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Is voluntary nutritional labelling efficient?
An analysis of the biscuits and cakes sector in France

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1. Introduction

To address the public health issues related to the link between food consumption and chronic diseases, policy makers in many countries have taken action to change consumers' behaviour by providing better information about food. Nutritional labelling is a crucial example of this type of information. Disclosure of the nutritional characteristics of most packaged foods became mandatory in the United States with the implementation of the Nutrition Labelling and Education Act (NLEA) in 1994. Under the NLEA regulations, a 'Nutrition Facts' panel on the product's package must display information on nutrients such as calories, total and saturated fat, cholesterol, and sodium in a standardised format. In the EU, labelling remains voluntary, and nutritional labelling is mandatory only if nutrition and health claims appear on the food product's packaging (Council Directive 90/496/EEC and Commission Directive 2003/120/EC)).

The extent of voluntary labelling varies between food sectors and countries in Europe. The "Flabel project" (Storcksdieck et al., 2010) audited 37,000 products from five food and beverage categories and found that 85% of the products provided back-of-pack (BOP) nutritional labelling (with values for specific countries ranging from 70% in Slovenia to 97% in Ireland), whereas 48% provided front-of-pack (FOP) information (ranging from 24% in Turkey to 82% in the UK). In France, nutritional labelling is quite common (87% of items), and the extent of nutritional labelling on packaging varies from 52% for jams to 99% for breakfast cereals[1]. However, the type of labelling varies greatly, from simple nutritional facts to detailed labels that include nutritional guidelines and consumption advice. Very heterogeneous label formats are used in practice leading to many discussions at the European and national levels. In this context, new labelling rules could be implemented in the immediate future.

[1] www.oqali.fr

Several issues are relevant to the prospect of the need of new labelling regulations. The first is related to the effects of nutritional labelling on consumer behaviour. The second is related to its effects on the behaviour of food processors and their incentive to increase the nutritional quality of the food supply. The third issue is related to the feasibility of achieving full disclosure of reliable information to all consumers.

On the consumer side, the influence of information policies on consumer behaviour has been extensively studied. A very broad body of literature deals with the responses of consumers to food nutrition labels and examines their knowledge and attitudes towards nutritional labelling (see Drichoutis *et al*. (2009b), Nayga (2008), Cowburn and Stockley (2005) and Grunert and Wills (2007) for literature reviews). The use of nutritional information on food labels and consumers' comprehension of this information have been investigated in several papers. For instance, Grunert et al. (2010 found in the UK that consumer comprehension is high, with up to 87.5% of respondents being able to identify the healthiest product. Differences between levels of label use are mainly related to interest in healthy eating, whereas the comprehension of nutritional information on food labels is mainly related to nutrition knowledge. Both are in turn affected by demographic variables. Other studies have dealt with the impacts of nutritional labelling on purchase decisions, nutrient intake and the nutritional quality of the diet (Drichoutis et al., 2009a; Loureiro et al., 2006; Kim et al., 2000; Mojduszka et al., 1999; Pietinen et al., 2008; Nayga, 2008; Variyam, 2008). Although the impacts sometimes seem to be modest, nutritional labelling results in a healthier diet and reduces, at least for a subset of consumers, caloric intake from total and saturated fat as well as the intake of cholesterol and sodium.

The labelling format and the quantity and type of information needed on the package to improve consumers' choices are important issues. Several papers have compared the effects of the traditional nutrition facts panel on consumer choice with those of other front-of-pack (FOP) labelling options such as traffic lights (TLs), guidelines of daily amount (GDA) (Kelly et al., 2009; Larsson et al., 1999; Feunekes et al., 2008; Borgmeier and Westenhoefer, 2009; Andrews et al., 2011; Van Kleef et al., 2008). Teisl et al. (2001) discuss the trade-off between the cost of information acquisition and information accuracy, and they address the optimum levels of simplicity and detail in the information provided on the label. To deal with the dilemma that too much information can confuse consumers and too little information can

mislead them, Wansink (2003) examined the effectiveness of various FOP health claims when used in combination with a full health claim on the back of the package. The results indicate that combining brief health claims on the front of a package with full health claims on the back of the package leads consumers to more fully process and believe the claim. The basic finding is that using two sides of a package (short claim on front; long claim on back) increases the believability of health claims. However, Andrews et al. (2011) wonder if simpler is always better. Studying the impact of the "Smart Choice" logo in the US, they find that this icon can lead to positive (and potentially misleading) evaluations of a product's healthfulness and nutritional value when compared to the TL-GDA icon or a control with no FOP icon. In this case, they find that nutritional awareness is more likely to moderate effects based on the Nutrition Facts Panel than on the FOP nutrition icon information.

Concerning the second issue related to the supply side, it is important to note that even if not all consumers modify their behaviour, labelling can influence the decisions of food processors and thereby benefit public health due to an improvement in the quality of processed foods. The relationship between labelling and the quality of the food supply has received less attention in the literature. However, nutrition labelling policies may have significant effects on firms' product reformulation and new product design strategies. These effects may derive from the need to preserve brand image or from the fact that labelling rules focus competition on nutrition.

In the US, several studies have focused on the introduction of mandatory nutrition labels that disclose calories, fat, sugars, and salt, and they have shown that these policies provide incentives for the food industry to reformulate products (Ippolito and Mathios, 1990; Mojduszka et al., 1999; Caswell and Modjuska, 1996). More recently, Unnevehr and Jagmanaite (2008) studied the effects of regulations requiring the disclosure of the trans fat acids (TFA) content on nutrition labels. They showed that this information policy led to significant product reformulation by the food industry. Similarly, Vyth et al. (2009) and Vyth et al. (2010) in the Netherlands investigated the effects of a nutrition logo on the development of healthier products by food manufacturers. They show that FOP nutrition labels encourage companies to reformulate existing products and develop new ones with healthier ingredients, especially where sodium and dietary fiber are concerned. In Canada, Ricciuto et al. (2008) examined the effects of labelling regulations on the fat composition and price of margarine. They showed that reductions in TFA in margarine were implemented when new labelling

regulations came into effect. However, the modifications were primarily made to the higher priced segments. The results suggest that voluntary labelling approaches result in minimal changes to the TFA content of low-cost products and thus may be of limited benefit to lower-income groups, who are at higher risk of heart disease.

The third important issue in the debate on labelling regulation is whether market forces result in the full disclosure of quality information to all consumers and lead to modifications that do not limit the consumption of healthier products to higher-income consumers. If so, government regulation of nutrition labelling would not be necessary: this solution places the fewest constraints on manufacturers while providing full and accurate information to consumers (Caswell et al., 2003). However, product quality signalling problems related to the reliability and consistency of information may lead to mandatory labelling.

A broad body of theoretical literature deals with information disclosure, product quality signalling and public policy options in the event of market failure (see Kirmani and Rao (2000) for a synthetic presentation). When applied to nutritional issues, signal theory provides an interesting framework for the debate on mandatory *versus* voluntary labelling (Caswell and Mojduska, 1996). Generally speaking, voluntary labelling policy is based on the following two assumptions:

(i) Firms that market the highest quality products have an incentive to inform consumers that their products are really better than others: thus, they label their products even if labelling is not mandatory. Other firms have no incentive to label their products because their quality is lower.

(ii) Even if there are no labels on the lowest quality products, the previous observation leads consumers to infer that non-labelled products are of lower quality.

If the assumptions *(i)* and *(ii)* are confirmed, mandatory labelling is not necessary because each consumer can assess the nutritional quality of each product even if not all products are labelled. If *(i)* and *(ii)* are not true, consumers face an information asymmetry problem because they cannot infer the quality of all the products from the quality of the voluntarily labelled products. This failure leads public health regulators to consider a second issue related to the product's prices. If labelled products are not more expensive than non-labelled products, there are no extra costs imposed by the labelling; in that case, mandatory labelling is required

because the general application of nutritional labelling will not induce higher prices. If labelled products are more expensive than non-labelled products, there are two possibilities:

- The higher prices are due to extra costs (e.g., packaging costs and analytical costs) imposed by the labelling (see European Advisory Service (2004) for a survey on this issue). In this case, the generalisation of nutritional labelling through mandatory rules may result in the exclusion of some producers from the market, an increase in prices and/or the reinforcement of market concentration (Moorman, 1998). The benefits of better product information through mandatory labelling must be balanced with the risk of increased prices.

- There are no extra costs imposed by labelling. Thus, voluntary labelling is used mainly for discrimination of consumers: labelling is used to provide additional information on the product's characteristics to more health-sensitive consumers with greater willingness to pay regardless of the nutritional quality of the product. In this case, mandatory labelling is required.

Relying on this theoretical framework, Mojduszka and Caswell (2000) discussed the effectiveness and the benefits of implementing mandatory nutrition labelling in the US. They studied the effectiveness of markets at providing information to consumers on the nutritional quality of processed food. Their results indicated that a mandatory system would benefit the food products market because it would increase the amount of information on nutrition available to consumers.

The goal of our research is similar to that of Mojduszka and Caswell's (2000) work because we aim to analyse the current development of nutritional labelling in France, and particularly the relation between labelling, product quality and price, to obtain some insight into whether mandatory nutritional labelling should be implemented. We distinguish several levels of information available on food packages, from no or simple nutritional panels to detailed nutritional panels with FOP information and consumption advice. We estimate the effects of nutrient content, brand and product category on the probability of adopting each type of label. We also investigate the effects of labelling adoption on prices. At this step, we focus on a specific sector, which is the biscuits and cakes sector in France. Our paper is also close to Van Camp et al.'s study (2010a and b), in which the authors examine the adoption of FOP

schemes by the UK and assess the likelihood of the use of various "levels" of FOP labelling as a function of food category, retailer/manufacturer brand, and nutritional attributes.

In the following section, we present the methods and the data. In the third section, we present the estimation results and discuss them in relation to the debate on voluntary *versus* mandatory labelling. In the last section, we mention the limits of the study and suggest some approaches to address them in further research.

2. Methodology and Data

Following Modjuszka and Caswell (2000), we consider here that the nutritional quality of a food product can be expressed in terms of the amounts of the various nutrients contained by the product. Large amounts of desirable nutrients (e.g., dietary fiber) in a product indicate high nutritional quality, whereas large amounts of undesirable nutrients (e.g., fat, sodium) indicate low nutritive value[2].

European directives make nutritional labelling on packaging optional but impose a format when it is provided. Information must be given in the form of either "group 1" (calories, protein, carbohydrates and fat) or "group 2" (the same plus sugars, saturated fat, dietary fiber and sodium) labels. When a nutritional claim is made for sugars, saturated fat, dietary fiber or sodium, the use of a group 2 label is mandatory. Nutrition labelling may also include the amounts of other nutrients such as saturated fat (for group 1), trans fats, starch, vitamins and minerals (for groups 1 and 2). In these cases, group 1 becomes "group 1+" and group 2 becomes "group 2+".

Drichoutis at al. (2011) distinguish three types of information: nutritional labels or fact panels, health claims (e.g., "plant sterols reduce blood cholesterol"), and nutritional claims (e.g., fat free, low calorie). In this paper, we distinguish the following:

- nutrition fact panels, which list nutrients in the various formats described above;
- claims based on nutritional or health issues;

[2] A more accurate approach of nutrition quality of foods would be preferable, for instance by using nutrient profiles. It was not possible to set up such an approach in this study.

- other information relevant to consumption recommendations (e.g., recommended serving size, recommended accompaniment).

We assume that it is possible to create a gradient characterising the level of information provided to consumers on the basis of the following:

- the presence/absence of a claim;
- the presence/absence of nutrition fact panels and their level of detail;
- the presence/absence and position on the package of additional information allowing consumers to assess the product's contribution to daily intake and/or the need to increase or limit the consumption of the product for health reasons.

Given the European regulation framework, firms must implement labelling with two considerations in mind. The first is related to nutrition and health claims. Before their use on a food item package, such claims must be accepted by the public authorities: indeed, processors must prove that the nutrient content on which the claim is made is below or above some publicly defined threshold. If the claim is allowed, processors are obliged to label the product and put a nutrition fact panel on the package. They can voluntarily add information such as recommended serving size, consumption guidelines, and other FOP and/or BOP information.

To analyze the characteristics of products with nutrition or health claims, we assume that the presence/absence of such claims on the package is a function of multiple product variables, including its nutrient content, its type of brand, its product category and other information available on the package. Because the dependent variable is the firm's choice and is therefore discrete, the logit model is used in this study.

If the product is marketed without nutrition or health claims, nutritional labelling is not yet mandatory. In this case, processors may use no label or several types of labels, from simple to more detailed. They can also decide to provide additional information such as FOP and/or BOP information related to calories or nutrients, consumption guidelines, and a recommended serving size. To deal with the variability in the choice of nutritional labelling used on food items (from no or limited information to extensive information), we assume that the type of nutritional label is a function of various product variables such as nutrient content, type of

brand, product category and extra information provided on the package. To exploit the ranked and multinomial features of the dependent variable, we use an ordered logit model.

In the following, we present two empirical procedures, the logit and ordered logit models described by Franses and Paap (2007). Then, we describe the data used in the paper.

Methodology

We start by the binary logit model supposing that an observed variable Y_i can take a value of only 0 or 1. For example, Y_i is 1 if a nutrition or health claim is used on a product's package and 0 otherwise. It can be written as

$$Y_i = \begin{cases} 1 \text{ if } y_i^* > 0 \\ 0 \text{ if } y_i^* \leq 0 \end{cases} \quad (1)$$

where

$$y_i^* = X_i\beta + \varepsilon_i \quad (2)$$

for *i*= 1, 2…, *N*. y_i^* is an unobserved variable called latent variable, X_i is a row vector of explanatory variables (e.g., nutrient content, type of brand…), β is a column vector of unknown parameters and ε_i is an error term. A model that correlates a binomial dependent variable with explanatory variables can be constructed as

$$\Pr[Y_i = 1/X_i] = \Pr\left[y_i^* > 0/X_i\right] = \Pr[\varepsilon_i \leq X_i\beta/X_i] = F(X_i\beta)$$

Assuming the cumulative distribution function *F* is logistic, the empirical specification is defined as

$$\Pr[Y_i = 1/X_i] = \frac{e^{X_i\beta}}{1 + e^{X_i\beta}}$$

The binary logit model is estimated by the Maximum Likelihood method using the logit command of the Stata software. To interpret the effects of the explanatory variables, it is usual to consider the odds ratio defined as

$$\frac{\Pr[Y_i = 1/X_i]}{\Pr[Y_i = 0/X_i]}$$

To explain the firm's choice of the type of nutritional label between no labelling and labels with extensive information, we estimated an ordered logit model also known as the proportional odds model. This model is a generalisation of the binary logit model that allows more than two outcomes, which can be ranked. In this case, (1) can be modified to be

$$Y_i = \begin{cases} 1 \text{ if } \alpha_0 < y_i^* \leq \alpha_1 \\ j \text{ if } \alpha_{j-1} < y_i^* \leq \alpha_j \text{ for } j = 2, \dots, J-1 \\ J \text{ if } \alpha_{J-1} < y_i^* \leq \alpha_J \end{cases}$$

where α_0 to α_J are unobserved thresholds and y_i^* is a latent variable defined as in (2). In this study, Y_i is 1 if no labeling or low information label is used on a product package and *J* if the highest information label is used. Because the boundary values of the latent variable are unknown, one can simply set $\alpha_0 = -\infty$ and $\alpha_J = +\infty$. The model is constructed as

$$\Pr[Y_i = j/X_i] = \Pr\left[\alpha_{j-1} < X_i\beta + \varepsilon_i \leq \alpha_j\right]$$

$$\Pr[Y_i = j/X_i] = F\left(\alpha_j - X_i\beta\right) - F\left(\alpha_{j-1} - X_i\beta\right)$$

where

$$F\left(\alpha_j - X_i\beta\right) = \frac{e^{\alpha_j - X_i\beta}}{1 + e^{\alpha_j - X_i\beta}}$$

The ordered logit model is estimated by the Maximum Likelihood method using the ologit command of the Stata software. Similarly to the binary logit model, it is usual to consider the odds ratio to interpret the effects of the explanatory variables, defined as

$$\frac{\Pr[Y_i \leq j/X_i]}{\Pr[Y_i > j/X_i]}$$

where

$$\Pr[Y_i \leq j/X_i] = \sum_{m=1}^{j} \Pr[Y_i = m/X_i]$$

The odds ratio for each explanatory variable is equal to $e^{\alpha_j - X_i\beta}$ and they are defined by the Stata software as e^{β}.

Data

The data used in this study are drawn from the Observatory of Food Quality (Oqali) database. The Oqali was created in 2008 by the French Ministries in charge of Food and Agriculture, Health, and Consumption. The goal was to set up an independent system of observation to assess the nutritional composition of food items marketed by all of the brands existing in the French market. As of 2011, the Oqali database contains about 20,000 items, covering the majority of processed food sectors and representing around 60% of the consumption of these types of food in France. Each product is described by several parameters including nutrient content (energy (calories), protein, total fat, saturated fat, total carbohydrates, sugars, dietary fiber and sodium), nutrition labelling, ingredient list, nutrition and health claims, recommended serving size, nutrition and consumption guidelines used on the package and the type of brand. The market share and the mean price of each food item are assessed by matching the Oqali database with data provided by the TNS Kantar panel, which records food purchases made by representative households in France during the year in progress.

In this study, we focus on the biscuits and cakes sector in 2008. This sector is important from a public health point of view because these products' contribution to carbohydrate intake ranges from 2.9% in adults to 4.5% in children, and they provide 2.1% of the daily fat intake for adults and 4.7% for children. It is important to note that biscuits and cakes are mostly consumed for hedonic reasons. For consumers, this can be an apparent contradiction with the nutritional aspect of the products.

A sample of 806 biscuit and cake items is used to estimate the binary logit model to explain the choice to market a food product with a nutritional or health claim (model 1). After deleting observations with claims, we consider a sample of 642 observations related to the ordered logit model used to estimate the voluntary choice of a nutritional label without health or nutritional claims (model 2).

The endogenous variable introduced in model 1 is an indicator of the use of a health or nutritional claim on the food package; it is coded as 1 if at least one nutritional or

health claim is used on the package and 0 if not. Several categories of explanatory variables are selected to explain this endogenous variable. The first is the nutritional quality of the food product, which is captured by 5 continuous variables that measure the food's nutrient content in terms of energy (calories), sugars, saturated fat, dietary fiber and sodium. Except in the case of calories, which are expressed in kcal/100 g, the other nutrients are expressed in g/100 g of food. Three dummy variables are used to categorise the product's brand as a national brand, a private label or a hard-discount brand. Additional variables are introduced to describe extra information used on the package and its location on the package (see the appendix 1 for illustrations of the various components of nutritional information on packaging). We consider 2 types of extra labels: daily amount guideline (GDA) and traffic lights (TL); we also consider information in two locations on the package: on the front of the package (FOP) and on its side and/or back (BOP) only. Three combinations are found in the data used: GDA on FOP; GDA only on BOP; TL only on BOP; and no GDA or TL, resulting in four dummy variables. Two dummy variables are used to describe available nutritional information concerning recommended serving size or consumption advice (for example, "serve yoghurt and fresh fruit with 3 cookies"). A dummy variable indicates the use of an organic or fair trade label. Finally, 7 dummy product category variables indicate if the product is plain, fruit or chocolate biscuits; plain, fruit or chocolate cakes; or another category.

The endogenous variable introduced in model 2 is an ordered indicator of the type of nutritional label used on packages without nutrition or health claims (see the appendix 1). More precisely, we define a gradient of information from low to high informational content as follows:

- "Gradient 1" : no labelling or groups 1 and 1+ as described above,
- "Gradient 2" corresponds to group 2 and group 2+,
- "Gradient 3" combines the information in gradient 2 with extra labels (GDA or TL) located only on the side and/or back of the package,
- "Gradient 4" combines the information in gradient 2 with extra labels (GDA or TL) located on the FOP.

Except the extra labels (GDA or TL) which are included in the definition of the dependant variable, the same set of explanatory variables used in model 1 is introduced in model 2. Moreover, to refine the explanation of the type of brand, the 3 dummy variables are broken down into 9 dummies: 3 types of national brands, 5 types of private labels and 1 grouping all hard-discount brands. Definitions and samples statistics of all variables are presented in Table 1.

Table 1. Variable definitions and sample means

Variable*	Binary logit model 806 obs.		Ordered logit model 642 obs.	
	Mean	**SD**	**Mean**	**SD**
Nutrition or health claims	0,213	0,410		
Gradient 1 to 4			2,412	1,136
Nutrient content				
Energy (kcal/100g)	454,689	52,658	461,011	52,837
Sugars (g/100g)	32,869	9,022	33,730	8,484
Saturated fat (g/100g)	9,695	5,452	10,578	5,579
Dietary fiber (g/100g)	3,039	1,854	2,549	1,356
Sodium (g/100g)	0,252	0,140	0,252	0,144
Type of brand				
National brands	0,294	0,456	0,251	0,434
. National brand 1			0,158	0,365
. National brand 2			0,022	0,146
. Other national brands			0,077	0,267
Private labels	0,520	0,500	0,573	0,495
. Private label 1			0,147	0,354
. Private label 2			0,119	0,324
. Private label 3			0,090	0,286
. Private label 4			0,070	0,255
. Other private label brands			0,147	0,354
Hard-discount brands	0,186	0,389	0,176	0,382
Additional information				
GDA FOP	0,218	0,413		
GDA BOP	0,103	0,304		
TL BOP	0,094	0,292		
No GDA or TL	0,584	0,493		
Consumption advice				
Recommended serving size	0,769	0,422	0,732	0,443
Recommended accompaniment	0,194	0,395	0,167	0,373
Organic or fair trade label	0,055	0,227	0,051	0,220
Category of products				
Plain biscuits	0,125	0,331	0,147	0,354
Fruit biscuits	0,134	0,341	0,101	0,301
Chocolate biscuits	0,412	0,492	0,407	0,492
Plain cakes	0,038	0,192	0,050	0,217
Fruit cakes	0,041	0,198	0,045	0,207
Chocolate cakes	0,105	0,307	0,125	0,331
Other category	0,144	0,351	0,125	0,331

* All dummy variables are coded 0-1 where 1 indicates a positive outcome. For example, Nutrition or health claims=1 if at least 1 claim is used on the food package.

3. Results

a. Labelling and nutrition claims

As mentioned above, nutritional labelling is mandatory when a nutrition or health claim is placed on a package. For this reason, it is interesting to identify the main differences between products with and without claims. Note that in the biscuits and cakes sector, nutrition and health claims are reported for about 21% of the products.

Table 2 presents the results of the binary logit model used to compare products with and without claims. In this table, an odds ratio greater (less) than 1 means that an increase in the continuous explanatory variable increases (decreases) the probability of a nutritional or health claim. Similarly, an odds ratio greater (less) than 1 means that the positive outcome of a dummy explanatory variable increases (decreases) the probability of a claim.

We test several set of explanatory variables. In column 1, we take into account the nutrient content, the type of brand and the products categories. In column 2, we add the nutritional information (GDA or TL on the FOP and the BOP). In column 3, we add the consumption advice and the organic or fair trade labels.

If we consider the nutrients listed on the labels, it appears that the products with nutritional claims are of better nutritional quality: the odds ratios are smaller than 1 for sugars and saturated fat and greater than 1 for the dietary fiber. It means that a lower level of saturated fat and carbohydrates and a higher level of dietary fiber increase the probability of a claim. This quality effect is interesting because the main nutritional claims used in the biscuits sector are not necessarily related to these nutrients. Indeed, more than half of the claims used in this sector are related to vitamins and minerals. The strongest effect is observed for dietary fiber content, which seems to play a major role in this sector. We will comment on this point later.

We also note that the product's category does not play an important role in whether its package contains a claim, and in general, the presence of a claim is not dependent on the product’s category within the biscuits sector. An exception is for the fruit biscuits.

Table 2. Maximum-Likelihood estimates of the binary logit model on the choice of marketing a food product with nutrition or health claims (model 1)

Nutrition or health claims	Odds ratio (1)	Odds ratio (2)	Odds ratio (3)
Nutrient content			
Energy (kcal/100g)	1,005	1,004	1,003
Sugars (g/100g)	0,933 ***	0,933 ***	0,939 ***
Saturated fat (g/100g)	0,713 ***	0,719 ***	0,731 ***
Dietary fiber (g/100g)	1,704 ***	1,723 ***	1,698 ***
Sodium (g/100g)	0,583	0,534	1,441
Type of brand			
National brands	2,634 ***	2,222 **	0,896
Private labels	0,565 **	0,663	0,303 ***
Hard-discount brands	*omitted*	*omitted*	*omitted*
Additional information			
GDA FOP		0,706	0,499 *
GDA BOP		0,413 *	0,294 **
TL BOP		0,356 *	0,192 ***
No GDA or TL		*omitted*	*omitted*
Consumption advice			
Recommended serving size			5,799 ***
Recommended accompaniment			2,280 **
Organic or fair trade label			3,108 **
Category of products			
Plain biscuits	2,237	2,614	1,602
Fruit biscuits	14,750 *	16,045 *	11,059 *
Chocolate biscuits	6,562	6,621	4,894
Plain cakes	*omitted*	*omitted*	*omitted*
Fruit cakes	1,867	1,973	1,245
Chocolate cakes	0,850	0,925	0,637
Other category	10,393	10,689	6,970
Pseudo R^2	0,417	0,424	0,460
Log pseudo likelihood	-243,84	-240,52	-225,54
% of correctly predicted	87,5	87,3	88,0

Note: Asterisks indicate levels of significance:***= 1%; **= 5%; *= 10%.

More interestingly, the probability of the presence of a nutritional claim is influenced by the type of brand: positively for national brands in columns 1 and 2 and negatively for private labels in columns 1 and 3. The development of nutritional claims is therefore due more to the strategies of the food processors than those of the retailers.

We only consider the non-mandatory nutritional information available on packages. It appears that the presence of additional information like GDA or TL on the FOP, as well as on the BOP, decreases the probability of the presence of a claim. Conversely, other information increases the probability of a claim: recommended accompaniments and serving sizes are likely to be associated with claims. Similarly, the presence of an organic or fair trade label is positively associated with the presence of a claim.

b. Labelling of products without nutritional claims

In the absence of a nutritional claim, product labelling is voluntary. The decision to label the product or not and the choice of the label format are interesting factors to analyse for the products without nutritional claims. Table 3 presents the results of the ordered logit used to assess the effects of a set of explanatory variables on the probability of having a label from one of the four labelling categories that we defined in the previous section. In Table 3, an odds ratio smaller than 1 means that a larger value of the explanatory variable is more likely to be observed in the first type of labelling (gradient 1: no label or group 1 label) and least likely to be observed in the last type of labelling (gradient 4: group 2 label + FOP logos); an odds ratio greater than 1 means that a greater value of the variable is more likely to be observed in the last type of labelling and least likely to be observed in the first type of labelling.

We test several set of explanatory variables. In column 1, we take into account the nutrient content, the aggregated brands and the products categories. In column 2, we take into account the brands in a desegregated form (individual brands). In column 3, we add the consumption advice and the organic or fair trade labels.

Table 3. Maximum-Likelihood estimates of the ordered logit model on the choice of the nutritional labelling from no or low information to high information (model 2)

Gradient 1 to 4	**Odds ratio** (1)	**Odds ratio** (2)	**Odds ratio** (3)
Nutrient content			
Energy (kcal/100g)	0,999	0,997	0,996
Sugars (g/100g)	1,003	1,001	1,001
Saturated fat (g/100g)	1,036	1,044 **	1,054 **
Dietary fiber (g/100g)	1,149 **	1,172 ***	1,161 **
Sodium (g/100g)	1,969	1,560	2,367
Type of brand			
National brands	0,457 ***		
. National brand 1		0,297 ***	0,076 ***
. National brand 2		0,225 ***	0,118 ***
. Other national brands		1,440	1,539
Private labels	3,907 ***		
. Private label 1		4,891 ***	1,629
. Private label 2		2,433 ***	1,432
. Private label 3		4,820 ***	2,115 ***
. Private label 4		26,303 ***	12,024 ***
. Other private label brands		4,310 ***	2,077 **
Hard-discount brands	*omitted*	*omitted*	*omitted*
Consumption advice			
Recommended serving size			7,667 ***
Recommended accompaniment			1,788 **
Organic or fair trade label			0,779
Category of products			
Plain biscuits	0,517	0,631	0,630
Fruit biscuits	0,575	0,672	0,723
Chocolate biscuits	0,605	0,668	0,618
Plain cakes	*omitted*	*omitted*	*omitted*
Fruit cakes	0,618	0,731	0,724
Chocolate cakes	0,697	0,891	0,711
Other category	1,195	0,972	0,966
Pseudo R^2	0,094	0,126	0,189
Log pseudo likelihood	-808,69	-780,13	-724,36
% of correctly predicted	41,3	50,0	50,0

Note: Asterisks indicate levels of significance:***= 1%; **= 5%; *= 10%.

It appears that a better nutritional quality does not increase the probability of the presence of a gradient 4 type of label. The values of the odds ratios for energy, sugars and sodium are not significant. However, an increase in the content of saturated fat increases the probability that the product's label will provide more detailed nutritional information. A larger amount of dietary fiber increases also the probability that the product's label will provide more detailed nutritional information.

The product category does not influence the choice of label type: regardless of the type of biscuits, the values are not significant. The decision to label the product and the choice of label format are not dependent on the type of products.

The package may provide additional information. We note that the presence of consumption recommendations (accompaniment and serving sizes) increases the probability of more detailed nutritional facts. Conversely, the presence of other labels (e.g., organic, fair trade) is not related to the presence of detailed nutritional labels.

As previously, the main effect is obtained for the type of brand. With the aggregated brands the odds ratios are respectively smaller and greater than 1 for the national brands and the private labels. With disaggregated brands, the same effect is shown even if some heterogeneity appears in column 3 among the private labels.

c. Relationships between labelling, quality, and price

As mentioned in the introduction, it is important to determine whether products with more detailed nutritional labelling are more expensive. Any observed price difference could be due to the following:

- higher labelling costs;
- higher production costs if the products with more detailed nutritional labelling are of better nutritional quality;
- consumer discrimination strategies used by firms if the more extensively labelled products are more expensive than the standard products but do not differ in nutritional quality.

We did not introduce the price variable as an exogenous variable in the binary and the ordered logit models because of the risks of simultaneity bias. To address this difficulty, it would be necessary to estimate a simultaneous equation model with a binary or ordinal nutritional labelling variable and a continuous price variable. It was not possible to develop this model in this paper. It will be the goal of further research. However we identified a clear "brand effect" as the type of brand clearly influences the choice of the type of label. First, we noted that if the product is marketed through a national brand, the probability of observing a nutritional claim is greater, but the probability of observing extensive information on the packages (gradients 3 or 4) is lower. We noted also that if the product is marketed through a private label, the probability of observing a nutritional claim is lower, but the probability of observing detailed and FOP nutritional label is greater. As the national brands have on average higher prices than the private labels, it is important to better identify the price impact of these strategies.

To obtain further insight into the relationships between labelling, quality, and price, we performed a hedonic price regression on two samples: one considering all of the products in the biscuits sector, and a second one with only the products without claims. The descriptive statistics and the results are given in appendix 2. The main results are the following.

Nutrients have a positive effect on price, but in an unexpected way from a public health perspective: more energy, more fat, and more carbohydrates are associated with higher price. This finding could be due to higher production costs (Do more sugar or more fat in the biscuit increase the production costs?) or to the consumers' WTP (Do they prefer fatty or sweet products?). Conversely, an increase in dietary fiber (which is in line with health recommendations) has a positive effect on price, but only when a claim is present.

Finally, it is important to note that the type of label used does not influence the price of products either with or without claims. On the opposite, the presence of a claim has a positive effect on price, as does the presence of an organic or a fair trade label.

d. Signalling and information disclosure

Our goal was to assess, for the biscuits sector in France, the market's effectiveness at providing information to consumers on the nutritional quality of processed foods.

We quantified the nutritional quality of food products by measuring their nutritional characteristics. We estimated the effect of these nutritional characteristics on the probability of voluntary disclosure by considering several types of labels, from no or very simple labels to detailed nutrition fact panels including additional information on the FOP.

The current European situation is complex because nutritional labelling is either mandatory or voluntary depending on the presence or absence of nutritional claims. Across all products, it appears that those with claims have the required nutrition fact panels and are of better nutritional composition than other products. However, generally speaking, neither GDA nor TL logos are used, even on the FOP. Thus, nutritional claims seem to be the main method of informing the consumer about the product's quality.

If we now consider food items without claims, it appears that voluntary signalling does not work perfectly. If the data supported effective quality signalling, the estimated odds ratios of undesirable nutrients would be lower than 1 showing that the higher their levels in a food, the lower the probability of a detailed nutrition information label being present. The estimated odds ratios of desirable nutrients such as fiber would be positive because it would be in the manufacturer's interest to disclose information about the high nutritional quality of their brands. In fact, we show that the voluntary disclosure of nutritional content by food companies does not result in reliable and consistent quality signals to consumers. Indeed, if we look at calories, sodium, sugars and fat, lower nutrient contents do not increase the probability to observe more nutritional information on the package. Moreover the content in saturated fat seems to be higher where more detailed nutritional information is provided on the package. An exception is dietary fiber content, which increases with more detailed nutritional information. Despite this exception, it is likely that consumers cannot infer from the absence or the presence of more nutritional information on the package the quality of the products available on the market.

e. Labelling and firms' strategies

What is the role of nutritional labelling in stakeholders' strategies (see Figure 1)?

On the one hand, processors respond to nutritional issues mainly through product innovation and by marketing products using nutritional claims. Because these products incur additional R&D and processing costs and because the targeted consumers may have a higher WTP for claims, these products are marketed with higher prices. Processing firms clearly use nutritional claims for vertical differentiation strategies within the biscuit sector. More detailed labelling than the level required by the nutritional claim regulations seems not to be an important issue for national brands. One can assume that consumers' WTP is more likely determined by the presence of a claim combined with certain other labels (organic or others) rather than by GDA or TL logos, even on the FOP. Consumption and accompaniment recommendations on the package may reinforce the WTP of targeted consumers, but it seems that the FOP information conveyed through GDA or TL logos does not play a role, at least for these brands, in the vertical differentiation of these products.

On the other hand, retailers respond with more detailed labelling through GDA and TL logos on the FOP, which do not impact price and are not clearly related to the nutritional quality of the food. One can assume that consumers' WTP for food items with more detailed nutritional labelling on the package is weak when these labels are not associated with claims.

Why then do retailers implement such nutritional labelling strategies? Two answers may be relevant:

- First, under pressure from public regulators and consumer associations, retailers may implement these strategies to demonstrate their corporate social responsibility.

- Second, one may assume that these strategies are used to compete with national brands using nutritional claims. Providing abundant nutritional information on the package and setting prices lower than those of products that make nutrition claims may limit consumers' tendency to switch to products with nutritional claims. In that sense, these labelling strategies might allow private labels to compete with national brands.

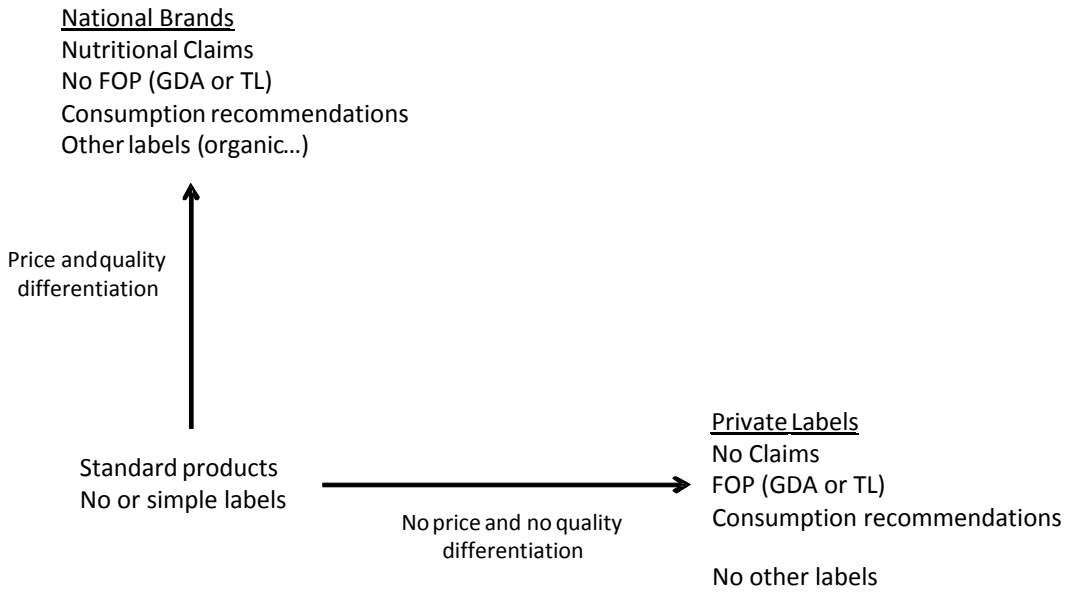

Figure 1. Nutritional strategies of national brands and private labels

4. Conclusion

Given the current public regulations and the extent of labelling in France, we analysed determinants of adopting a detailed nutritional information label and its relation to quality and price. It appears that consumers can only distinguish lower and higher quality products through nutritional claims, but they cannot infer the product quality from the presence or absence of extensive information on the package: detailed nutrition fact panels, GDAs or TL logos on the FOP do not signal higher quality products.

Unlike Van Camp et al.'s (2010) study in the UK, we considered it was necessary to distinguish products with nutrition and health claims (for which labelling is mandatory) from other products (for which labelling is still voluntary). In doing so, we confirm that the labelling decision is clearly related to brand strategies, but in a different way for national brands than for private labels.

It has been shown that national brands are involved in the development of nutrition and health claims, but they do not frequently use detailed nutritional information, like GDAs or TLs on the BOP or the FOP. These claims are tools for implementing vertical differentiation strategies, which are sometimes complemented by the use of other quality signals such as organic and fair trade labels. In contrast, for private labels, detailed GDAs and additional FOP information seem to be widely used either for corporate social responsibility reasons or to compete with national brands. These labelling strategies have no impact on either price or nutritional quality, but they may limit the market share extension of products with nutritional claims.

Our study clearly has some limitations. We studied only one food sector, and it will be necessary to examine other sectors in order to confirm our conclusions. To go further in the analysis, it will be interesting to develop a simultaneous equation model of the relationship between labelling and price.

It will also be important to study the impacts of the strategies we identified on consumers' purchase decisions. Such a study is possible because our database on food characteristics (nutrients and label descriptions) is matched with a consumption database that lists prices, market shares and households' socio-demographic characteristics.

Our analysis suggests that it is important to consider the role of labelling in competition within the food sector. At equilibrium, the use of nutritional labelling and its impacts on consumption and health depend not only on consumers' reactions to the information provided on the package but also on the way firms use nutritional labelling in the competition between brands. Is the situation analysed here a market equilibrium? In other words, given the additional costs of producing higher nutritional quality and given consumers' WTP for better nutritional quality on the one hand and additional information on the other hand, is the adoption of nutritional labels by firms and the market shares of the various types of products (e.g., with and without claims, with and without a detailed FOP GDA) stable? Will new type of firms adapt their nutritional information strategies? How would mandatory nutritional labelling modify this equilibrium and what would the consequences be for price, quality and consumption? These questions will be important to address in further research.

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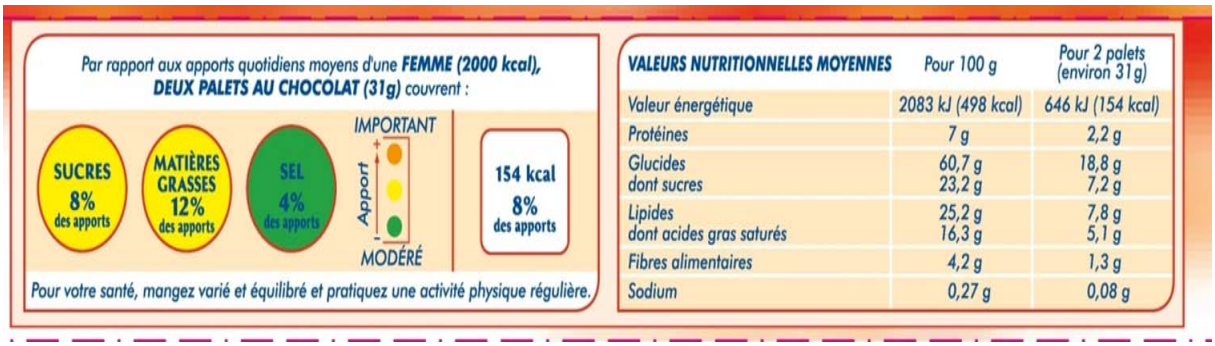
Appendix 1

Gradient 1

Gradient 2

TL on BOP



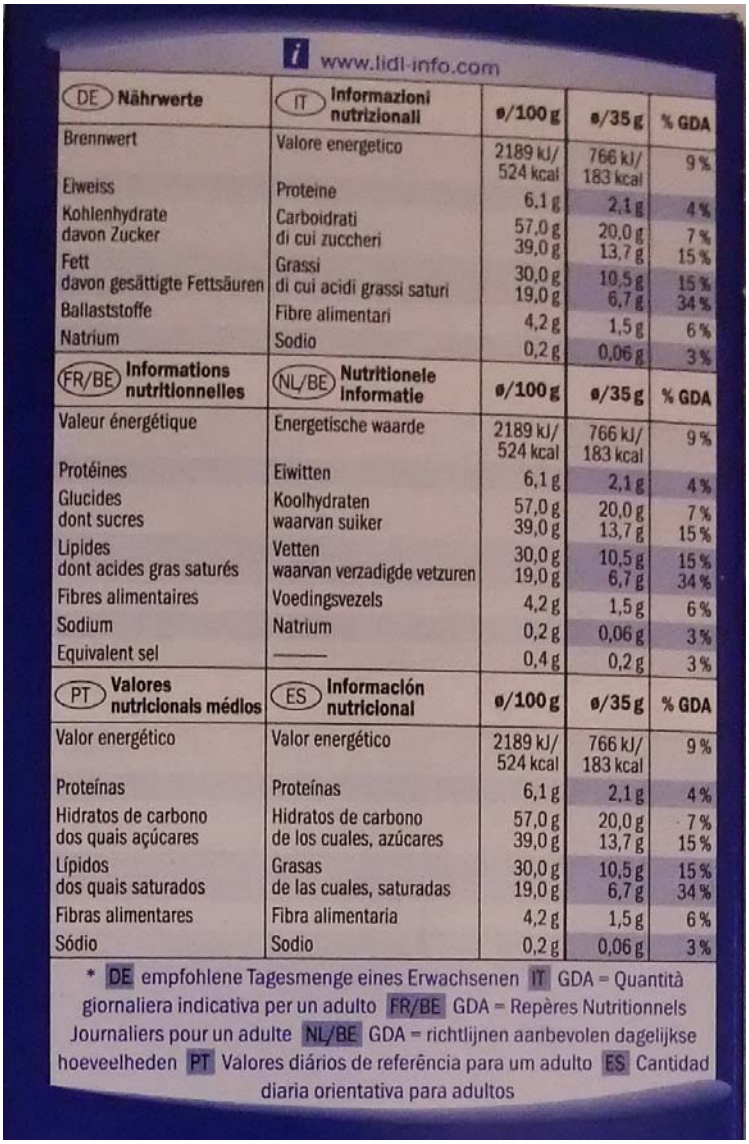
Gradient 3 (with TL on BOP)

Nutritional Claim

GDA on BOP

Nutrition fact panel

Gradient 3 (with GDA on BOP)



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DE Nährwerte	IT Informazioni nutrizionali	ø/100 g	ø/35 g	% GDA
Brennwert	Valore energetico	2189 kJ/ 524 kcal	766 kJ/ 183 kcal	9 %
Eiweiss	Proteine	6,1 g	2,1 g	4 %
Kohlenhydrate	Carboidrati	57,0 g	20,0 g	7 %
davon Zucker	di cui zuccheri	39,0 g	13,7 g	15 %
Fett	Grassi	30,0 g	10,5 g	15 %
davon gesättigte Fettsäuren	di cui acidi grassi saturi	19,0 g	6,7 g	34 %
Ballaststoffe	Fibre alimentari	4,2 g	1,5 g	6 %
Natrium	Sodio	0,2 g	0,06 g	3 %
FR/BE Informations nutritionnelles	**NL/BE Nutritionele informatie**	**ø/100 g**	**ø/35 g**	**% GDA**
Valeur énergétique	Energetische waarde	2189 kJ/ 524 kcal	766 kJ/ 183 kcal	9 %
Protéines	Eiwitten	6,1 g	2,1 g	4 %
Glucides	Koolhydraten	57,0 g	20,0 g	7 %
dont sucres	waarvan suiker	39,0 g	13,7 g	15 %
Lipides	Vetten	30,0 g	10,5 g	15 %
dont acides gras saturés	waarvan verzadigde vetzuren	19,0 g	6,7 g	34 %
Fibres alimentaires	Voedingsvezels	4,2 g	1,5 g	6 %
Sodium	Natrium	0,2 g	0,06 g	3 %
Equivalent sel	——	0,4 g	0,2 g	3 %
PT Valores nutricionais médios	**ES Información nutricional**	**ø/100 g**	**ø/35 g**	**% GDA**
Valor energético	Valor energético	2189 kJ/ 524 kcal	766 kJ/ 183 kcal	9 %
Proteínas	Proteínas	6,1 g	2,1 g	4 %
Hidratos de carbono	Hidratos de carbono	57,0 g	20,0 g	7 %
dos quais açúcares	de los cuales, azúcares	39,0 g	13,7 g	15 %
Lípidos	Grasas	30,0 g	10,5 g	15 %
dos quais saturados	de las cuales, saturadas	19,0 g	6,7 g	34 %
Fibras alimentares	Fibra alimentaria	4,2 g	1,5 g	6 %
Sódio	Sodio	0,2 g	0,06 g	3 %

* DE empfohlene Tagesmenge eines Erwachsenen IT GDA = Quantità giornaliera indicativa per un adulto FR/BE GDA = Repères Nutritionnels Journaliers pour un adulte NL/BE GDA = richtlijnen aanbevolen dagelijkse hoeveelheden PT Valores diários de referência para um adulto ES Cantidad diaria orientativa para adultos

Gradient 4 (with GDA on FOP)

Appendix 2

The hedonic price method is a useful approach to studying the price-quality relationship for a product. The method amounts to a (possibly nonlinear) regression analysis of price on the characteristics of the product. The implicit price of a characteristic is defined as the derivative of the price with respect to the product's attributes. Rosen (1974) has shown under which market conditions that the implicit price can be interpreted as the value consumers place on an additional unit of the characteristic. If the estimated implicit price turns out not to be significantly different from zero, then the characteristic is not valued by consumers, or the characteristic is not considered important or relevant in connection with the product. The limits of this method are, however, well known. We use it here for a first approach to understanding the relationship between labeling, quality, and price.

Descriptive statistics and OLS estimates of the hedonic price function

	Descriptive statistics				Estimation results	
	All Sample		Sample without claims		All Sample	Sample without claims
	685 obs.		553 obs.			
	Mean	SD	Mean	SD	Coeff.	Coeff.
Price (€/kg)	6,658	3,579	6,362	3,452		
Nutrient content						
Energy (kcal/100g)	454,864	53,041	460,432	52,948	0,020 ***	0,023 ***
Sugars (g/100g)	32,892	8,922	33,663	8,422	0,108 ***	0,087 ***
Saturated fat (g/100g)	9,689	5,461	10,502	5,547	0,093 ***	0,064 **
Dietary fiber (g/100g)	2,972	1,749	2,530	1,312	0,263 ***	0,076
Sodium (g/100g)	0,252	0,142	0,252	0,144	1,020	-0,242
Nutritional labelling						
Gradient 1	0,266	0,442	0,302	0,460	*omitted*	*omitted*
Gradient 2	0,309	0,463	0,250	0,433	0,379	0,420
Gradient 3	0,213	0,410	0,224	0,417	-0,088	0,301
Gradient 4	0,212	0,409	0,224	0,417	-0,460	-0,115
Nutrition or health claims	0,193	0,395			0,902 **	
Type of brand						
National brands	0,312	0,464	0,266	0,442	3,743 ***	4,222 ***
Private labels	0,534	0,499	0,584	0,493	0,210	0,026
Hard-discount brands	0,153	0,361	0,150	0,357	*omitted*	*omitted*
Consumption information						
Recommended serving size	0,772	0,420	0,732	0,443	0,642 **	0,472
Recommended accomp.	0,196	0,397	0,163	0,369	-0,094	0,836 ***
Organic or fair trade label	0,053	0,223	0,047	0,212	3,660 ***	3,917 ***
Category of products						
Plain biscuits	0,140	0,347	0,157	0,364	-0,673	-0,696
Fruit biscuits	0,131	0,338	0,101	0,302	-1,653 ***	-1,268 **
Chocolate biscuits	0,394	0,489	0,394	0,489	1,771 ***	1,125 **
Plain cakes	0,041	0,198	0,051	0,219	*omitted*	*omitted*
Fruit cakes	0,045	0,208	0,047	0,212	2,364 ***	1,757 ***
Chocolate cakes	0,105	0,307	0,125	0,331	0,929 *	0,530
Other category	0,143	0,350	0,125	0,331	0,043	0,387
Intercept					-9,919 ***	-9,671 ***
R^2					0,465	0,498

Note: Asterisks indicate levels of significance:***= 1%; **= 5%; *= 10%.