producer price response, mandatory labels yield only a 1.5% decrease in fat purchases, as against −9% for the fat tax. This is explained by the producer price response, which neutralises up to 96% of the impact of mandatory labelling on consumer demand.This illustrates how market forces can defeat any intended effect of market-based public health actions.

*Corresponding author: Fabrice Etilé, INRA UR1303 ALISS, F-94205 Ivry-sur-Seine, France. E-mail: Fabrice.Etile@ivry.inra.fr.

The authors thank Armelle Champenois for the bibliographic research, and Christine Boizot for data assistance. This paper benefited from discussions by Laura Grant, Eric Delattre and comments by seminar participants at the 1st joint EAAE/AEAA conference (Freising, Germany), Imperial College, York Seminar in Health Econometrics, University Paris 1, the ERS Conference on scanner data and food policy, the IRDES workshop on health policy evaluation, the Paris School of Economics and the Journées Louis-André Gérard-Varet. Financial support from the "ANR-French National Research Agency", project ANR-07-PRNA-018 ALIMINFO is acknowledged.

1 Introduction

What would be the respective effects of a mandatory labelling policy and a fat tax policy on food markets? In the context of a worldwide rise in overweight and obesity, these market-based policies have attracted a great deal of interest from policy-makers and public health advocates. This paper provides an empirical evaluation of these options, comparing their effects on key market and health outcomes, such as equilibrium prices, market shares, consumer welfare, producer profits and household fat intake.

We here study front-of-pack (FOP) labels. Consumer surveys and experiments show that they are easier to use than back-of-pack nutritional facts panel, which are already mandatory (Grunert and Wills, 2007). In 2011, after discussion of a proposal from the European Commission, the European Parliement eventually decided to let FOP nutritional labelling voluntary (See EUFIC, 2012, for an update on nutrition labelling in EU). A key element of the debate is that voluntary FOP labelling does not only serve an informational role. It also participates to a strategy of differentiation and market segmentation. When labelling is voluntary, producers are more likely to display "low-fat" than "high-fat" labels on the front of the packages. This has two important consequences. First, it is not obvious that making FOP labels mandatory will make consumers better off, as they can already infer from the absence of label that the product is high in fat, albeit with some uncertainty. Second, the producer's decision to have FOP labels may depend on unobserved consumer tastes, which renders the labelling variable endogenous in any demand function. Difficulties to find exogenous variations in labelling decisions and credible control groups are major obstacles to evaluation. The effect of nutritional information on consumer choices has mostly been investigated through consumer responses to hypothetical choices, which can lead to overestimation biases (Cowburn and Stockley, 2005; Grunert and Wills, 2007). Some studies have however been able to use quasi-natural or field experiments (Ippolito and Mathios, 1990; Mathios, 2000; Teisl *et al.*, 2001; Variyam, 2008; Kiesel and Villas-Boas, 2010; Berning et al., 2010). They provide mixed results, for the U.S. case only and different labelling (back-of-pack or shelf labels). We here focus on mandatory FOP labels, as the issue is extensively debated and regulatory frameworks are still in the pipeline of many administrations. In addition, we use the fat tax as a benckmark for three reasons. First, the mere existence of consumption externalities (if any) is sufficient to justify the implementation of a fat tax. Letting paternalistic considerations aside, there is a clear normative justification for intervening. In addition, its impact on consumer choices is also easier to evaluate (see, for instance, Chouinard *et al.* 2007; Allais *et al.* 2010). Last, legislations on nutritional taxes have been passed in several U.S. states, Denmark or France. The OECD has called for the implementation of tax policies as a means of fighting the obesity epidemic in a recent report (OECD, 2010).

Previous analyses of fat policies suffer from three critical weaknesses. First, the research has often used continuous choice demand models. This approach allows for substitutions between food categories, more or less aggregated, but ignores substitutions either within food categories or towards an outside good. Yet, it is more credible to consider that a fat tax will make consumers of high fat-content items exiting the market or switching to the nearest low fat-content counterparts in the same food group, rather than substituting from one food category to another. Second, the strategic reactions of producers are generally ignored, except in Griffith et al. (2010) and Bonnet and Réquillart (2011). These authors analyse taxes on respectively saturated fats in butter and margarine and sugar in soft drinks, and they estimate the firms' pass-through rate of the tax to consumer prices in a differentiated product oligopoly setting. The strategic reactions of the supply to mandatory labelling have never been explored. Last, as outlined above, empirical evidence on the impact of mandatory food labels on purchase behaviour in a natural shopping environment is quite scarce. The current paper improves on these three points, by combining a structural modelling of the French market of *fromages blancs* and dessert yogurts[1], and a "quasi-natural experiment" that is specific to this market.

We use scanner data, collected in a representative sample of households in 2007 and disaggregated at both household and product levels, to estimate a Mixed Multinomial Logit model of discrete choice. The model allows both for substitutions between products within a same food group and for an outside option. In the estimation, we control for the (usual) endogeneity of prices, using past price variations as instruments, but not only. We also control for the endogeneity of fat-content labels, exploiting an exogenous discontinuity in labelling legal requirements. The French legislation requires producers to signal the percentage of fat contained in *fromages blancs* by a fat-content label displayed on the front of the packages, while fat-content labelling is not mandatory for yogurts. In particular, producers never put FOP fat labels on full-fat dessert yogurts, but they have to for full-fat *fromages blancs*. Combining these exogenous variations in labelling legal requirements with brand labelling strategies, between products with different fat contents and between dessert yogurts and *fromages blancs*, and controlling for brands, distribution channels and demographics, we are able to identify the consumer preferences for fat and for fat-content labels separately. The unbiased demand estimates are used to compute price-cost margins for producers, assuming that they compete *à la Nash* in a Bertrand oligopolistic game, in the spirit of Berry *et al.* (1995) and Nevo (2001). The new market equilibrium implied by each fat policy can then simulated.

We use the model to conduct four simulations. First, we consider that FOP fat labels would be mandatory for dessert yogurts and that producers would remain passive. The average yearly fat purchases by consuming households in this market would fall by about 38%. This is largely due to an aversion to fat labels by consumers of dessert yogurts, which is interpreted as a desire

[1] We show that the standard yogurts can be excluded from the relevant market for *fromages blancs*. The *fromage blanc* is a creamy, soft, fresh, white cheese made from whole, half-skimmed or skimmed milk. It has the consistency of a sour cream. In this paper, following the French legislation, we include in the *fromages blancs* category the *faisselles*, which have similar culinary uses. Dessert yogurts gather together products like the strained/greek style yogurts and *fromages blancs* or yogurts mixed with cream or other animal fats.

to have the taste without the guilt of eating unhealthy. Second, we show that an ad-valorem tax of 10% (5%) on the producer price of full-fat (half-skimmed) products would have about the same impact (36%). Third, we consider again the mandatory labelling policy, and examine what happens when producers can adjust their prices. Perhaps surprisingly, mandatory labelling now increases the market share of dessert yogurts. This result is caused by important price cuts that would be operated by producers, through drastic reductions in margins (-68% for full-fat dessert yogurts). When labelling becomes mandatory for all products, product differentiation is lower, which intensifies the price competition. The price response of the producers of dessert yogurts is then made possible by large initial margins on dessert yogurts, and large price elasticities just after the policy shock: the fall in margins are offset by the recovery of large market shares. The producers are able to offset 96% of the effect produced by the policy on consumer demand. Four, the effect of the fat tax is also computed with producer price response. The tax is somewhat more effective than the labels at lowering fat purchases. Here, the global market shares of all full-fat products decrease slightly. One reason is that the fat tax maintain the segmentation between the *fromages blancs* and the dessert yogurts, which avoids intensifying the price competition.

Both policies would thus result in a fall of producers' annual profit, but it would be considerably larger under the mandatory labelling policy (-21%) than under the fat tax (-6%). The fat tax and mandatory labelling policies would eventually reduce the yearly fat purchases by 9% and 1.5% respectively. From a health policy perspective, these results suggest that the fat tax dominates the mandatory labelling policy. From a consumer policy perspective, however, they suggest the opposite: assuming perfect rationality, consumer welfare in this market would increase by 53% with mandatory labelling, as a result of the fall in prices, and decrease by 2% with the fat tax. These results outline the difficulty of using market tools to achieve public health objectives, as market forces can defeat any intended policy effect.

The paper is organized as follows. Section 2 details the context of the study. Section 3 presents the data and discusses the boundaries of the market. Section 4 outlines the empirical model and the estimation strategy. The estimation results are discussed in Section 5 and the simulations are proposed in Section 6. The last section concludes.

2 Data

We use scanner data collected in 2007 from a panel of households maintained by Kantar Worldpanel (KWP). There are $13,380$ households in the starting sample, which is nationally representative of the French population. The data record, on a daily basis, all purchases of yogurts and *fromages blancs* made for home consumption by the households throughout the year. The Universal Product Code (UPC) of each purchase is registered through the use of a handheld scanner, as well as the quantity purchased and the associated expenditures. KWP does not provide UPCs, but a large set of product attributes. We choose to divide the year into 13 periods of four weeks (the time unit t in the next section) . We thus focus on representative purchase behaviours in each four-week period, *i.e.* the choices that are the most frequently observed in a sense that will be defined below.

2.1 The relevant market

There are three broad categories of yogurts and *fromages blancs*: the standard yogurts; the standard *fromages blancs*; and the dessert yogurts. This market was chosen for three reasons. First, it accounts for a quite substantial share of household fat purchases (2.75%). Second, a large variety of products are offered, which allows consumers to easily switch from one brand to another. Last, the fact that in France labelling is mandatory for the *fromages blancs* and not for yogurts makes it easier to identify the consumer preferences for labelling and for fat separately. We restrict the analysis to nature products, which represent 43% of all purchases of yogurts and *fromages blancs*. Flavored yogurts and *fromages blancs* contain sugar additives. As such, fat-content labels are likely to be less salient for consumers, and less relevant from a nutritional point of view. We also eliminate products that are not made from milk cow (4.5% of all purchases), and we exclude drinking yogurts and yogurts with cereals, which account for less than 1.5% of all purchases.

In the remaining sample, 46.3% of those households who consumed *fromages blancs* in a four-week period also purchased standard yogurts, while only 5.4% purchased dessert yogurts. These statistics suggest that *fromages blancs* and standard yogurts are probably not substitutes competing on a same market, which is the case for *fromages blancs* and dessert yogurts. A formal test of this can be obtained by analyzing household budget choices between standard yogurts, dessert yogurts and *fromages blancs*, in a classic demand system setting. Household expenditures on these three categories are aggregated over the year, and local price indices are computed for each category as in Lecocq and Robin (2006). An Almost Ideal Demand System is then estimated and the uncompensated cross-price elasticities are derived (Deaton and Mullbauer, 1980). We only find one significant cross-price elasticity, indicating that the *fromages blancs* are substitutes to the dessert yogurts (the elasticity is +0.398). An increase in the price of dessert yogurts or *fromages blancs* does not significantly impact the consumption of standard yogurts (additional results available upon request). Hence, the analysis will focus on the relevant market for nature *fromages blancs*, which includes nature dessert yogurts but not standard yogurts.[2]

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

[2] This result is in line with the professional practice in marketing of considering that the dessert yogurts and the *fromages blancs* compete on the market of *fromages frais*, while the yogurts form another market: see for instance the professional review *Linéaires*, n°173, September 2002, p. 98, or n°187, December 2003, p. 110, or n°190, March 2004, p. 74. A last argument supporting this view is that *fromages blancs* and dessert yogurts often have the same culinary use: they are both served as desserts, frequently added with sugar, marmalade, honey or fruits.

choices. This leaves us with 1785 households.

2.2 Product attributes

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

2.2.1 Fat content and fat-content labels

Using the fat content, we sort the products into three categories: full-fat (more than 6% of fat), half-skimmed (between 3% and 6%), or skimmed (less than 3%).[3] Fat-content labels are mandatory for all *fromage blanc* products.[4] But the data do not provide any information about the *presence* of fat-content labels on the dessert yogurts. We therefore collected additional data from several sources of information: the online Mintel's Global New Products Database (GNPD), the monthly French review *Linéaires*, the popular websites www.flickr and www.ciao.fr; and old TV advertisements from audiovisual archives.

2.2.2 Other characteristics

We control for a number of other product characteristics. Differences in hedonic characteristics are captured by a set of discrete attributes that indicate whether the product is a *fromage blanc* or a dessert yogurt, and whether its texture is smooth or not. Differences in health characteristics other than the fat content are captured by a dummy variable that indicates whether the product is organic or has been supplemented with probiotics. Another binary variable shows whether the product is sold in individual portions (200g or less). Last, there are 15 dummy variables that control for brand heterogeneity. There are the main national producers (Yoplait, Danone, Triballat, etc.) and the main retailer brands (Carrefour, Leclerc, Intermarché, etc.). The small national brands are grouped together, as well as the small retailer brands. We also control for brand quality, in three levels (low-, mid- and high-quality brand). The low-quality category includes the hard-discount and the first-price retailer brand. The national brands and the high-quality retailer brands form the high-quality category. These attributes define 279 distinct varieties of dessert yogurts and *fromages blancs*.

2.3 Household choice set, choice and prices

These 279 products are distributed through a number of stores, supermarkets and hypermarkets. To simplify the analysis, we define 14 homogenous categories of distribution channels, according

[3] Note that this corresponds closely to the division adopted in food marketing, see for instance the professional review *Linéaires*, n°187, December 2003, p. 110 [4] See the *décret* 88-1206 in the *Journal Officiel de la République Française*, 31/12/1988.

to two key determinants of quality positioning and pricing strategies: the retailer company (for supermarkets and hypermarkets) and the store format (hard-discount, hyper and supermarkets, grocery stores).

For each distribution channel, we assume that the set of products that are observed in the yearly purchase data is the set of products that were available at each period. For each period, we know the distribution channels that were visited by each household. We define each household choice set as the set of all products available in these channels. Choice sets therefore vary from one period to another for the same households, and across households (even living in the same place) in the same period, if they visited different distribution channels.

Regarding the household choice in each period, there are two situations. If the household did not make any purchase or did purchase a single product, then defining its choice is not a problem. However, when more than one product were purchased, we have to choose the one that is the most representative of household's preferences. In order to avoid arbitrary choices, we select it at random with probabilities of selection being proportional to the share of each product in the household's annual purchases.[5] The price of each product in the household choice set is constructed in two steps. First, we calculate the mean unit prices of this product in each distribution channel and each period; then, we average these mean unit prices over the distribution channels that were visited by the household during the period. Hence, the prices vary over time and between households according to the visited distribution channels.

2.4 Market characteristics

Given that the estimation procedure is time-consuming, we reduce somehow the data set by randomly selecting five periods for each household. To avoid having too much noise in the estimation process, we also exclude products that were purchased less than 10 times in a period. This leaves 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, simply because many of them are private labels that can be found in only one distribution channel.

[Table 1 about here]

The main characteristics of the market are given in Table 2. The final sample contains $8,985$ observations describing the choices of $1,795$ households over five periods. First note that 12 out of the 24 half-skimmed dessert yogurts have a fat-content label, while none of the full-fat dessert yogurts (20 products) are labelled. *Fromages blancs* account for 70.8% of choices, dessert yogurts for 23.9%, and the outside alternative of consuming none of these products in a four-weeks period

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

for 5.4%. More than 54% of the *fromages blancs* purchased are half-skimmed, about 23% are skimmed, and as much are full-fat. By contrast, 72% of the dessert yogurts purchased are full-fat. On average, full-fat products are more expensive than others, with smaller variations in prices for dessert yogurts than for *fromages blancs*.[6]

[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 variables are interacted with product attributes in the estimation to adjust for the effect of observable characteristics on preferences.

[Table 3 about here]

3 Empirical modeling

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

3.1 Structural model for the demand side

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

[6] 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 $i = 1, ..., N$ faces a set of J_{it} products in a choice situation $t = 1, ..., T$.[7] Each product $j \in J_{it}$ is described as a bundle of characteristics. Denote p_{ijt} the price of good j faced by household i in period t, and l_j the binary variable indicating whether a fat-content label is displayed or not on the package of j. Further denote x_j the vector of observed exogenous attributes of j and let $j = 0$ be the outside (or no purchase) option, whose characteristics are all set to zero. Considering that each household buys only one product at a time, the utility that household i obtains from the consumption of one unit of good j in period t can be written as

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

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

3.1.2 Endogenous prices and fat-content labels

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

We instrument the current price by its past variations. The identifying assumption is that, controlling for brands, distribution channels, and demographics, the individual valuation of the product-specific unobserved characteristics, ε_{ijt}, is independent from its own 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.[8] Conversely, common production and/or distribution costs imply that the price of a product within a distribution channel will be correlated with its past variations, which therefore can be used as valid instrumental variables (IVs). The

[7] In the empirical section below, a choice situation is defined as a four-week period; the set of products is indexed by i because the households visit different distribution channels and therefore face different choice sets (see Section 2). [8] This is quite similar to Villas-Boas and Winer (1999), except that they instrument current prices by past prices in level. This choice is valid only if ε_{ijt} is uncorrelated through time. Here, we rather consider that ε_{ijt} is likely to be stable through time, because it essentially relates to time-invariant attributes such as the colour and the shape of the packaging, the name etc.

price variations that we consider are those observed between the current and the last period. They are constructed in the same way as the prices in level: for each product, the mean unit price and its variation are first computed in each distribution channel and period; then, these mean unit price variations are averaged over the distribution channels that were visited by the household in the corresponding period.

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

An IV for fat-content labels can be constructed by exploiting the "quasi-natural experiment" provided by the exogenous variation in the labelling 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 labelling is mandatory), and more or less positive for dessert yogurts, depending on their fat content. Then, the marginal value of a fat-content label is identified from the empirical market shares, using a difference-in-difference estimator, under the assumption that the differences in unobservable factors between full-fat and half-skimmed consumers are the same for *fromages blancs* and dessert yogurts. This assumption and the resulting exclusion restriction hold if consumers of *fromage blancs* are not more sensitive to a fat increase than consumers of dessert yogurts. In addition, it is reasonable to consider that the decision to label a dessert yogurt is taken once and for all when introducing the product on the market. Changes in unobserved factors over time, in customer services or 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) dummy variables is a good predictor of the producer's labelling decision: the fatter is the dessert yogurt, the less likely is the producer to signal it to consumers. In our data set, full-fat dessert yogurts are indeed never labeled.

3.2 Empirical estimation of the demand functions

3.2.1 A control function approach to endogeneity

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

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

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

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

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

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

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

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

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

where

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

The tastes for the observed product characteristics, α_i^p, α_i^l 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_i^p and α_i^l to depend on unobservable attributes of the household. Formally, denote respectively s_i and ν_i the vectors of observed and unobserved attributes of household i, and let $\alpha_i = (-\alpha_i^p, \alpha_i^l)$. Then

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

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

3.2.3 Likelihood and estimation procedure

The choice probabilities can be obtained by summing the choices implied by the utility model on the distribution of the unobserved attributes of households in the population of interest, ν_i and $\widetilde{\varepsilon}_{ijt}$, as well as on the distribution of the error components, η^p_{ijt} and η^l_{ijt}. Define y_{ijt} an indicator variable equals to 1 if household i purchases good j in period t, and to 0 otherwise. Each household being supposed to choose the option that maximises 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).[9]

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[10]

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

where $\eta_{ijt} = \{\eta^p_{ijt}, \eta^l_{ijt}\}$, θ is the full set of parameters, $P(y_{ijt} = 1 \mid \eta_{ijt}, \nu_i; \theta)$ is the probability that alternative j is purchased by household i at time t conditional on η_{ijt} and ν_i, and the utility derived from the consumption of the outside alternative is normalized to zero. Then, the probability 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.

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

[9] Although very attractive because of its extreme tractability, the MNL model restricts substitution patterns in an unreasonable fashion (see, for example, Berry, 1994). [10] In order to make the writing lighter, all other conditioning arguments (product and consumer attributes, reduced-form residuals) are omitted here.

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 $\hat{\mu}^p_{ijt}$ and $\hat{\mu}^l_j$ are predicted by regressing the price and label variables against the instruments, and all product characteristics, including their interactions with household attributes, listed in Table 3, distribution channel and brand fixed effects.[11] Then, these residuals are used as control functions in the above likelihood function. The variance-covariance matrix is corrected to account for the additional variance induced by the first-stage estimation.

3.3 Structural model for the supply side

Producers are likely to adjust to exogenous shocks and ignoring their strategic behaviour may lead to under or over-estimate the impact of public policies (Griffith *et al.*, 2010; Bonnet and Réquillart, 2011). Simulating policy effects on the market equilibrium therefore requires a structural model for the supply side. In the demand model, two variables are considered as resulting from firms' strategic decisions: price and label.[12] However, it seems reasonable to suppose that the labelling decision is taken when the product is introduced, and that it would hardly be affected by a fat tax policy (it becomes strictly exogenous in the case of a mandatory labelling policy).[13] We thus focus on price as the sole strategic variable for producers.

3.3.1 The linear pricing model

We assume that firms compete *à la* Nash-Bertrand, *i.e.* by setting prices in order to maximise their profit conditional on demand parameters and other firms' prices, as in Berry *et al.* (1995) or Nevo (2001).[14] Suppose that there are M producers on the market, each producing a subset G_m of G, the total number of products on the market. Denoting p_j and c_j the price and the

[11] A F-test reveals that both instruments are highly significant in the first-stage regressions; In each equation, the F-statistic is higher than 1000. [12] 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.
[13] This is justified by the fact that firms often prefer introducing new food products rather than modifying the characteristics of existing ones. [14] A recent literature enriches this setup, by taking into consideration vertical relationships between manufacturers and retailers (see Villas-Boas, 2007; Bonnet and Dubois, 2010; Bonnet *et al.*, 2012). The hypothesis of capacity constraints is maintained, which means that our results will pertain to the short-term equilibrium effects of policies.

(constant) marginal cost of production for product j, respectively, the profit of producer m, π_m, can be written as

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

where $s_j(p;\theta)$ is the predicted market share of product j for all $j \in G$, depending on the prices of all products, p, and demand parameters.[15] The market share is computed as $s_j(p;\theta) = \sum_{i,t} P(y_{ijt} = 1 \mid \theta)$, where

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

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

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

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

3.3.2 Simulation algorithm

Implementing a mandatory labelling policy amounts to replace the label variable by a vector of ones, l^*.[16] We recalculate, for each producer m and each item belonging to G_m, the new market shares, $s_j^*(p;\theta)$, and all corresponding derivatives, $\partial s_k^*(p;\theta)/\partial p_j$, using the new label variable, l^*, the estimated demand parameters and probability (14), where v_{ijt} and c_{ijt} are now as follows

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

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

[15] 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.

[16] We assume that the labeling cost is null or negligible for two reasons: first, the fat-content being listed in the nutrient facts displayed on the packaging of all products, its determination for dessert yogurts is costless; second, as mandatory labeling simply consists in sticking a fat-content label on the front of the package, marketing and associated costs should be small relative to the whole cost of the product.

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 (14) with

$$v_{ijt} = v_{ij} = -\alpha^p_i p^*_{j,iter-1} + \alpha^l_i l^*_j + \beta'_i x_j \quad \text{and} \quad \varphi_{ijt} = \lambda^p \hat{\mu}^{p*}_{j,iter-1} + \sigma^p \eta^p_{ijt},$$

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

Regarding the fat tax policy, we assume an ad-valorem tax, proportional to the fat content, such that the *consumer* price for product j is

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

where p_j denotes the producer price for product j and $\tau_{cat,j}$ the tax rate assigned to product j belonging to the fat-content category cat. Below, $\tau_{cat,j}$ equals 0, 0.05 or 0.10 when j is a skimmed, half-skimmed or full-fat product, respectively. As for the algorithm described to get the equilibrium prices in the mandatory labelling case, we obtain a new vector of *producer* prices, p^*_{iter}, at the $iter$-th iteration solving

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

for all $j \in G_m$ and $m = 1, ..., M$, where $p^{\tau*}$ represents the new consumer price vector whose j-th element $p^{\tau*}_j$ is given by $p^{\tau*}_j = (1 + \tau_{cat,j})p^*_{j,iter-1}$. 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.[17] The variances of the estimators are corrected by standard formulas for two-step estimators (Murphy and Topel, 1985), given the extra source of variations caused by the introduction of the residuals of first step instrumental regressions.

4.1 Utility functions

Table 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, price and label marginal utilities

[17] 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.

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. All are significant at the 1% level, indicating that the marginal utilities of price and label do vary with some unobservable household characteristics. The remaining columns report the coefficients for a number of interactions between product characteristics, listed in the first column, and household characteristics, which appear in the first row (household income quartiles, household size, the main shopper is risky overweight, is a man, is aged over 65). For instance, the difference in the mean marginal utility of price between the reference shopper and a shopper in the first income quartile (first line, fourth column) is -0.232 units of utility. The lower part of Table 4 provides the estimates of the price and label control functions and the variances of the associated error components.

[Table 4 about here]

As expected, the probability of choosing an alternative decreases on average with its price. The marginal utility of price is the converse of the marginal utility of income. Its mean is negative (-1.870), and higher in magnitude for households under the median income, which is consistent with poorer households having a higher marginal utility of income. The standard deviation of the random effect on price is quite high (1.995), which implies that the marginal utility of income is very heterogeneous, beyond discrepancies captured by observed socio-demographic attributes.

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

The coefficients of the control functions, at the bottom of Table 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 labelling is not mandatory, firms decide to display a label according to the consumer positive valuation of some unobserved product characteristics. We imagine well that, in the case of half-skimmed dessert yogurts, the label is just one component of the whole packaging, which can also generate hedonic and health expectations through the use of specific colors, shapes, etc. (see *inter alia* Ares and Deliza, 2010). Likewise, the marginal disutility of price would have been slightly underestimated had the presence of unobserved product characteristics been ignored (-1.763 *vs.* -1.870).

Households tend to prefer half-skimmed and full-fat products to skimmed ones. This taste for fat is even more developed in low-income households or when the main shopper is a male or an elderly. Valli and Traill (2005) already noted that the French dislike low-fat yogurts, as compared to the British, Dutch, Spanish and Portuguese. Due to space limitations, the other results are not commented here.

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

The Willingness-To-Pay (WTP) for a label is defined as the price variation (here expressed in €) needed to maintain utility unchanged when a fat-content label is added to the front and the sides of the package. A household-specific WTP can be computed from the estimates, conditionally on household-specific information (observed choices, product and household characteristics), by using equation (16) in Appendix A.1.

Our key finding is that a non negligible fraction of households (38%) have WTPs lower than or equal to zero, as shown by Table 5.[18] This proportion shows some variations across demographic groups, but not so much: in particular, it is about the same whether the main shopper in the household is risky overweight or not, and it is only slightly higher (41%) when she is obese; it is slightly lower in the first income quartile (35% *vs.* 39-40% in the upper quartiles), which is noteworthy as it suggests that labelling policies may not have regressive welfare effects.

[Table 5 about here]

Hence, fat-content labels are not positively valued by all consumers, and a mandatory labelling policy may then harm their welfare, at least on the short term. This result is at odds with the standard predictions from the economics of information, where information provision is considered as always enhancing consumer welfare. It favors market segmentation, which leads to a better match between consumer preferences and product characteristics. Here, it seems rather that the *absence* of information favors market segmentation. Fat is actually a vector of immediate hedonic pleasure, but it is also associated with unpleasant health consequences (Wardle and Solomons,1994; Westcombe and Wardle, 1997; Grunert et al., 2000). When consumers have a conflict between the short-term pleasure of eating and the long-term goal of health preservation, informing them about the nutritional value of the choice options is likely to increase the anticipated guilt and the psychic costs associated to the less healthy products. The decrease in utility is more important for the consumers who have a strong hedonic taste for fat (Wansink and Chandon, 2006, Kivetz and Keinan, 2006, Okada, 2005). They may thus prefer not to deal with information, in order to

[18] See Appendix A.1. for the formula used to compute the distribution of WTP. Note that, when we constrain the marginal utility of information to be positive, the estimates do not converge, showing that such a constraint is rejected by the data.

peacefully enjoy the pleasure of eating a tasty product.[19] Nevertheless, it remains that a large majority of households are ready to pay a positive amount to have a fat-content label displayed on the front-of-pack. This is also true for those in the first income quartile and with a risky-overweight/obese main shopper, which suggests that the welfare benefits produced by fat-content labelling is likely to be positive in the populations usually targeted by public health policies.

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

4.3 Price-cost margins

Marginal costs are recovered for each product by inverting the first-order conditions (15). Their average (and standard deviation), as well as the associated average price-cost margins, are then computed for each producer. These, however, cannot be reported in details here for confidentiality reasons. On average, the marginal costs and price-cost margins are equal to €1.33 (with a standard deviation of €0.69) and 47%, respectively. Unsurprisingly, unit costs are lower for the main retailer brands (between €0.73 and €1.02) than for the main national brands (between €1.23 and €1.69) Nevertheless, price-cost margins for both types of brands are quite similar. Hence, the difference in production costs is passed on consumer prices. The upper panel of Table 6 reports the initial market shares, producer prices and margins for five categories of products (skimmed, half-skimmed or full-fat *fromages blancs*, and half-skimmed or full-fat dessert yogurts). The margins are between 60% and 70% for the dessert yogurts, and around 45% for the *fromages blancs*.

5 Ex ante policy evaluation

The methodology described in Section 3.3 is applied to the demand functions estimated above, in order to produce an *ex ante* evaluation of two fat policies: (i) a mandatory labelling policy that requires all products to exhibit a fat-content label on the front-of-pack (ii) an ad-valorem fat tax that increases the producer price by 10% for all full-fat products and by 5% for all half-

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

skimmed products.[20] We evaluate their impact on market shares, prices and consumer surplus, and we compare their effectiveness at reducing the quantity of fat provided by the market. We first simulate the policies without producer price response. The rate of 5% and 10% have been chosen for the fat tax, because they generate almost the same decrease in fat purchases as mandatory labelling. We then simulate the policies with producer price response. Here, the policy effects diverge. We first present the results in terms of health (fat purchases) and welfare. We then explore in details the market mechanisms that explain these results.

5.1 Variations in household fat purchases and welfare

Household annual fat purchases can be calculated by multiplying the predicted choice probabilities by the fat content of each product, times the purchase frequency observed in 2007. Before the implementation of the policy, 844g of fat are purchased on average by a household participating to this market. Ignoring producer price response, the policies generate a large fall in fat purchases: about $300 - 325$g (around -38%) After accounting for producer price response, the fat tax reduces this quantity by 76.5g (-9.1%), whereas the decrease is much smaller (-12.5g or -1.5%) for the labelling policy. If we aggregate these results over all households and extrapolate them to the entire French population, $2,361$ tons of fat are initially provided to households through *fromage blanc* and dessert yogurt consumption. The fat tax leads to a 5.55% decrease, and the mandatory labelling to a smaller figure of 0.9%.

We have also computed changes in consumer welfare, when the producer price response is taken into account.[21] The fat tax policy reduces the average surplus by 2.1% on average, since consumer prices increase. Conversely, the mandatory labelling policy induces an important rise in the average surplus, 52.5%. Why do the mandatory labelling generate such an increase in consumer surplus? As we now show, it is generated by the large fall in the producer price of dessert yogurts, which more than offsets the disutility for labels mainly found among consumers of dessert yogurts.

5.2 Impact on market equilibrium, producer margins and profits

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

[20] 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. [21] The formulas for these welfare calculations can be found in Appendix A.3. Of course, these are short-term welfare variations, since the welfare impact of health changes are not integrated.

responses are made possible.

[Table 6 about here]

A first striking result is that the simulated market equilibrium is totally different whether the producers' price responses are taken into consideration or not. Ignoring them, as already shown by the variations in fat purchases, both policies hit the target, but through different ways. Overall, mandatory labelling appears more efficient than the fat tax at reducing the demand for full-fat products (−8.6 pp *vs.* −4.9 pp). The fall in the market share of full-fat dessert yogurts, from 17.6% to 5.0% (−12.6 pp), induced by the addition of a label is far from being compensated by the increase in the market share of the (cheaper) full-fat *fromages blancs* (+4 pp). All *fromage blanc* categories (the outside option as well as) take the advantage of this fall. The explanation is that, beyond their strong taste for fat, most consumers of dessert yogurts are primarily fat lovers who do not want to be informed about the fat they eat. And indeed, their WTP for fat-content labels is very low, often negative: for instance, the median WTP among the households who purchased at least once a full-fat dessert yogurt is −€4.74. In comparison, the households who purchased at least once a full-fat *fromage blanc* is €0.42 (see Table A.1 in Appendix A.1). As a consequence, the consumers of dessert yogurts may move not only to full-fat *fromages blancs* because they are cheaper, but also to lighter categories of *fromages blancs* to attenuate the psychic costs of eating fatty products; they may stop consuming as well.

Allowing for price responses on the supply side, however, completely changes the results. The labelling policy then leads to a small increase in the market share of dessert yogurts (+1.1 pp for full-fat dessert yogurts), at the expense of skimmed and half-skimmed *fromages blancs* (−1.9 pp and −8.1 pp, respectively). This can be explained by the large reduction in the prices of dessert yogurts: the half-skimmed and full-fat dessert yogurts show a decrease in prices of about €0.95 and €1.39, respectively, hence becoming the cheapest products sold on this market. In spite of this fall in prices, the margins remain positive for all products.[22]

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

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

intended policy shock on consumer prices.

Additional computations show that, under mandatory labelling, the consumption of full-fat dessert yogurts increases more in the households whose main shopper is obese (+4.7 pp, compared to +1.1 pp for the whole population). In addition, they consume less skimmed and half-skimmed *fromages blancs*, with market shares decreasing by 3.0 pp and 10.1 pp, respectively. Hence, the labelling 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 a better option, as it induces a substitution from full-fat products to skimmed and half-skimmed products for households with obese main shoppers.

The variations in profits and the market shares are not reported here in details for reasons of confidentiality. The annual profits are calculated using the predicted market shares, and observed household purchase frequencies for *fromage blancs* or dessert yogurts over the year, and extrapolated to the entire French population using the sampling weights provided by Kantar WorldPanel. Both policies result in a fall of the annual profit of producers, which is larger for the labelling policy (−21.0% *vs.* −6.1% for the fat tax). The price responses of producers help them limit the fall in sales, but require them to reduce their margins (especially under mandatory labelling). The main national brands suffer much more from the labelling policy than the retailer brands, the decrease in profits ranging between 34.4% and 76.6% for the former, and between 11.3% and 20.6% for the latter.

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

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

6 Conclusion

This paper has developed an *ex ante* evaluation of the impact of a mandatory labelling policy on market equilibrium, with a fat tax as a benchmarkpolicy. This evaluation requires that consumer preferences for fat-content labels and for fat be separately identified. This is made possible by an exogenous source of variation in fat-content labelling legal requirements in the French *fromage blanc* and dessert yogurt market. Following the recent literature in empirical industrial organization, we have combined a flexible discrete choice model of demand, estimated on scanner data (disaggregated at both household and product levels), with a linear pricing model of supply to recover the price-cost margins for each manufacturer and to determine the impact of each food policy on market outcomes.

In the absence of producer price response, making fat labels mandatory would reduce household fat purchases by about 38%. A similar effect is obtained by implementing an ad valorem tax of 10% and 5% on the producer price of full-fat and half-skimmed products respectively. Taking into account the producer price response to public policies has been shown to have a dramatic impact on the evaluation. A fat tax policy would then result in a more modest decrease of about 9%. But, mandatory labelling would reduce household fat purchases by 1.5% only, because the producers of dessert yogurts would accept to cut their margins to retain customers. This producer reaction entails a large decrease in the price of dessert yogurts, which offsets 96% of the impact of front-of-pack fat-content labels. Since the prices are lower, the mandatory labelling policy is likely to increase consumer welfare on the short term, while the fat tax policy has the opposite effect. Although these welfare calculations do not take into consideration the long-run benefits of reduced fat intake, the estimated variations in fat intake are very small..Taking into account the differential in health effects would hardly change the picture.

Hence, the key policy message of the research is that there is no magic bullet to curve fat consumption if one relies only on standard policy tools, because market mechanisms — here, producer reactions to policies — tend to neutralise any intervention. In addition, such reactions strongly depend on the market under consideration. For instance, Griffith et al. (2010) find higher pass-through rates and effects of a tax on saturated fat in the British butter and margarine market. One alternative policy option, that is currently considered by the French public health authorities in agreement with the producers, is to promote voluntary limitations in the fat (and sugar) content of products. Whether nutrient-content regulations should remain voluntary or become mandatory is an important research question.

While this paper is, to our knowledge, the first to encompass in a structural approach the question of prices and that of labels, they are three limitations to the analysis. First, all simulation results are based on a supply model without explicit modelling of the vertical relationships between retailers and producers. Although the results are very similar when we model the latter as a two-part tariffs contract with resale price maintenance, it would be interesting to check whether other types of vertical relationships between producers and retailers have important consequences on market equilibrium. Second, the set of products is supposed to be fixed, and only pricing strategies are possible for firms. But firms may reformulate their product as well; new products may enter the market, other products may exit. Last, the demand model does not take into account, in a structural manner, the health effect of fat consumption. As such, it is difficult to evaluate the long-run welfare effect of each policy, and to rank the various options in this health perspective. While the short- and long-term welfare effects would probably display little differences for a single product, this would certainly not be the case for policies targeting large ranges of products. We leave these questions for future research.

References

[1] Ackerberg, D., Benkard, L., Berry, S.T. and Pakes, A. (2007) "Econometric tools for analyzing market outcomes", in Heckman J.J. (ed.) *Handbook of Econometrics,* Vol. 6A (Amsterdam: Elsevier Science), 4171-4276.

[2] Allais, O., Bertail, P. and Nichèle, V. (2010) "The effects of a fat tax on French households' purchases: a nutritional approach", *American Journal of Agricultural Economics* **92**, 228-245.

[3] Ares, G and Deliza, R.(2010) "Studying the influence of package shape and colour on consumer expectations of milk desserts using word association and conjoint analysis", *Food Quality and Preferences,* **21**, 930-937.

[4] Bajari, P., Fox, J.T., il Kim, K. and Ryan, S.P. (2012), "The random coefficients logit model is identified", *Journal of Econometrics,* **166**, 204-212.

[5] Baumeister, R.F. (2002), "Yielding to Temptation: Self-COntrol Failure, Impulsive Purchasing, and Consumer behaviour", *Journal of Consumer Research,* **28**, 670-676.

[6] Berning, J.P., Chouinard, H.H., and McCluskey, J.J. (2010), "Do Positive Nutrition Shelf Labels Affect Consumer Behavior? Finding from a field Experiment with Scanner data", *American Journal of Agricultural Economics*, **93**, 364-369.

[7] Berry, S.T. (1994) "Estimating discrete-choice models of product differentiation", *The RAND Journal of Economics,* **25**, 242–262.

[8] Berry, S.T., Levinsohn, J. and Pakes, A. (1995) "Automobile prices in market equilibrium", *Econometrica,* **63**, 841-890.

[9] Berry, S.T. and Haile, P.A. (2009) "Nonparametric identification of multinomial choice demand models with heterogeneous consumers", *NBER Working Paper* n°**15276** (Cambridge, MA: National Bureau of Economic Research).

[10] Berry, S.T. and Haile, P.A. (2010) "Identification in Differentiated Products Markets Using Market Level Data", *NBER Working Paper* n°**15641** (Cambridge, MA: National Bureau of Economic Research).

[11] Bonnet, C. and Dubois, P. (2010) "Inference on vertical contracts between producers and retailers allowing for nonlinear pricing and resale price maintenance", *Rand Journal of Economics,* **41**, 139-164.

[12] Bonnet, C. and Réquillart, V. (2011) "Strategic Pricing and Health Price Policies", *IDEI Working Paper n°***671** (Toulouse: Toulouse School of Economics).

[13] Bonnet, C., Dubois, P., Villas Boas, S.B. and Klapper, D. (2012) "Empirical Evidence on the Role of Non Linear Wholesale Pricing and Vertical Restraints on Cost Pass-Through", *Review of Economics and Statistics*, forthcoming.

[14] Brownell, K. D. (1994), "Get Slim with Higher Taxes", *New York Times*, Dec. 15: A-29.

[15] Caplin, A. and Leahy, J. (2001), "Psychological Expected Utility Theory and Anticipatory Feelings", *The Quarterly Journal of Economics*, **116**, 55-79.

[16] Caraher, M. and Cowburn, G. (2005) "Taxing food: implications for public health nutrition", *Public Health Nutrition,* **8**, 1242-1249.

[17] Cherchi, E. and de Dios Ortúzar, J. (2008) "Empirical identification in the mixed logit model: analysing the effect of data richness", *Networks and Spatial Economics,* **8**, 109-124.

[18] Chiou, L. and Walker, J. (2007) "Masking identification of discrete choice models under simulation methods", *Journal of Econometrics,* **141**, 683-703.

[19] Chouinard, H., Davis, D., LaFrance, J. and Perloff, J. (2007) "Fat taxes: big money for small change", *Forum for Health Economics & Policy*, **10**, http://www.bepress.com/fhep/10/12/12.

[20] Coelho do Vale, R., Pieters, R. and Zeelenberg, M. (2008) "Flying under the radar: perverse package size effects on consumption self-regulation", *Journal of Consumer Research,* **35**, 380-390.

[21] Cowburn, G., and Stockley, L. (2005), "Consumer understanding and use of nutrition labelling: a systematic review", *Public Health Nutrition,* **8**, 21-28.

[22] Crawford, G.S. and Shum, M. (2001) "Empirical modeling of endogenous quality choice: the case of cable television" (Unpublished manuscript, Duke University, http://public.econ.duke.edu/webfiles/gsc/endog.pdf).

[23] Deaton, A.S. and Muellbauer, J. (1980) "An almost ideal demand system", *American Economic Review,* **70**, 312-326.

[24] Delipalla, S. and Keen, M. (1992), "The comparison between ad valorem and specific taxation under imperfect competition", **49**, 351-357.

[25] Etilé, F. (2011) "Food consumption and health", in Lusk J., Shogren J. and Roosen J. (eds.) *Oxford Handbook of the Economics of Food Consumption and Policy* (Oxford: Oxford University Press), 317-346.

[26] EU Commission (1997) "Commission notice on the definition of the relevant market for the purpose of the community competition law", *Official Journal of the European Union,* **372** (9.12.1997), 5–13.

[27] EUFIC (2012), *Global Update on Nutrition Labelling* (Brussels: European Food Information Council).

[28] Fox, J.T., il Kim, K., Ryan, S.P. and Bajari, P. (2011) "A simple estimator for the distribution of random coefficients", *Quantitative Economics,* **2**, 381-418.

[29] Griffith, R, Neshheim, L. and O'Connell, M. (2010) "Sin taxes in differentiated product oligopoly: an application to the butter and margarine market", *CeMMAP working papers* n°37/10 (London: Institute For Fiscal Studies and University College London).

[30] Grunert, K.G., Bech-Larsen, T. and Bredahl, L. (2000), "Three issues in consumer quality perception and acceptance of dairy products", *International Dairy Journal*, **10**, 575-584.

[31] Grunert, K.G. and Wills, J.M. (2007) "A review of European research on consumer response to nutrition information on food labels", *Journal of Public Health,* **15**, 385-399.

[32] Ippolito, P. and Mathios, A. (1990) "Information, Advertising and Health Choices: A Study of the Cereal Market", *RAND Journal of Economics,* **21**, 459-480.

[33] James, P., Jackson-Leach, R., Ni Mhurchu, C., Kalamara, E., Shayeghi, M., Rigby, N., Nishida, C. and Rodgers, A. (2004) "Obesity and overweight (high body mass index", in Ezzati, M. Lopez, A., Rodgers, A. and Murray, C. (eds) *Comparative Quantification of Health Risks. Global and Regional Burden of Disease Attributable to Selected Major Risk Factors* (Geneva: World Health Organization), 497-596.

[34] Kiesel, K. and Villas-Boas, S.B. (2009) "Can information costs affect consumer choice? Nutritional labels in a supermarket experiment", CUDARE working paper n°1060r2 (Berkeley, CA: University of California Berkeley).

[35] King, G.A., Herman, P. and Polivy, J. (1987) "Food Perception in Dieters and Non-Dieters", *Appetite*, **8**, 147-158.

[36] Kivetz, R. and Keinan, A. (2006) "Repenting Hyperopia: An Analysis of Self-Control Regrets", *Journal of Consumer Research*, **33**, 273-282.

[37] Köszegi, B. (2003) "Health anxiety and patient behaviour", *Journal of Health Economics*, **22**, 1073-1084.

[38] Lecocq, S. (2010) "Variations in choice sets and identification of Mixed Logit models: Monte Carlo evidence" (Mimeo, INRA, ALISS).

[39] Lecocq, S. and J.-M. Robin (2006) "Estimating demand response with panel data", *Empirical Economics,* **31**, 1043-1060.

[40] Marshall, T., E. Kennedy and S. Offutt (2000). Exploring a fiscal food policy: the case of diet and ischaemic heart disease. *BMJ* 320(7230), 301-305.

[41] Mathios, A.D. (2000) "The impact of mandatory disclosure laws on product choices: an analysis of the salad dressing market", *Journal of Law and Economics,* **43**, 651-678.

[42] McFadden, D. and Train, K. (2000) "Mixed MNL models for discrete response", *Journal of Applied Econometrics*, **15**, 447-470.

[43] Murphy, K. and Topel, R. (1985) "Estimation and Inference in Two-Step Econometric Models", *Journal of Business & Economic Statistics,* **3**, 370-79.

[44] Mytton, O., Gray, A., Rayner, M. and Rutter, H. (2007) "Could targeted food taxes improve health?", *Journal of Epidemiology and Community Health*, **61**, 689-694.

[45] Nevo, A. (2001) "Measuring market power in the ready-to-eat cereal industry", *Econometrica,* **69**, 307-342.

[46] OECD (2010), *Obesity and the Economics of Prevention: Fit not Fat* (Paris: OECD).

[47] Okada, E.M. (2005) "Justification Effects on Consumer Choice of Hedonic and Utilitarian Goods", *Journal of Marketing Research,* **42**, 43-53.

[48] Oliver, J.E. (2006) *Fat Politics: The Real Story Behind America's Obesity Epidemic* (Oxford: Oxford University Press).

[49] Olley, S. and A. Pakes (1996) "The dynamics of productivity in the telecommunications equipment industry", *Econometrica,* **64**, 1263-1298.

[50] Popkin, B.M. and P. Gordon-Larsen (2004) "The nutrition transition: worldwide obesity dynamics and their determinants", *International Journal of Obesity*, **28**(S3): S2-S9.

[51] Petrin, A. and K. Train (2010) "A control function approach to endogeneity in consumer choice models", *Journal of Marketing Research,* **47**, 3-13.

[52] Revelt, D. and K. Train (2000) "Customer-specific taste parameters and mixed logit: households' choice of electricity supplier", *UCB Department of Economics Working Paper n°*E00-274 (Berkeley, CA: University of California).

[53] Shiv, B. and Fedorikhin, A. (1999) "Heart and Mind in Conflict: The Interplay of Affect and Cognition in Consumer Decision Making", *Journal of Consumer Research,* **26**, 278-292.

[54] Small, K.A. and Rosen, H.S. (1981) "Applied welfare economics with discrete choice models", *Econometrica,* **49**, 43-46.

[55] Stearns, P.E. (2002) *Fat History — Bodies and Beauty in the Modern West* (New-York: New-York University Press).

[56] Stern, N. (1987) "The effects of taxation, price control and government contracts in oligopoly and monopolistic competition", *Journal of Public Economics*, **32**, 133-158.

[57] Stroebele N., Ogden, L. and Hill, J. (2009) "Do calorie-controlled portion sizes of snacks reduce energy intake?", *Appetite,* **52**, 793-796.

[58] Teisl, M., Bockstael, N. and Levy, A. (2001) "Measuring the welfare effects of nutrition information", *American Journal of Agricultural Economics,* **83**, 133–149.

[59] Valli, C. and Traill,W.B. (2005) "Culture and food: a model of yogurt consumption in the EU", *Food Quality and Preference,* **16**, 291-304.

[60] Variyam, J.N. (2008) "Do nutrition labels improve dietary outcomes?", *Health Economics*, **17**, 695-708.

[61] Villas-Boas, S.B. (2007) "Vertical relationships between producers and retailers: inference with limited data", *Review of Economic Studies,* **74**, 625-652.

[62] Villas-Boas, M. and Winer, R.S. (1999), "Endogeneity in Brand Choice Models", *Management Science*, **45**, 1324-1338.

[63] Wansink, B., Sonka, S.T. and Hasler C.M. (2004), "Front-label health claims: when less is more", *Food Policy*, 29, 605-617.

[64] Wansink, B. and Chandon, P. (2006), "Can "Low-Fat" Nutrition Labels Lead to Obesity?", *Journal of Marketing Research*, **43**, 605-617.

[65] Wardle, J. and W. Solomons (1994). Naughty but nice: a laboratory study of health information and food preferences in a community sample. *Health Psychology* 13(2), 180-183.

[66] Wertenbroch, K. (1998), "Consumption Self-Control via Purchase Quantity Rationing", *Marketing Science*, **17**, 317-337.

[67] Westcombe, A. and J. Wardle (1997). Influence of relative fat content information on responses to three foods. *Appetite,* **28**, 49-62.

A Appendix

A.1 Distribution of the household WTP conditional on observed choices

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

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

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

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

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

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

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

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

Table A.1. **-Households' product choice and WTP for a fat-content label**

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

A.2 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)

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

where $|\alpha_i^p|$ is the estimated marginal disutility of the price for consumer i. The consumer surplus is computed given the household specific taste parameters, by using the formula in equation (16). The change in surpluses produced by the mandatory fat-content labelling 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 substitutions between the alternatives.

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

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

Note: Mean over 8497 observed purchases

Table 2: **Market characteristics**

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

Note: The mean prices are computed in the universal product set; Using the household choice sets yields quite similar results.

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

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

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

Table 4: **Estimated coefficients**

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

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

Table 5: **Descriptive statistics of the WTP for a fat content label**

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

[a] Proportions of households with negative WTP

Table 6: **Variations in market shares and prices produced by a fat tax policy and a mandatory fat-content labeling policy, by product category**

		Fromages blancs			Dessert yogurts	
	Outside option	Skimmed/fat-free	Half-skimmed	Full-fat	Half-skimmed	Full-fat
Initial market shares (%)	6.18	15.88	38.09	15.46	6.77	17.62
Initial producer prices (€)		1.98	1.97	2.95	2.87	3.06
Initial margins (%)		46	44	41	57	67
			Mandatory labeling policy			
Share variation with no firm response (pp)	4.87	2.03	3.73	4.00	-2.04	-12.59
Share variation with firm response (pp)	3.79	-1.88	-8.06	1.88	3.16	1.11
Producer price variations (€)		0.06	0.06	0.21	-0.95	-1.39
Margin variations (pp)		1	1	1	-9	-22
			Fat tax policy			
Share variation with no firm response (pp)	0.86	2.94	0.02	-2.56	1.06	-2.32
Share variation with firm response (pp)	0.58	2.98	-0.88	-2.3	1.01	-1.39
Producer price variations (€)		-0.03	-0.02	-0.07	-0.07	-0.17
Margin variations (pp)		-1	-0	-1	-1	-2

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