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Simulating welfare effects of the European nutrition and health claims' regulation: the Italian yogurt market

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Abstract

With the enactment of Regulation (EC) No. 1924/2006, 20 December 2006, '*On nutrition and health claims made on foods*' several health claims can no longer be used on food products in European markets. We simulate the overall impact of the regulation on consumers and producers using the Italian yogurt market as a case study, and data prior to the introduction of the policy. We quantify welfare losses incurred if accepted claims were false, and simulate scenarios where rejected truthful health claims are removed, considering also the case where the products carrying them exit the market. We find that consumers can incur large welfare losses if approved claims are untruthful; if truthful claims are instead denied both consumers and producers may incur losses, with consumers being penalised more than producers.

Keywords: health claims regulation, EFSA, welfare, nested-logit, counterfactual simulations

JEL classification: Q18, L66, M38

1. Introduction

Policymakers' attention to the relationship between health and food, as well as changes in consumers tastes, have led to an improvement of food products' nutritional profiles (Heasman and Mellentin, 2001; Nestle, 2002), and to food manufacturers' fortifying, enriching and adding *functional* (i.e. delivering benefits beyond nutrition)[1] features to their products. Latherhead Food Research estimates a value for the functional foods market exceeding USD

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1 Several definitions of functional foods exist. See Diplock *et al.* (1999) for an overview.

25 billion in 2011; 28.8 per cent of which are attributable to European markets (Sepessey, 2012).

Manufacturers use health claims to signal higher product quality,[2] relying on consumers' higher willingness to pay for food with health-enhancing features (e.g. West *et al.*, 2002; Markosyan, McCluskey and Wahl, 2009) to recover the costs of developing these products.[3] However, as functionality is a credence attribute (Grunert, 2005), information asymmetry between producers and consumers may lead to consumers' distrust of these products' beneficial properties (e.g. Verbeke, 2005a, 2005b). In markets characterised by information asymmetry, manufacturers may have an incentive to claim higher quality levels, resulting in consumers' welfare losses. Third-party labelling and labelling regulation emerge as viable options to reduce asymmetric information and enhance consumer welfare (e.g. Caswell and Padberg, 1992; Caswell and Mojduszka, 1996; Teisl and Roe, 1998).

Regulation (EC) No. 1924/2006, of the European Parliament and of the Council of 20 December 2006 (henceforth Nutrition and Health Claims Regulation—NHCR), aims to '. . . ensure that any claim made on foods' labelling, presentation or marketing in the European Union is clear, accurate and based on evidence accepted by the whole scientific community' (EC, 2006). The NHCR requires manufacturers to submit dossiers substantiating their claims' truthfulness if they want to sell a product in Europe using health claims.[4] Dossiers are reviewed by the Dietetic Products, Nutrition and Allergies (NDA) panel of the European Food Safety Authority (EFSA) for approval. Rejected claims can no longer be displayed on the product or used in commercial communications, but claims rejected for 'insufficient evidence' are given the opportunity to be resubmitted.[5]

The NHCR is expected to enhance welfare if false claims are rejected. However, the EFSA's focus on minimising the risk of having Type-I errors, i.e. authorising false claims, is likely to result in a higher probability of having Type-II errors, i.e. rejection of truthful claims (Hartmann *et al.*, 2008). From a consolidated list of 4,637 'general function' claims, the 222 approved claims were published in Regulation 432/2012. Effective 14 December 2012, rejected claims could no longer be used on products' packaging or in

2 Manufacturers may also use other tools to signal quality to consumers, such as prices and/or advertising (Milgrom and Roberts 1986). See Kirmani and Rao (2000) for a review of the marketing tools used to signal quality.

3 According to Menrad (2003), Unilever spent more than USD 50 million to develop the functional yogurt Nestlé *LC1* and the proactive margarine Becel®, 25 times the cost of developing a conventional food product.

4 The types of claims manufacturers can submit are referred to using the article of Regulation (EC) No 1924/2006 where they are listed. Article 13.1 claims are 'general function' claims, regarding the growth, development and functions of the body; psychological and behavioral functions; or slimming or weight control functions; Article 13.5 claims are similar to those included in Article 13.1 but based on new or emerging science; Article 14 claims are reduction of disease risk claims. Products carrying comparative claims, also referred to as Article 9 claims, are not subject to the same types of approval of those mentioned above.

5 Although a comprehensive review of the NHCR's workings is outside the scope of this article, the interested reader can refer to van Loveren, San and Salminen (2012) for more details.

communication campaigns in Europe (EC, 2012). Opinion leaders and industry pundits fear that the regulation may turn the European food industry into an 'innovation wasteland' (Starling, 2009), jeopardising R&D and reducing consumers' welfare as well. The European Federation of Associations of Health Product Manufacturers (EHPM) has called for a reappraisal of the EFSA process, calling the legislation 'unduly restrictive' (Stodell, 2011).

Consumers' welfare losses as a result of restrictive labelling policies are also predicted by theory: Roe and Sheldon (2007) show that, for vertically differentiated goods, if the government has the exclusive authority to certify the 'quality' of credence goods, and standards are too strict, firms producing high-quality products may not gain positive profits; if unprofitable products are no longer offered, consumers' welfare may decrease. Also, some evidence exists that, in the context of health claim advertising regulation, reducing stringency may benefit consumers. Ippolito and Mathios (1990) show that, in the USA when the ban on health-claim advertising on cereals was lifted, manufacturers increased the development of fibre cereals, fibre consumption went up and the consumption of cereals with fibre grew across consumer types. Little effort has been made to assess the impact of the NHCR on consumers and manufacturers. Only a few studies investigate consumers' perception of nutritional claims in the context of the NHCR (e.g. Hartmann *et al.*, 2008; Stranieri, Baldi and Banterle, 2010), or analyse the policy's impact on the industry (e.g. Brookes (2010) survey of EU food supplement manufacturers).

This article explores the potential effect of the NHCR on manufacturers and consumers, using the Italian yogurt market as a case study. As a way to assess the maximum potential beneficial effect of the policy, we measure welfare losses that may occur if the products sold in the market carried false claims. We also simulate the policy impact if the claims denied were truthful (i.e. a Type-II error scenario). For the latter case we evaluate welfare changes due to product 'de-labelling' (i.e. health claims are removed but there is no change in product lines), or the de-labelled products' disappearing from the markets ('withdrawal' scenario). These simulations provide examples of losses due to excessive regulation, arising if the claims rejected were untruthful.

We use 3 years (January 2005–December 2007) of monthly sales data of yogurt for 45 products (12 functional and 33 conventional) sold in 13 Italian regions. Following other analyses of the Italian yogurt market (e.g. Di Giacomo, 2008; Bonanno, 2012), we model the demand for yogurt in Italy using a nested-logit discrete choice model (Berry, 1994). We adopt a Generalized Method of Moments (GMM) estimator to account for the endogeneity of prices and conditional shares. The estimated demand parameters are used in counterfactual simulations, under the assumption that yogurt manufacturers in Italy act as differentiated product oligopolistic firms, playing a Bertrand game in prices in the short-run and investing in communication of the health properties of their functional alternatives in the long-run. The Italian yogurt market represents a good case study, since leading yogurt manufacturers operating in Italy have heavily invested in developing and marketing functional products, and because their operations have been impacted by the NHCR, as most claims submitted were denied.

The results show that Italian consumers value functional attributes differently across vendors and types of claims. In addition, margins of functional alternatives are on average as high as or higher than those of conventional products. Our simulations indicate that, in the presence of false claims, consumers may experience considerable welfare losses, and since only parts of these losses are transferred to producers, deadweight losses occur. On the other hand, if truthful claims are denied, consumers are always worse off. The industry as a whole may not be affected if only specific claims are rejected, as profits will redistribute across manufacturers. If functional alternatives carrying truthful health claims disappear from the market, both consumers and producers appear to be worse off. Comparing the different sets of welfare measures, we find that, in presence of false claims, consumers' losses are larger than those experienced if true claims were denied, even though total welfare losses are larger in the latter case. Because consumers are affected more than manufacturers by the policy, they would benefit the most if the policy effectively reduced information asymmetry, but they might also lose the most if Type-II errors occur.

The remainder of the article presents an illustration of the Italian yogurt market, the theoretical and empirical frameworks used in the analysis, and a discussion of our counterfactual analyses. We continue by describing the data and the estimation method used, followed by a discussion of the econometrics and simulation results. After an illustration of the results' policy implications, we conclude with final remarks.

2. The Italian yogurt market

The Italian yogurt market can be characterised as an oligopoly where the largest seven manufacturers (Danone, Gruppo Granarolo, Latteria Vipiteno, Mila, Müller, Nestlé and Parmalat) controlled approximately three quarters of the entire market in 2007, whose estimated value was of EUR 1,365 million (Mark Up, 2008). Previously characterised as a mature market, the Italian yogurt market expanded in the last two decades particularly in response to the growth of the functional segment, which appears to have attracted new consumers without affecting negatively sales of conventional alternatives. Such expansion occurred thanks to some specific sub-categories that provide higher margins and more opportunities for product differentiation, such as functional drinkable yogurts (Bonanno, 2012; 2013), which captured about 60 per cent of the 'functional' sub-category in the period 2005–2007 (Bonanno, 2012).

Several types of functional alternatives were present in the Italian yogurt market during the period 2005–2007. The options available to consumers included products claiming to fight the development of pathogens in the intestine and to strengthen the immune system, thanks to specific strains of live bacteria (e.g. Nestlé's *LC1*); other products claimed to help the functioning of the intestinal tract due to the presence of beneficial bacteria (e.g. Danone's *Activia*), and to help reduce the absorption of cholesterol thanks to the presence of phytosterols (e.g. Granarolo's Yomo Abc *Equicol*), while others claimed to reduce the risk of cardiovascular problems (e.g. Parmalat's *Omega-3 Plus*) (see Bonanno, 2012 for more details). During the same period, more competitors entered the market, including private labels, which implemented *me too* strategies and competitive pricing (Mark Up, 2008) likely to maintain at bay the pricing power of the leading companies.

The NHCR has considerably impacted Italian, and more generally European, yogurt manufacturers. Rejection rates for claims based on probiotic[6] components approached 100 per cent due to insufficient evidence supporting a cause–effect relationship between the probiotic strain and the claimed health effect, or lack of characterisation (for more details, see Katan, 2012). Large companies have been impacted just as much as small ones: the case of Danone is exemplary. In April 2009, Danone withdrew two article 13.5 submissions: a digestive health claim for Activia and an immunity claim for Actimel, seeking further guidance from EFSA. Both claims were re-submitted (although that for Actimel as an article 14—disease reduction—claim) later the same year, receiving another rejection. The company implemented a 'Zero Claims' policy in some European markets, selling the two products without advertising their (alleged, according to the EFSA's panel) health properties (Starling, 2010).

3. A framework to measure the impact of the NHCR on the Italian yogurt market

This section presents a description of the demand and supply frameworks we adopt to analyse the Italian yogurt market, and the methodology used to simulate consumers' and manufacturers' welfare changes due to the NHCR. The Italian yogurt market is modelled by combining a discrete choice demand model with an oligopolistic supply side, following an approach used extensively in the industrial organisation literature (e.g. Berry, Levinsohn and Pakes, 1995; Nevo, 2001; Petrin, 2002; Cohen, 2008; Di Giacomo, 2008). The demand-side of the market is the result of the aggregation of consumers' discrete choices; a product's market share, representing the probability that a product will be chosen in the market, is embedded into a differentiated product oligopoly supply-side model, where firms follow a two-stage decision process, making communication/labelling decision first and then competing on prices, playing a Bertrand game. Once demand estimates and profits are obtained, we measure the amount of welfare losses consumers may incur if they overpaid for false functional attributes, and the resulting manufacturers' gains. Then, manipulating some of the products' attribute profiles, we simulate consumers' choices in the presence of different information regarding functional attributes, how these choices result in different market shares, and how firms' profits are impacted before and after prices are revised (de-labelling scenarios). Last, we repeat the same simulation (i.e. calculating new market shares and manufacturers' profits) for scenarios where some of the functional products exit the market (withdrawal

6 Roberfroid (2007) defines a probiotic as a viable microbial dietary supplement that beneficially affects the host through its effects in the intestinal tract.

scenarios). Consumers' and producers' welfare changes are obtained for all the scenarios.

3.1. A model of yogurt demand in Italy

To model demand for yogurt in Italy, we chose a discrete-choice nested-logit framework (Berry, 1994). The use of a discrete-choice demand model to analyse the yogurt market has numerous precedents in the literature: see, for example, Draganska and Jain (2005, 2006), Villas-Boas (2007), Di Giacomo (2008) and Bonanno (2012). The last two studies focus specifically on the Italian yogurt market. Since, according to AstraRicerche (2012), three-quarters of the Italian population consumes yogurt or fermented milk at least occasionally (once a month), with half of them consuming these products at least once a day, the inherent assumption of 'discrete' consumption of the product seems reasonable. Furthermore, as suggested by Huang, Rojas and Bass (2008), discrete-choice (logit) models can produce elasticity estimates closer to the 'true' values even when the underlying data-generating process is that of a continuous demand model, and it lends favourably to supply-side simulations (merger analysis, in their case).[7] Last, the nested-logit demand model is also consistent with the assumptions we use for modelling the supply side of the market (multi-product Bertrand competition). Anderson and de Palma (1992) show the existence of a symmetric Bertrand oligopoly equilibrium for multi-product firms where demand takes the nested-logit form.[8]

Consider t markets ($t = 1, \ldots, T$), defined as a specific geographic area and a specific time period, each with I rational consumers indexed with i ($i = 1, \ldots, I_t$). Consumer i chooses one unit of product among $J_t + 1$ yogurt alternatives, where $j = 0$ indicates the outside option of not purchasing yogurt.[9] Following Berry (1994), we assume that consumers perceive products sharing some attributes as closer substitutes, and that all possible alternatives are grouped into $G + 1$ mutually exclusive groups (G groups plus the outside option, making a group on its own). The conditional indirect utility that i receives from one unit of product j is:

$$V_{ij} = -\alpha p_j + X_j^{'}\beta + \xi_j + \zeta_{ig} + (1-\sigma)\nu_{ij}, \quad i = 1, \ldots, N, \; j = 1, \ldots, J, \tag{1}$$

where p_j is the per-unit price of j; X_j is a vector of product j's observable

7 We thank an anonymous reviewer for suggesting this reference.

8 However, in the conclusion of their paper, Anderson and de Palma (1992) discuss how it is relatively easy to introduce different marginal costs and perceived qualities into the model to allow for asymmetric equilibrium, which is the case in the current study. We thank an anonymous referee for bringing our attention to this detail.

9 As an anonymous reviewer pointed out, the assumption that a consumer chooses one unit of product from the available product space, necessary for discrete choice model (e.g. Berry, Levinsohn and Pakes, 1995; Nevo, 2001; Petrin, 2002; Cohen, 2008; Di Giacomo, 2008) may be restrictive. Other methods exist which relax this assumption; however, these methods require using much more detailed data than those at our disposal: see, for example, Dubé (2004) and Richards, Gómez and Pofahl (2012).

attributes (i.e. fat content, presence of a functional attribute etc.); ξ_j indicates product j's unobserved (by the researcher, but known to the consumers) characteristics; ζ_{ig} is a random term common to all the products in group g ($g = \{0,1, \ldots, G\}$) for individual i; the parameter σ ($0 < \sigma < 1$) measures the degree of substitutability of products in the same group. A value close to one indicates that alternatives within a group are perceived as closer substitutes than those across groups, and vice versa, while ν_{ij} is a random term. The distribution of ν_{ij} is an extreme value, while that of ζ_{ig} is the particular distribution (illustrated in Cardell, 1997) such that the entire term $\zeta_{ig} + (1 - \sigma)\nu_{ij}$ is a distributed extreme value.

Consumer i chooses j if it provides her with the highest level of utility among all the alternatives in the market. That is, product j is chosen over k if

$$V_{ij} > V_{ik} \quad \forall k \neq j. \tag{2}$$

Using these assumptions and following Berry (1994), let δ_j denote the portion of utility for good j common to all consumers, i.e. j's mean utility, which depends upon product attributes and the parameters α and β, so that $\delta_j = -\alpha p_j + X_j^{'}\beta + \xi_j$. Also let d_{jg} be an indicator variable equal to 1 if $j \in g$ and 0 otherwise, so that $\zeta_{ig} + (1 - \sigma)\nu_{ij} = \sum_g d_{jg}\zeta_{ig} + (1 - \sigma)\nu_{ij}$. Thus, one has

$$V_{ij} = \delta_j + \sum_g d_{jg}\zeta_{ig} + (1 - \sigma)\nu_{ij}. \tag{3}$$

Given equation (3), we follow Berry (1994) to define market share functions representing the probability that the set of consumer unobservables falls into a set of values leading to the consumption of j. The conditional share of product j in group g is $S_{j|g} = D_g^{-1} \exp(\delta_j/(1 - \sigma))$, where $D_g = \Sigma_{k \in g} \exp(\delta_k/(1 - \sigma))$. The share of all the products in group g is $S_g = D_g^{(1-\sigma)}/\Sigma_g D_g^{(1-\sigma)}$ so that the unconditional market share of product j is

$$S_j = \frac{\exp(\delta_j/(1 - \sigma))}{D_g^{\sigma} \sum_g D_g^{(1-\sigma)}}, \quad j = 0, \ldots, J. \tag{4}$$

Assume further that the mean utility of the outside option can be normalised to 0, so that $S_0 = 1/\Sigma_g D_g^{(1-\sigma)}$. Given that equation (4) is invertible, one can obtain an estimable demand equation combining equation (4) with those of S_0 and $S_{j|g}$:

$$\ln(S_j) - \ln(S_0) = -\alpha p_j + X_j^{'}\beta + \sigma \ln(S_{j|g}) + \xi_j, \tag{5}$$

whose left-hand side is the log-odds of choosing alternative j instead of the outside option. Equation (5) represents a discrete-choice nested-logit demand model that can be estimated using aggregate-level sales data. The assumptions leading to equation (5) allow a compromise between maintaining a somewhat flexible substitution pattern (the Independence of Irrelevant

Alternatives applies only to goods in the same group) while using traditional econometric methods to obtain parameters estimates.[10]

3.2. The supply side

Consistent with the features of the industry discussed above, the supply-side of the model treats Italian yogurt manufacturers as oligopolistic firms selling differentiated products (Di Giacomo, 2008; Bonanno, 2013) and follows a setup consistent with a two-stage decision process (following Sutton, 1998). There are N yogurt manufacturers; the n-th manufacturer produces J_n products, some functional (J_n^f), others conventional (J_n^c), whose number is given, i.e. there is an 'entry' stage from which we abstract for simplicity. Given their portfolio of products, manufacturers decide how much to invest in advertising/labelling to inform consumers about the quality of their products (communication/labelling stage) and then compete on price in the second stage (competition stage). We solve the competition stage first; manufacturer n solves

$$\max_{p_j} \ \pi_n = M \sum_{j \in J_n} S_j(p_j - c_j) - F_j \tag{6}$$

where M is the size of THE market, c_j is product j's (constant) short-run marginal cost and F_j is the long-run cost (including labelling and communication expenditures) assumed in this stage to be fixed. Following Nevo (2001), and consistent with other analyses of the Italian yogurt market (e.g. Di Giacomo, 2008; Bonanno, 2013), we assume prices to be the outcome of a multi-product Nash–Bertrand equilibrium. The problem in equation (6) leads to the vector of first-order conditions:

$$p - c = -\Omega^{-1} S(\cdot) \tag{7}$$

where $p - c$ is a $(J_n \times 1)$ vector of price cost margins (PCM), $S(\cdot)$ one of market shares, and each element of the matrix Ω is defined as $\Omega_{jk} = \Omega^*{}_{jk} \Delta_{jk}$ where, under multi-product Nash–Bertrand:

$$\Omega^*_{jk} = \begin{cases} 1 & \text{if } k, j \in J_n \\ 0 & \text{otherwise} \end{cases} \quad \text{and} \quad \Delta_{jk} = \frac{\partial S_j(\cdot)}{\partial p_k} \tag{8}$$

that is Ω^* represents the ownership matrix, designed by the researcher, while the elements of Δ are partial derivatives of the share equation with respect to each element of the vector of prices, obtained from the demand estimates.[11]

10 Otherwise, as Berry (1994), Berry, Levinsohn and Pakes (1995), and Nevo (2001) discuss, ε_{ij} can be a combination of random and deterministic components or $\varepsilon_{ij} = \sum_{j,l} \theta_{jl} z_{il} x_j + e_{ij}$, where z_{il} is consumer i's l-th characteristic, θs are parameters to be estimated, x_s are observable product characteristics and e_{ij} is an i.i.d. type-I extreme-value random term. The market share function for the random coefficients model is not invertible and, in spite of resulting in flexible substitution patterns, it requires complex estimation algorithms (i.e. Berry, Levinsohn and Pakes's (1995) nested-fixed point algorithm or Dubé, Fox and Su's (2012) mathematical programming with equilibrium constraint).

11 Although the assumption of the existence of a multi-product Nash-Bertrand equilibrium is rather standard in analyses of differentiated product markets with a large number of alternatives, other

In the first-stage of the game, manufacturers who use health claims invest in communicating the health properties of their products to consumers. An implicit assumption is that, if communication is possible, manufacturers will choose to inform consumers about the health properties of their products. For simplicity, we abstract from the possibility that manufacturers communicate quality through other means, including price or uninformative advertising (Milgrom and Roberts, 1986) or other marketing variables (Kirmani and Rao, 2000). Such strategies become suitable options for manufacturers if their claims are rejected, as we illustrate in the next section.

In the first stage of the game, manufacturers maximise profit by choosing the level of communication of health claims. Let h_j be a measure of a manufacturer's efforts to communicate the health properties of product j ($j \in J_n^f$) to consumers. Manufacturer n solves

$$\max_{h_j} \ \pi_n = M \sum_{j \in J_n} S_j(p_j - c_j) - F_j; \tag{9}$$

which, assuming that production costs are not impacted by labelling, leads to the following FOCs:

$$\frac{\partial \pi_j}{\partial h_k} = M\left[\sum_j \frac{\partial S_j}{\partial h_k}(p_j - c_j) + \sum_j \frac{\partial S_j}{\partial p_k}\frac{\partial p_k}{\partial h_k}(p_j - c_j) + \sum_j S_j \frac{\partial p_j}{\partial h_k}\right] - \sum_j \frac{\partial F_j}{\partial h_k} = 0. \tag{10}$$

To simplify equation (10) we assume that product j's price is not impacted by the communication efforts for the functional alternative k or $\partial p_j / \partial h_k = 0, \ \forall j \neq k$. This assumption is valid insofar as communicating the properties of product h does not directly impact prices of other products; as target markets of products k and j are likely to be different, manufacturers do not expect changes in consumers' willingness to pay for products other than those advertised. Similarly, we assume away communication economies or diseconomies of scope, or $\partial F_j / \partial h_k = 0, \forall j \neq k$. This assumption holds if an increased effort in communication for a specific claim does not impact the cost of communicating other claims (i.e. communication cost is linearly separable), which applies to cases where types of messages and communication strategies differ because of the need to reach different target markets. Market shares are allowed to change because as the level of information changes, consumers will switch between alternatives in the market.

Stacking the J_n FOCs and using matrix notation one has

$$M[\Xi(p - c) + \Omega\Lambda(p - c) + \Lambda S(.)] = \nabla Fi \tag{11}$$

assumptions about the conduct of the firms in the market could have been made. A brief discussion of the implications of using different assumptions and the complications that come with them is presented in the 'discussion' section.

where

$$\Xi_{jk} = \frac{\partial S_j}{\partial h_k},$$

$$\Lambda_{jk} = \begin{cases} (\partial p_j/\partial h_k) & \text{if } k,\ j \in J_n^f \\ 0 & \text{otherwise} \end{cases},$$

$$\nabla F_{jk} = \begin{cases} (\partial F_j/\partial h_k) & \text{if } k = j;\ j \in J_n^f \\ 0 & \text{otherwise} \end{cases},$$

i is a conformable row-vector of 1s and Ω is discussed above. Using the Nash–Bertrand assumption, i.e. equation (8), one has $\Omega\Lambda(p-c) = \Omega\Lambda(-\Omega^{-1}S(\cdot)) = -\Lambda S(\cdot)$ which, substituted into equation (11) gives

$$M\Xi(p-c) = \nabla Fi. \tag{12}$$

Equation (12) states that yogurt manufacturers will invest in communicating the health properties of their products up to the point where the marginal cost of communication, ∇Fi, equals the additional profits obtained from a marginal change in demand due to communication. Equation (12) is of importance as it allows us to capture manufacturer losses that would be incurred, were they no longer be able to communicate the health properties of their product, while prices are still set at the previous equilibrium point (that is, if truthful claims were denied and the market had yet to reach a new equilibrium).

3.3. Simulating the impact of Reg. (EC) No. 1924/2006 on the Italian yogurt market

In the discussion that follows we illustrate our approach to simulating the impact of the NHCR. We first discuss our strategy to measure the welfare implications of the presence of false health claims for both consumers and producers.[12] Second, we discuss our methods to simulate welfare changes resulting from the rejection of truthful claims and the disappearance of the products carrying them from the market.

We evaluate the potential benefit of rejecting false claims, measuring the amount that consumers may be overpaying for untruthful claims and the associated welfare losses incurred by consumers, as well as the producers' surplus internalised by manufacturers. Under the nested-logit demand assumptions, consumers valuation of functional attribute H is β^H. Since α represents consumers marginal disutility of price, the monetary value attached to the Hth attribute is $-\beta^H/\alpha$, representing also how much consumers would be *overpaying* for a product falsely claiming to provide a health benefit. Let p_j^0 be the price

12 The evaluation of this scenario was suggested by two anonymous reviewers, independently. We are grateful to the reviewers for their suggestions.

of product j observed in the data: if j carries an untruthful claim then $p_j^{UC} = p_j^0 - \beta^H/\alpha$ is the price consumers should have been paying for it, given that the product's value is lower because of the false claim. To obtain a measure of consumers' welfare, one needs to calculate the inclusive value function (IVF) for each consumer, which is the same across all consumers. Following McFadden (1981), the IVF for the nested-logit demand model is

$$V_i^{\text{Scen}} = \ln\left(1 + \sum_g \left(\sum_{k\in g} \exp\left(\frac{\delta_k^{\text{Scen}}}{1-\sigma}\right)\right)^{1-\sigma}\right) \tag{13}$$

where Scen represents one of the possible scenarios we consider. Using p^0 to indicate the vector of prices observed in the data, i.e. the baseline scenario, and p^{UC} the vector containing p_j^{UC} for each product with untruthful claims, p_j^0 otherwise, changes in welfare for each unit consumed by consumer i under the scenario 'UC', i.e. 'untruthful claims' is

$$EV_i = e(p^0, V_i^{UC}) - e(p^{UC}, V_i^{UC}) = \frac{V_i^{UC} - V_i^0}{\alpha} \tag{14}$$

Total consumer welfare change is obtained multiplying equation (14) times the size of the market M. Using p^{UC} we can calculate the additional producer surplus (profits) manufacturers are able to acquire thanks to charging an extra $-\beta^H/\alpha$ for the products carrying the false claims. Letting S^0 be the vector of shares observed in the data, one has

$$\Delta\pi_n{}^{UC} = M\sum_{j\in J_n} S_j^0(p_j^{UC} - p_j^0 - c_j) \tag{15}$$

This amount is likely lower than consumers' welfare losses because of the non-perfectly competitive nature of the market. Thus, we expect deadweight losses. The relative magnitude of transfers from consumers to producers, and that of deadweight losses, cannot be predicted *a priori*. Before proceeding, it should be noted that the vector p^{UC} is not an equilibrium vector as its elements are not equilibrium prices. Therefore, given the actual shares and price vectors (S^0, p^0), equations (14) and (15) measure the portion of consumer welfare attributable to the presence of the health claims, and how much of that welfare is internalised by manufacturers.

In simulating the rejection of truthful claims we consider two outcomes: manufacturers remove claims from their products (de-labelling) or withdraw products from the market. Under de-labelling, consumers no longer have the necessary information about the health-enhancing features of the products. As consumers have less information, the demand for the de-labelled products is expected to decrease, which in turn will trigger manufacturers to adjust their prices, leading to a new market equilibrium. Since health claims can no longer be used, manufacturers may choose to lower prices only by small amounts, and use high prices to signal high quality levels (e.g. Milgrom and Roberts, 1986). Thus, although equilibrium price and quantity for the de-labelled products are both expected to decrease, the extent of such decreases is hard to predict *a priori*.

Let X_j^H be a binary variable indicating whether product j contains the functional attribute H. We simulate consumers not being able to observe that product j contains H by setting $X_j^H = 0$. After setting $X_j^H = 0$ for a subset of products, we use equation (4) to calculate a new vector of shares that captures how consumers adjust demand in absence of the health claims. Defining this new vector of shares as S_j^{del0}, the simulated (before any price adjustments) effect of de-labelling is

$$\Delta\pi_n{}^{del0} = M \sum_{j \in J_n} (S_j^{del0} - S_j^0)(p_j^0 - c_j) \tag{16}$$

which is the discrete analogue of equation (12), which also captures changes in profits due to using profit-maximising prices obtained in the presence of health claims, even though these are removed. Again, S^0 and p^0 represent, respectively, the vectors of price and shares observed in the data.

The pair $(S_j^{del0}; p_j^0)$ does not represent an equilibrium: new vectors of equilibrium shares and prices (S^{del1} and p^{del1}) are obtained solving simultaneously equation (5) (shares) and equation (7) (prices) under $X_j^H = 0$. To that end, we obtain estimates of the marginal cost vector by inverting equation (7) (marginal costs are assumed not to change with de-labelling), along with the estimated demand parameters. Changes in producers' surplus as a result of de-labelling are measured as

$$\Delta\pi_n{}^{del1} = M \sum_{j \in J_n} \left\{ S_j^{del1}(p_j^{del1} - c_j) - S_j^0(p_j^0 - c_j) \right\}, \tag{17}$$

while consumers' welfare variation is obtained by means of equations (13) and (14), using p_j^{del1} in place of p_j^{UC}. As long as consumers value health claims positively, if truthful claims are rejected, their welfare will decrease. If health claims offer the opportunity to differentiate among products, producers' surplus may decrease as well. However, since manufacturers use price strategically, and consumers substitute away from de-labelled products, the industry as a whole may not incur a loss. It is hard to predict *ex ante* which effects are likely to prevail.

In the withdrawal scenarios the choice set is artificially reduced, removing de-labelled products. In a sense, this represents a long-run scenario where, given the NHCR's strictness, manufacturers stop producing and marketing functional products. As such, it is analogous to Roe and Sheldon's (2007) scenario where, subject to strict standards, firms stop supplying high-quality products because they are no longer profitable. Let the number of the remaining products in the market produced by the nth manufacturer be J_n', where $J_n' \leq J_n$; let $-j$ indicate a functional alternative no longer in the market. Indicating with S_j^{with} and p_j^{with}, respectively, the new equilibrium market shares and prices for the J'_n products, one has

$$\Delta\pi_n^{\text{with}} = M \sum_{j\in J'_n} \left\{ S_j^{\text{with}}(p_j^{\text{with}} - c_j) - S_j^0(p_j^0 - c_j) - M\} \right\} \sum_{-j\in(J_n - J'_n)} S_{-j}^0(p_{-j}^0 - c_{-j}) \tag{18}$$

To assess the sources of welfare changes after product withdrawals, we follow Chaudhuri, Goldberg and Jia's (2006) adaptation of Hausman's (1996) and Hasuman and Leonard's (2002) method for assessing newly introduced products' welfare effects. We decompose consumers' welfare changes into two components:[13] a competition effect, capturing the effect of price changes because of decreased competition, and a variety effect, capturing the effect of a decrease in the number of products available.[14] Examples of studies assessing the welfare effects of new-product introduction using Hausman and Leonard's (2002) approach are Petrin (2002), Di Giacomo (2008) and Pofahl and Richards (2009). To measure the variety effect, we calculate the *virtual prices* of the withdrawn products, i.e. those prices which set their demand to zero, leaving other products' prices unchanged. The difference between the EV before withdrawal and that calculated using the virtual prices captures the variety effect. The competition effect is the difference between the EV calculated at the virtual prices and that at the new equilibrium prices and shares, obtained by solving equations (4) and (7) simultaneously for the subset of products still in the market. In the withdrawal scenario we expect both consumers' and producers' welfare to decrease, generating welfare losses; how such losses are shared between producers and consumers cannot be determined *a priori*.

4. Data and estimation

4.1. Data and variables description

We use scanner data supplied originally by Information Resources Incorporated (IRI) and provided by the Zwick Center for Food and Resource Policy, University of Connecticut.[15] The data contain monthly (four- or five-weekly) points-of-sales data for yogurt sales in hypermarkets and supermarkets for the 36-month period from January 2005–December 2007, in 13 Italian IRI

13 Chaudhuri, Goldberg and Jia (2006) use a two-level AIDS model, estimating an additional intermediate effect, the *expenditure-switching effect*, accounting for adjustments in expenditure shares due to changes in the price index.

14 According to Hausman (1996), consumers gain from the introduction of new products because of the additional variety and the increased competition from more products being in the market. The latter effect may not subsist in the case of product line extensions, as manufacturers could benefit from more market power (Hausman and Leonard, 2002).

15 Rigoberto A. Lopez, director of the Zwick Center for Food and Resource Policy, is gratefully acknowledged for granting access to the IRI data.

Table 1. Average share (cumulative), price (€/serving) number of conventional (N Conv) and functional (N Funct) alternatives by each firm in the choice set

Firm	Share (%)	Price	N Conv	N Funct
Firm 1	3.07	0.60	6	7
Firm 2	1.18	0.51	6	1
Firm 3	1.75	0.43	7	
Firm 4	0.43	0.59	2	2
Firm 5	1.37	0.33	8	
Firm 6	0.50	0.46	4	2
Conventional	5.85	0.44	33	
Functional	2.45	0.63		12

regions.[16] The choice set consists of 45 yogurt alternatives, 33 conventional and 12 functional, sold by six leading firms in Italy, for a total number of 21,060 observations. The functional yogurts included have, broadly defined, two types of health claims, which we will refer to as 'Claim A' and 'Claim B'.[17] Volume and value of sales are used to calculate prices in euros/serving.

In this analysis, the total potential market size of market t (Total Vol_t) used to compute market shares is defined based on total consumption in volume. Specifically, it is calculated as the per capita consumption of yogurt times the population of the region. Following Di Giacomo (2008), the size of the Italian yogurt market is calculated assuming that each consumer in each region consumes one serving (i.e. 125 grams) of yogurt daily. The region-level population data, obtained from the Annuario Statistico Italiano of the Istituto Nazionale di Statistica (ISTAT), is divided by 0.125 and by the number of days in each IRI month, resulting in an average estimated market size of 12.82 million kg per region per month. Then market share for product j in market t (including the outside options) is calculated as $\text{Vol}_{jt}/\text{Total Vol}_t$.

Table 1 presents a summary of shares and prices for each firm in the choice set, along with the number of functional and conventional alternatives they sell. Four out of six firms carry both conventional and functional yogurts in their portfolios. For firms 3 and 5, the top two sellers in the conventional segment, only conventional products are included. From the values in Table 1 it appears that yogurt manufacturers in the Italian market perceive a sizable premium for functional alternatives, as the average prices of functional yogurts are 43 per cent higher than conventional ones. Furthermore, conventional products seem to enjoy higher shares (on average) than their functional counterparts.

16 Some of the regions were excluded as their markets are characterised by prevalence of local brands, suggesting that the choice set for consumers in those regions could be substantially different than in the rest of the Italian territory. The regions excluded are Sicily, Sardinia, Calabria+ Basilicata and Trentino Alto Adige.

17 The two claims considered were based on the presence of beneficial bacteria. They belong to two of the claims most prominently adopted by Italian yogurt manufacturers prior to the NHCR, which can be found in Bonanno (2012). Further information is concealed to prevent identification of the brands included in the analysis.

Table 2. Summary sample statistics ($N = 20{,}160$)

Variable	Mean	SD	Min	Max
Price (€/serving)	0.491	0.122	0.229	0.781
Sj	0.002	0.002	0.000	0.014
So	0.773	0.064	0.642	0.914
Conditional share	0.133	0.155	0.001	0.909
Firm 1 Claim A	0.111	0.314	0	1
Firm 1 Claim B	0.044	0.206	0	1
Firm 2 Claim B	0.022	0.147	0	1
Firm 4 Claim B	0.044	0.206	0	1
Firm 6 Claim B	0.044	0.206	0	1
Average items store[a]	3.857	2.789	1	18.05
Skim	0.378	0.485	0	1
Whole	0.556	0.497	0	1
Mixed/unspecified[b]	0.067	0.249	0	1
Plain	0.244	0.430	0	1
Fruit pulp	0.178	0.382	0	1
Fruit pieces	0.200	0.400	0	1
Other flavours	0.178	0.382	0	1
Drinkable	0.156	0.362	0	1

Source: Authors' elaboration from data originally provided by Information Resource Incorporated. The data are averages across 13 regional markets, 36 monthly time periods.

[a]Average Items per Store: average number of SKUs for a given product carried by stores in a given region, measuring the depth of distribution of a given alternative.

[b]Some of the functional and drinkable yogurts in the data did not contain information on the fat content, and for some it was possible to recover the information from other sources. The excluded 'fat' category is for products whose fat content is unknown, representing one fifteenth of the sample.

Other product characteristics used in the demand equations are: indicators of fat content (skim and whole), a drinkable indicator, and flavour indicators (plain, fruit pieces and fruit pulp). In addition, we include, from the IRI data, the average number of items sold in order to capture market penetration of the different products, firm-level and regional fixed effects to control for time-invariant unobservables, and monthly dummies to capture seasonal variation in the demand for yogurt. Table 2 reports the summary statistics for the estimation sample.

4.2. Model specification, estimation and identification strategy

Two empirical issues exist when using a nested-logit demand model. The first is that a nesting structure must be assumed. In the context of this analysis we chose a nesting structure where consumers group products according to flavours and other sensory characteristics, resulting in the products being divided in six groups: fruit flavoured, fruit in pieces, fruit others, other flavours, plain and drinkable. The distribution of the product across nests appears relatively similar: most groups contain 7 to 9 alternatives, with the exception of the 'plain' group (11 products) and the 'fruit others' (two products); four groups out of six contain functional alternatives, the largest presence being in the 'drinkable' group, with five out of seven products being functional.[18] Our grouping choice is motivated by the existing literature as well as modelling constraints. First, previous literature shows that in the Italian yogurt market flavour has the largest impact on the substitution patterns of these products (Bonanno, 2013). Second, under the multiproduct Nash–Bertrand assumption, grouping products by vendor may lead to problems in the values of the calculated PCMs, as we show in Appendix 1. Third, if products are grouped by functional attributes, the execution of the counterfactual analysis becomes complex, as both the nests' composition and the number of products in each nest will vary as we manipulate health claims.

The second issue is that both price and conditional shares are endogenous, as they are likely to be correlated with unobservable product characteristics. To test, and to correct for endogeneity we use an IV approach and instruments based upon the following identification strategy. First, since all firms in our sample operate on a national scale, variations in input costs, which correspond to changes in retail yogurt prices, are unlikely to be correlated with regional demand shocks. Thus, following Bonanno (2013), input prices can be used to isolate exogenous variation in yogurt prices. Second, both direct observation and empirical work (Draganska and Jain, 2005; 2006) consider yogurt manufacturers adopting product-line pricing where, within the same product line, yogurts of different flavours (and in most cases fat content) are uniformly priced. Thus, if the price of inputs specific to one alternative increases, manufacturers may find easier to temporarily limit the supply of that specific alternative instead of changing prices of the entire product line; therefore, variation in input prices may also capture exogenous variation in conditional shares.

We use the following input prices as instruments: price of cream at the origin (national, monthly, EUR/kg) interacted with the fat indicator; farm-level price of fruits (national, monthly, EUR/kg) interacted with the two fruit indicators, and farm-level price of hazelnuts (national, monthly, EUR/kg) interacted with the 'other flavours' indicator, from the DATIMA database of the Istituto per lo Studio dei Mercati Agricoli (ISMEA); the European import price (CIF) of sugar (national, monthly, USD/lb), by Index Mundi; Commercial price of electricity at the source (regional, monthly, EUR /Mw) from the Manager of the Energy Market to account for refrigeration and processing costs, and the average volume per unit (from IRI data) as a proxy for packaging cost. Also, as the Italian retailing industry shows geographic disparities in food stores' type and size (Cozzi, 2008), part of the regional variation in product availability

18 We estimated another demand specification where consumers group products according to their fat content. Due to space limitations we do not provide a discussion of the results for this model specification, although we mention some of the key features in the 'Discussion' section. Full sets of results are available upon request to the authors.

is likely correlated with the differences in shelf space available, but uncorrelated with temporary demand shocks. Thus, the log of the number of items' conditional shares is used as an additional instrument for the logarithm of the conditional shares.

We estimate equation (5) using a GMM estimator. Using the same notation as Nevo (2001), we define the vector of instruments as $Z=[z_1,\ldots,z_M]$, satisfying $E[Z'\omega(\theta^*)]=0$, where $\omega(\theta^*)$ is a function of the true values of the parameters of the model θ^*; in our case $\omega(\theta^*)$ is the product-specific unobservable ξ_j, i.e. the structural error term in equation (5). The vector of GMM estimates $\widehat{\theta}$ solves

$$\widehat{\theta}=\arg\min_{\theta}\ \omega(\theta)'ZA^{-1}Z'\omega(\theta) \tag{19}$$

where A is a consistent estimate of $E[Z'\omega\omega'Z]$.

We test for endogeneity of price and conditional shares using a C statistic, obtained as difference of two Sargan statistics (Hayashi, 2000: 232), under the null hypothesis that the suspected endogenous variables are exogenous. Low p-values of the test statistic (distributed chi-squared with degrees of freedom equal to the number of endogenous variables) indicate that the null hypothesis of exogeneity can be rejected. We test the orthogonality of the over-identifying instrument using Hansen's (1982) J-statistic, distributed chi-squared with a number of degrees of freedom equal to the number of over-identifying restrictions, under the null hypothesis of the overidentifying instruments being uncorrelated with the errors. The relevance of the instruments is evaluated using Shea's (1997) partial R^2 and Staiger and Stock's (1997) 'rule of thumb', which considers a value of the F-statistic for a test of the joint significance of the instruments' parameters in the first-stage regressions exceeding 10 large enough to discard weak instruments issues. Data manipulation and estimation were performed using STATA version 10 and the simulations in Matlab 2011b.

5. Empirical results, simulation, and discussion

5.1. Estimated parameters, elasticities and PCMs

Estimates of the demand coefficients (equation (5)) are presented in Table 3, where the two columns represent OLS and GMM estimates, respectively. The model fits the data well, and the small p-value associated with the C-statistic suggests the necessity to correct for endogeneity bias. The p-value of the J test is 0.930 ($\chi^2_{(4)}=0.074$), supporting the orthogonality of the over-identifying instruments used. The F-statistics values of the instruments' coefficients joint-significance in the first stage regressions are 570.76 and 1061.86, for price and conditional shares, respectively, suggesting that our results are free from weak instruments problems. The relevance of the instruments is further supported by the relatively large values of Shea's (1997) partial R^2

Table 3. Estimated demand parameters and model performance

Variables	Estimator: OLS	GMM
Price	−1.128*** (0.039)	−4.166*** (0.169)
$\ln(sh_{m\|j})$	0.877*** (0.004)	0.470*** (0.008)
Firm 1 Claim A	−0.269*** (0.011)	0.324*** (0.018)
Firm 1 Claim B	0.360*** (0.015)	1.048*** (0.031)
Firm 2 Claim B	0.157*** (0.015)	0.173*** (0.035)
Firm 4 Claim B	0.215*** (0.016)	0.419*** (0.033)
Firm 6 Claim B	0.156*** (0.011)	0.709*** (0.036)
Average item sold	0.0288*** (0.001)	0.130*** (0.002)
Whole	0.00093 (0.011)	0.419*** (0.021)
Skim	−0.0341*** (0.012)	0.323*** (0.020)
Fruit pulp	0.390*** (0.005)	0.296*** (0.013)
Fruit pieces	0.471*** (0.005)	0.186*** (0.011)
Other flavours	0.176*** (0.006)	0.134*** (0.012)
Drinkable	0.0673*** (0.012)	0.298*** (0.019)
Firm 1	0.218*** (0.009)	0.738*** (0.038)
Firm 2	0.106*** (0.007)	0.308*** (0.030)
Firm 3	0.120*** (0.006)	0.417*** (0.019)
Firm 4	0.138*** (0.011)	0.434*** (0.046)
Firm 5	−0.0077 (0.006)	−0.00775 (0.017)
Constant	−4.307*** (0.019)	−4.932*** (0.070)
R^2	0.954	0.894
C stat (p-val)	$\chi^2_{(2)} = 1982.19$; (0.000)	
Hansen J (p-val)	$\chi^2_{(4)} = 0.074$; (0.993)	
Instrument power	P	$\ln(s_{j\|g})$
$F_{(5,21014)}$	570.763	1061.86
Shea's partial R^2	0.160	0.259
(First-stage R^2)	(0.875)	(0.743)

Note: *, **, and *** represent 10, 5 and 1% significance levels standard errors in parenthesis. Fixed effects coefficients omitted for brevity; *Hansen J*: test value and p-value in parenthesis under the null of overidentifying instruments being uncorrelated to the errors. First Statge IV $F_{(.)}$: F-statistic for the test of joint significance of the IVs coefficients in the first-stage regressions.

(18.3 per cent for price and 34.8 per cent for the log of conditional shares, respectively). Also, the first-stage instruments' parameters, reported in Appendix 2, show for the most part the expected sign.[19]

The OLS price parameter is −1.128, while the GMM one is −4.166. The conditional share's coefficient decreases from 0.877 to 0.470 (OLS vs. GMM).

19 In the first-stage price equation, the coefficients of raw sugar price, proxy for packaging cost, and the log of conditional weighted distribution shares have the expected, positive sign, while two show perverse (negative) signs. In the conditional share equation, only the price of raw sugar gives an unexpected (positive) coefficient, while all the other statistically significant coefficients for the excluded instruments present the expected sign.

Table 4. Average price (P), market shares (Sh%) summary of estimated elasticities, price cost margins (PCM) and marginal cost (C)

Vendor	*P*	Sh(%)	Elasticity	PCM	C
All					
Average	0.49	0.17	−3.62	0.15	0.35
Min	0.23	0.01	−5.03	0.13	0.15
Max	0.78	1.40	−2.18	0.24	0.52
Conventional	0.44	0.16	−3.30	0.14	0.30
Functional	0.63	0.19	−4.46	0.17	0.47
Firm 1					
Conventional	0.55	1.04	−4.14	0.16	0.40
Claim A	0.66	1.11	−4.21	0.19	0.44
Claim B	0.68	0.92	−4.49	0.20	0.48
Firm 2					
Conventional	0.49	1.12	−3.60	0.14	0.35
Claim B	0.63	0.06	−4.88	0.13	0.50
Firm 3					
Conventional	0.43	1.75	−3.14	0.15	0.28
Firm 4					
Conventional	0.55	0.15	−4.23	0.13	0.42
Claim B	0.63	0.28	−4.68	0.15	0.48
Firm 5					
Conventional	0.33	1.37	−2.46	0.14	0.19
Firm 6					
Conventional	0.40	0.42	−3.04	0.14	0.26
Claim B	0.60	0.08	−4.63	0.13	0.47

Source: Authors' calculation from estimated parameters.

These results indicate that the demand for yogurts in Italy would have appeared more inelastic and characterised by heavily polarised substitution patterns had endogeneity not been controlled for. All the GMM coefficient estimates of firm-specific functional indicators are positive and significant. This indicates that Italian yogurt consumers value functional attributes: firm 1's Claim B product seems to be the most valued by consumers, while the least valued is firm 2's Claim B product. Other product characteristics behave consistently with extant analyses of the Italian yogurt market (Di Giacomo, 2008; Bonanno, 2012), showing that consumers have a preference for skim, drinkable products with either fruits or other flavours, and they prefer products of the market leaders. Also, depth of distribution (number of items available to consumers per store) impacts positively the demand for yogurt.

Table 4 presents summaries of average prices, shares, own-price elasticities, PCMs and marginal costs. PCMs and marginal costs are calculated under the Nash–Bertrand assumption and equation (7), as in Nevo (2001). The average own-price elasticity is approximately −3.62, ranging from −2.20 to −5.15,

Table 5. Simulated welfare impacts of the presence of untruthful claims

Products affected	Baseline (a)	Average premium	Welfare: no premium (b)	Δ Welfare (a) − (b)	%Δ Welfare [(a)–(b)]/(a)
Claim A					
CS	328.96	0.0779	346.08	−17.12	−5.19
PS	190.56		178.16	12.40	6.51
TW	519.52		524.16	−4.64	−0.90
Claim B					
CS	328.96	0.1411	408.8	−79.84	−24.26
PS	190.56		151.36	39.20	20.56
TW	519.52		560.16	−40.64	−7.82
All claims					
CS	328.96	0.1284	425.12	−96.16	−29.22
PS	190.56		138.96	51.60	27.07
TW	519.52		564.08	−44.56	−8.57

Source: Authors' simulations from estimated parameters.

consistent with previous literature.[20] The estimated average PCMs for the functional alternatives are 17 per cent higher than the conventional ones, and the estimated marginal production cost are 54 per cent higher. No clear patterns emerge for the elasticities reported in Table 4, besides that of the demand for functional alternatives being on average more price elastic. As for the PCMs, only firms 1 and 4 are able to obtain higher margins for their functional products than their conventional counterparts, confirming that functionality per se may not be the only driver of successful product differentiation in the Italian yogurt market (Bonanno, 2013). Firms 1 and 4, who garner twice as big market shares from their functional products than their conventional counterparts, enjoy about 36 and 8.5 per cent higher PCMs for these alternatives compared with conventional ones (respectively). In contrast, the PCMs of firms 2 and 6's functional products, which show limited penetration in the segment, are ∼4 per cent lower than conventional ones.

5.2 Simulating the impact of NHCR on firms' performance and consumers' welfare

Given the demand results, we simulate the impact of the NHCR. Since the demand results are based on data prior to the NHCR implementation, they are used to establish the baseline scenario for the simulations. Table 5 presents

20 Di Giacomo's (2008) estimated brand-level price elasticities for yogurt in Italy vary between −0.88 to −2.66, with an alternative specification giving an average value of −3.17. Bonanno (2012) finds own-price elasticity of demand for yogurt sub-categories in Italy between −2 and −4.74. Bonanno (2013) presents two range of elasticities between −1.22 and −6.86 (average −3.14) and −1.27 and −9.38 (average value −3.76). Similar values are also recorded in the US yogurt market: Draganska and Jain (2006) find estimates of brand-level own-price elasticities for yogurt between −2.45 and −6.25, while Villas-Boas's (2007) retail-chain estimates show an average value of −5.64.

the estimated average premium that consumers overpay if health claims are false, along with the welfare losses associated with it. The (annual) baseline consumer surplus (CS) is EUR 328.96 million, producer surplus (PS) is EUR 190.56 million and total welfare (TW) is 519.52 (EUR million). The average premium overpaid by consumers varies from 0.078 to 0.14 EUR/serving (indicating a price premium of 12.4–22.4 per cent). Table 4 also shows that the presence of unjustified price premiums would lead to decreases in consumer welfare that grow larger with the number of products carrying false claims. Consumers' losses vary from EUR 17.12 million (circa) if only Claim A was untruthful, and to about EUR 96 million if all claims were false. The industry would internalise only part of these losses, between 12.40 to 51.60 EUR million (i.e. from 6.5 to 27.1 per cent). Deadweight losses due to the presence of the unjustified premiums reach values as large as EUR 44.56 million (circa −8.6 per cent).

Table 6 shows the simulated changes in shares, margins and profits for the Type-II error simulations, i.e. for de-labelling and withdrawal of products carrying false claims. The values presented in the 'No price adjustment' column are percentage changes in profits when firms remove claims without adjusting prices, calculated using equation (16) divided by the baseline profits. The values of the other eight columns represent two sets of simulated values, respectively, of percentage changes in equilibrium prices, margins, equilibrium shares, and standardised (divided by the baseline values) profits obtained using equations (17) and (18). The two sets of four columns refer to the de-labelling and withdrawal scenarios, respectively. The three panels of Table 6 present values of the policy affecting Claim A (top panel), Claim B (intermediate panel) and all products carrying a health claim (bottom panel).

The no-price adjustment scenario is a discrete counterpart of equation (12), i.e. it indicates the level of additional sales needed to justify the cost of labelling or, alternatively, an indication of the effect of health claims communication on market shares (either direct or indirect) and on profits. In other words, the values in the first column of Table 6 illustrate how market shares of the different products are impacted by communicating health claims to consumers. The values in the third panel (all products are de-labelled) show that for firm 1 the decision to invest in communications for the Claim A products is justified by a 29 per cent increase in shares, and by a 73 per cent increase for Claim B products; for firm 6 the increase in shares of Claim B products reaches 70 per cent, while for firm 4 it is about 10 per cent. From a strategic point of view our results suggest that firm 2 may be better off not carrying products with health claims as the share of its functional alternative increases by more than 30 per cent when claims are removed.

The results of the de-labelling scenarios show firm 1 (in particular for Claim B) and firm 6 being penalised the most (in relative terms), losing, respectively, up to about 73 and 70 per cent in shares. This result is expected since consumers seem to value the functional attributes of these two products the most (the estimated demand parameters are 1.05 and 0.71, respectively). Another expected result is that of conventional products gaining market shares once functional products are de-labelled. A counterintuitive result is that of firm 2's functional

Table 6. Simulated effects of NHCR implementation with Type-II errors: de-labelling and withdrawal of product with truthful claims (% changes relative to baseline scenario)

		No p. adj.	De-labelling				Withdrawal			
Firm	Product type	Π	p	p-c	Sh	π	p	p-c	Sh	π
Claim A										
1	Conv.	14.78	−0.38	−1.35	17.58	14.99	−1.30	−4.59	23.08	18.82
1	Claim A	−29.12	−0.46	−1.51	−28.00	−28.89	284.8[a]			−100
1	Claim B	11.91	0.04	0.15	10.98	11.94	−0.09	−0.31	12.20	12.54
2	Conv.	8.56	0.04	0.13	7.62	8.39	0.28	0.99	11.43	13.47
2	Claim B	3.87	−0.03	−0.15	4.09	3.93	−0.03	−0.08	−0.40	−0.47
3	Conv.	12.95	0.33	0.97	12.90	12.83	0.73	2.14	16.13	17.38
4	Conv.	6.60	−0.01	−0.04	7.14	6.71	−0.01	−0.04	7.14	7.26
4	Claim B	13.72	0.05	0.21	16.67	13.79	0.03	0.14	16.67	14.14
5	Conv.	7.80	0.13	0.30	8.53	7.88	0.53	1.22	10.85	11.65
6	Conv.	1.91	−0.04	−0.11	2.05	1.93	0.08	0.22	0.75	3.62
6	Claim B	18.03	0.04	0.19	14.29	17.54	0.20	0.92	28.57	34.97
Claim B										
1	Conv.	23.03	−0.74	−2.17	23.08	23.46	0.05	0.16	34.07	40.47
1	Claim A	10.42	0.04	0.23	10.00	10.42	0.08	0.24	11.00	11.18
1	Claim B	−73.12	−3.61	−12.45	−68.29	−72.63	263.3[a]			−100
2	Conv.	6.84	−0.04	−0.17	7.62	6.94	−0.05	−0.17	7.62	7.55
2	Claim B	30.35	0.43	2.14	16.67	25.03	280.3[a]			−100
3	Conv.	13.15	0.30	0.85	12.90	13.03	0.82	2.40	17.42	17.02
4	Conv.	7.01	0.01	−0.04	7.14	7.07	−0.04	−0.19	7.14	7.51
4	Claim B	−10.39	0.67	2.99	−16.67	−14.32	284.8[a]			−100
5	Conv.	6.59	−0.05	−0.12	6.20	6.75	−0.03	−0.09	6.20	7.31
6	Conv.	1.77	−0.24	−0.70	2.56	1.84	−0.27	−0.81	3.13	2.30
6	Claim B	−70.97	−0.26	−1.19	−71.43	−70.86	298.5[a]			−100

All claims										
1	Conv.	25.03	−1.36	−4.23	27.47	25.62	−1.48	−5.24	47.25	47.05
1	Claim A	−28.07	−0.48	−1.81	−28.00	−27.84	284.8[a]			−100
1	Claim B	−73.03	−3.68	−12.70	−68.29	−72.55	263.3[a]			−100
2	Conv.	9.82	0.10	0.23	9.52	9.63	0.34	1.20	13.33	15.87
2	Claim B	30.74	0.43	2.14	16.67	25.22	280.3[a]			−100
3	Conv.	16.02	0.52	1.47	14.84	15.65	1.48	4.28	23.23	24.62
4	Conv.	7.31	0.01	−0.04	7.14	7.37	−0.04	−0.19	7.14	8.35
4	Claim B	−10.13	0.66	2.99	−16.67	−14.18	284.8[a]			−100
5	Conv.	8.91	0.18	0.38	8.53	8.93	0.64	1.47	12.40	13.60
6	Conv.	2.72	−0.21	−0.61	3.33	2.70	−0.21	−0.65	2.38	5.04
6	Claim B	−68.36	−0.22	−1.00	−71.43	−68.41	298.5[a]			−100

Source: Authors' simulations from estimated parameters.

[a]Virtual prices: artificial prices setting the demand for the withdrawn products to 0.

shares (and therefore profits) increasing (by approximately 31 per cent – without price adjustments; 25 per cent after price adjustments), when Claim B is removed.[21]

The magnitudes of the price adjustments are relatively small (in the order of half percentage point, in either direction), with the exception of firm 1, whose price for the Claim B product decreases by 3.6–3.7 per cent to recover (in part) the losses in demand from de-labelling. Firm 1 also lowers the prices of its conventional alternatives by up to −1.36 per cent (scenario where all claims are removed) to avoid sales cannibalisation. The same strategy will be followed by firm 6, resulting in lower prices of both functional and conventional alternatives (respectively, −0.21 and −0.22 per cent, all claims removed). In terms of profits, our simulation indicates that firms with higher market shares in the functional segment are disproportionally penalised when losing their claims, whereas firms with little or no functional market shares may benefit from it. Profits from conventional products' sales seem also to increase in all the simulated de-labelling scenarios.

Moving to the simulation of functional products' withdrawals, virtual prices of the withdrawn products (i.e. those prices setting their demand to zero), indicated with an asterisk in the fourth to last column of Table 6, are about 2.6 to three times the baseline prices, suggesting a fairly high consumer valuation of these products. Also, firms withdrawing their functional products seem to generally lower prices of their conventional products (with a few exceptions),[22] recovering part of their losses thanks to increased demand for those alternatives still in the market. However, such benefits are trivial. When firm 1's Claim A product exits the market, firm 1 lowers the price of both its conventional alternatives and the products carrying Claim B, while other firms respond generally by increasing prices. Firms not offering functional alternatives, gain from the exit of functional products with small increase in prices accompanied by large increases in shares and higher profits, from 7 to 25 per cent.

Table 7 presents a summary of simulated welfare changes for the de-labelling and withdrawal scenarios. Industry profits increase by 8.24 EUR million when the Claim A product is de-labelled, indicating a redistribution of sales between firm 1 and its competitors. As consumers' welfare decreases by an amount 30 per cent higher than producers' gain, most of consumers' losses appear internalised by manufacturers. Under the de-labelling of Claim B products, consumers are

21 This result may be the outcome of consumers switching after de-labelling: firm 2 has the smallest functional market share, and the least valued functional alternative in our choice set (according to the demand estimates). Thus, when claim B is removed, firm 2's shares decrease less than those of other firms. As consumers switch across products, share re-allocation can overcompensate for such losses.

22 This result supports Hausman's (1996) intuition that when new products are product-line extensions or additions to a portfolio of existing products, the increase in the number of products may not necessarily result in lower prices, since the increase in market power for the manufacturer launching the new product may exceed any pro-competitive price decreasing effect. In fact, we observe a price increase for conventional alternatives sold by firms selling only these products (although in a modest range) suggesting that less competition benefits these firms' pricing power. We also observe small price reductions for the products of the manufacturers whose functional products are withdrawn, suggesting a minor decrease in pricing power.

Table 7. Comparison of welfare measures for the different Type II error scenarios: Denied truthful claims (changes are relative to baseline values)

		De-labeling						Withdrawal					
		No price adjustment			Price adjustment			Variety effect			Total		
		Consumer surplus											
Products affected	Baseline	NewCS	ΔCS	%ΔCS	NewCS	ΔCS	%ΔCS	New CS	ΔCS	%ΔCS	New CS	ΔCS	%ΔCS
Claim A	328.96	318	−10.96	−3.33	317.92	−11.04	−3.35	298.32	−30.64	−9.32	297.44	−31.6	−9.60
Claim B	328.96	303.2	−25.84	−7.85	304	−24.96	−7.59	289.36	−39.6	−12.04	288.56	−40.48	−12.29
All	328.96	292.08	−36.96	−11.23	293.44	−35.6	−10.81	258.00	−70.96	−21.58	256.64	−72.32	−21.99
		Producer surplus											
	Baseline	NewPS	ΔPS	%ΔPS	NewPS	ΔPS	%ΔPS				New PS	ΔPS	%ΔPS
Claim A	190.56	198.80	8.24	4.32	198.8	8.32	4.35				182.72	−7.84	−4.11
Claim B	190.56	187.84	−2.64	−1.40	187.84	−2.72	−1.41				180.00	−10.56	−5.53
All	190.56	179.28	−11.28	−5.92	179.12	−11.44	−6.00				154.64	−35.92	−18.83
		Total welfare											
	Baseline	NewTW	ΔTW	%ΔTW	NewTW	ΔTW	%ΔTW				New TW	ΔTW	%ΔTW
Claim A	519.52	516.80	−2.72	−0.52	516.72	−2.80	−0.54				480.16	−39.36	−7.58
Claim B	519.52	491.04	−28.48	−5.48	491.84	−27.68	−5.33				468.56	−50.96	−9.81
All	519.52	471.36	−48.16	−9.27	472.56	−46.96	−9.04				411.28	−108.24	−20.83

Source: Authors' simulations from estimated parameters;
Note: Total CS changes under withdrawal are obtained by adding the competition effect to the variety effect. For brevity, competition effects' results not presented.

still penalised (losing ~8 per cent of the baseline surplus), while manufacturers' losses are minor (about 1.4 per cent of baseline PS). Thus, while the industry is unaffected, deadweight losses occur at the expenses of consumers (about EUR 28.5 million or −5.5 per cent). If all claims are dropped, industry losses will be as large as 6 per cent of the baseline scenario. But CS losses are larger, exceeding 10 per cent of the initial surplus, for deadweight losses of about EUR 47 million. As expected, both CS and PS decrease when functional yogurts exit the market, with consumers being affected more than manufacturers: twice as much in absolute terms and by similar amounts (−22 and −19 per cent) in relative terms. The largest portion of CS losses comes from the decreased product variety: a reduction in competition only leads to 0.28 per cent lower CS when Claim A products exit the market, and 0.41 per cent when all the functional products exit.

5.3. Discussion, policy implications and limitations

The simulation results presented above lead to some points of discussion. On one hand, if no policy was in place, the presence of false claims could result in consumers being considerably worse off; as manufacturers internalise circa half of consumers' losses, deadweight losses appear substantial. On the other hand, if the policy resulted in the disappearance of truthful claims, consumers might be penalised more than manufacturers, and even more so if some of the products disappeared from the market.

These results have important implications. First, our findings suggest that, if some of the rejected health claims were false, consumers will benefit largely from the NHCR, because the presence of untruthful claims may lead to consumers' losses more than twice as large as those calculated in the scenario where all truthful claims are de-labelled (respectively, −96.2 and −35.6 EUR million). Second, the deadweight losses existing because of information asymmetry are comparable to those obtained if the regulation removed truthful claims from the market, even though, in the latter case, losses are distributed between consumers (75 per cent) and producers (25 per cent). Third, manufacturers losses are smaller in the case of denied truthful claims (stringent policy) than the amounts they would internalise selling products with false claims. Thus, if truthful claims are denied, producer surplus would decline by EUR 11.44 million (de-labelling) to EUR 35.49 million (withdrawal); the profits internalised are much larger, at EUR 44.56 million.

Our results are not without limitations. First, our data are prior to the implementation of the NHCR, which only allows us to simulate the impact of the policy by inferring the values that consumers give to each product's label. Although this approach serves the purpose of our analysis, as it provides a benchmark against which to measure the impact of the policy, the use of data prior to the implementation comes with two drawbacks. First, we cannot evaluate, or judge, the truthfulness of the health claims for the products included in the analysis. While a more detailed analysis of all the dynamics in the market could have been addressed if we had had much more detailed data, with a longer time series component to span from periods prior to the implementation of the law, the second issue would be impossible to solve with the methodology used in this analysis. Second, we cannot capture in full the evolution of the industry. When we were completing this paper, of the five functional brands considered, one was no longer in the market, another no longer carried a health claim, and the other three products, whose health claims were originally based on probiotic bacteria were denied, are being marketed using approved health claims, thanks to reformulation. Industry reports show that most functional brands in the Italian market lost competitive foothold in the period 2010–2013, during which the NHCR ban on sales of products carrying rejected claims came into effect. Industry figures (Euromonitor International, 2014) indicate that leading functional brands lost a portion of their market shares, which, according to our calculations, represent changes in value shares between −5 per cent (Danone Activia) and −20 per cent (Nestle's *LC1*); in spite of such changes being smaller than those we simulate, they highlight how the Italian yogurt industry has been impacted by the regulation. However, the question remains as of whether our simulated shares can represent reliable predictions of market behaviour. To assess how our model performs in producing out-of-sample predictions, we re-estimated equation (5) excluding the last six and three months of data, and comparing in-sample predictions with out-of-sample ones. The additional results (omitted for brevity and available upon request) show stable point estimates in the different subsamples and relatively small prediction errors between the observed and predicted ratios S_j/S_0 for in-sample observations (on average circa 7.2–7.4 per cent) and out-of-sample ones (on average circa 0.5–2 per cent); this may suggest that our (out-of-sample) simulated shares can be accurate predictions of market behaviour (conditionally on the validity of our Nash Bertrand and scenarios assumptions).

The second limitation of our analysis is two-fold and relates to the nested logit (NL) demand model. The marginal dis-utility of price is the same across consumers, and the groups' structure is an *a priori* decision of the researchers. With respect to the first point, although more sophisticated methods (e.g. the RPL discussed in footnote 9) would allow us to account for more heterogeneity in consumers' price sensitivity, such sophistication appears unnecessary to achieve our objective, which is to measure the aggregate impact of the NHCR on consumers' and producers' welfare. As for the second point, we evaluated our results' robustness by estimating an alternative model specification, where consumers group products according to fat content. Our findings appear robust to the specification of the nesting structure. The econometric results are quantitatively similar to those presented above, with own price elasticities ranging from −1.96 to −5.34, for an average of −3.34, and the simulated welfare changes are comparable in magnitude and direction with those illustrated in the previous section (results available upon request to the authors).

Third, our results' validity relies on the assumption that the observed prices and shares represent the Nash equilibrium of a multi-product Bertrand game. However, as yogurt manufacturers operating in Italy could play a different game, our results portray only a partial picture of the likely consequences of the policy. Given the number of products in our choice set, finding the game which most appropriately describes the actions of the major players in the

Italian yogurt market is impossible,[23] leading us to choose one of the possible market forms. Departing from the multi-product Nash–Bertrand assumption, the number of possible strategic scenarios multiplies. For example, one could assume that prior to the NHCR, firms played a Stackelberg game, with manufacturers of functional products being the leaders, and other firms the followers. This assumption is unlikely to hold in some of the simulated scenarios as manufacturers of de-labelled products may have to revert to Bertrand pricing. Alternatively, to counteract the effect of de-labelling, producers of de-labelled products may collude, which would likely lead to price changes smaller than those discussed.

Fourth, our analysis only focuses on health claims falling under the three main articles used by the NHCR: 'general function'; 'innovative products'; and 'reduction of a risk factor in the development of a disease/claims relating to children's development and health'. As suggested by an anonymous reviewer, a more comprehensive analysis should have considered claims, such as 'reduced fat' or 'high in protein', which do not fall under these articles. Due to the limitations of the information included in the data we were unable to provide this level of detail in our analysis.

Fifth and last, our withdrawal simulations do not account for the effect that decreased congestion in the product-space can have on consumers' welfare. As Ackerberg and Rysman (2005) show, using discrete choice models can lead to an overestimation of welfare increases due to new product introduction, since they do not take into account that the benefits from more products in the market decrease as the number of products become larger.[24] Using the same logic, our simulated welfare changes for the withdrawal case may be biased upwards, and even more so if all functional products were withdrawn from the market.

6. Concluding remarks

As the number of health-enhancing food products proliferates, policymakers are developing laws regulating health claims to improve transparency and reduce information asymmetry. Regulation (EC) No. 1924/2006, of the European Parliament and of the Council of 20 December 2006, requires food manufacturers to submit dossiers containing scientific evidence in support of the truthfulness of the health claims they carry. The European Food Safety Authority (EFSA), in charge of reviewing the dossiers, has adopted a stringent approach to minimise the risk of incurring in Type-I errors (authorising untruthful claims), while

23 The number of possible pure-strategy equilibria that one could choose from would be extremely large for a market with 45 products sold by six manufacturers. In their analysis of the US soda market, Dhar *et al.* (2005) highlight that for a four-brand case, considering only pure strategies, there are 256 possible equilibria.

24 Similarly, Iyengar and Lepper (2000) use choice experiments to show evidence that individuals are more responsive to a limited number of alternatives in their choice sets and reported higher satisfactions with their choices when exposed to smaller number of items to choose from. We thank an anonymous reviewer for suggesting this additional reference.

increasing the risk of incurring in Type-II errors (rejecting truthful claims). Some pundits believe this approach could jeopardise innovation and the growth of the European food industry. Excessive stringency could also hurt consumers, as the search cost to obtain information on health properties of foods could increase and product variety decrease.

This study provides empirical insights into the potential economic effects of the NHCR. Using sales data on the Italian yogurt market prior to the adoption of the policy, we estimate a nested-logit demand model and simulate the impact of the policy on consumers' and producers' welfare. We consider a case where the policy is able to correct for information asymmetry and scenarios where truthful claims are removed and functional alternatives are withdrawn from the market. Our results suggest that if health claims are false, consumers may experience considerable welfare losses. Also, if truthful claims are denied, the industry's losses may be smaller than the profits internalised if claims were false, while consumers appear to be penalised by the loss of information. In sum, although the NHCR stringency may jeopardise consumers' well-being more than producers', its beneficial effects in the presence of false claims are large. However, the presence of untruthful claims may lead to consumers' welfare losses more than twice as large as those arising in the case of the de-labelling of all truthful claims.

Future research should explore further whether the Regulation's outcome is that of more informed, and ultimately better-off, consumers, which is one of the main assumptions necessary for the policy to have any ameliorating effect. Also, we only focus on one case study, the Italian yogurt market. Thus, we cannot claim that the impacts we measure will hold for products belonging to different categories or across types of claims. Empirical analyses considering comparisons across categories and claims should be undertaken to assess fully the impact of the policy and its reach.

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Appendix 1

In this Appendix we show that, under the Nash–Bertrand Assumption, a nesting structure where manufacturer (brand) is chosen first results in equal margins for all the products produced by the same firm, the same result one would have in models estimated using a multinomial Logit (MNL). For ease of exposition, and without loss of generality, we use a case of a manufacturer selling two products, 1 and 2; the discussion can easily be generalised to a manufacturer producing N products. Keeping in mind that under the Nash–Bertrand assumption, only the derivative of demand (shares) of the products produced by the manufacturer of interest matters for its profitability, since the matrix Ω^* is block diagonal, expanding equation (8) gives

$$\begin{bmatrix} p_1 - c_1 \\ p_2 - c_2 \end{bmatrix} = -\begin{bmatrix} \dfrac{\partial S_1}{\partial p_1} & \dfrac{\partial S_1}{\partial p_2} \\ \dfrac{\partial S_2}{\partial p_1} & \dfrac{\partial S_2}{\partial p_2} \end{bmatrix}^{-1} \begin{bmatrix} S_1 \\ S_2 \end{bmatrix}$$

$$= \frac{1}{(\partial S_1/\partial p_1)(\partial S_2/\partial p_2) - (\partial S_2/\partial p_1)(\partial S_1/\partial p_2)} \times \begin{bmatrix} -\dfrac{\partial S_2}{\partial p_2} & \dfrac{\partial S_1}{\partial p_2} \\ \dfrac{\partial S_2}{\partial p_1} & -\dfrac{\partial S_1}{\partial p_1} \end{bmatrix} \begin{bmatrix} S_1 \\ S_2 \end{bmatrix}$$

So that

$$p_1 - c_1 = \frac{-(\partial S_2/\partial p_2)S_1 + (\partial S_1/\partial p_2)S_2}{(\partial S_1/\partial p_1)(\partial S_2/\partial p_2) - (\partial S_2/\partial p_1)(\partial S_1/\partial p_2)};$$

$$p_2 - c_2 = \frac{(\partial S_2/\partial p_1)S_1 - (\partial S_1/\partial p_1)S_2}{(\partial S_1/\partial p_1)(\partial S_2/\partial p_2) - (\partial S_2/\partial p_1)(\partial S_1/\partial p_2)}$$

If demand is estimated using an MNL one has

$$\frac{\partial S_1}{\partial p_1} = -\alpha S_1(1 - S_1); \quad \frac{\partial S_2}{\partial p_2} = -\alpha S_2(1 - S_2); \quad \text{and} \quad \frac{\partial S_1}{\partial p_2} = \frac{\partial S_2}{\partial p_1} = \alpha S_1 S_2.$$

So that $(\partial S_1/\partial p_1)(\partial S_2/\partial p_2) - (\partial S_2/\partial p_1)(\partial S_1/\partial p_2) = \alpha^2 S_1 S_2(1 - S_1)(1 - S_2) -\alpha^2 {S_1}^2 {S_2}^2 = \alpha^2 S_1 S_2(1 - S_1 - S_2); -(\partial S_2/\partial p_2)S_1 + (\partial S_1/\partial p_2)S_2 = \alpha S_2(1- S_2)S_1 + \alpha S_1 S_2^2 = \alpha S_1 S_2$ and, similarly, $(\partial S_2/\partial p_1)S_1 - (\partial S_1/\partial p_1)S_2 = \alpha S_1 S_2$.

Thus, one has $p_1 - c_1 = p_2 - c_2 = 1/\alpha(1 - S_1 - S_2)$.

Assume demand is estimated using an NL model, where consumers chose vendor first and then one alternative from the chosen vendor. As a result, in this example, both alternatives sold by the manufacturer are in the same nest, defined with A. Under these conditions, the own and cross-derivative of shares with respect to prices are

$$\frac{\partial S_1}{\partial p_1} = -\frac{\alpha}{(1-\sigma)} S_1(1 - \sigma S_{1|A} - (1-\sigma)S_1);$$
$$\frac{\partial S_2}{\partial p_2} = -\frac{\alpha}{(1-\sigma)} S_2(1 - \sigma S_{2|A} - (1-\sigma)S_2);$$

and

$$\frac{\partial S_1}{\partial p_2} = -\frac{\alpha}{(1-\sigma)} S_1(-\sigma S_{2|A} - (1-\sigma)S_2);$$

and

$$\frac{\partial S_2}{\partial p_1} = -\frac{\alpha}{(1-\sigma)} S_2(-\sigma S_{1|A} - (1-\sigma)S_1)$$

So that $(\partial S_1/\partial p_1)(\partial S_2/\partial p_2) = (\alpha^2/(1-\sigma)^2)S_1 S_2(1 - \sigma S_{1|A} - (1-\sigma)S_1) (1 - \sigma S_{2|A} - (1-\sigma)S_2)$ and $-(\partial S_2/\partial p_1)(\partial S_1/\partial p_2) = -(\alpha^2/(1-\sigma)^2)S_1 S_2 (-\sigma S_{1|A} - (1-\sigma)S_1)(-\sigma S_{2|A} - (1-\sigma)S_2)$. Since $S_{1|A} + S_{2|A} = 1$ $(\partial S_1/ \partial p_1)(\partial S_2/\partial p_2) - (\partial S_2/\partial p_1)(\partial S_1/\partial p_2) = (\alpha^2/(1-\sigma)^2)S_1 S_2(1 - \sigma S_{1|A} - (1- \sigma)S_1 - \sigma S_{2|A} - (1-\sigma)S_2) = (\alpha/(1-\sigma))S_1 S_2(1 - S_1 - S_2)$ The other terms become: $-(\partial S_2/\partial p_2)S_1 + (\partial S_1/\partial p_2)S_2 = (\alpha/(1-\sigma))S_1 S_2(1 + \sigma S_{2|A}+ (1-\sigma)S_2 - \sigma S_{2|A} - (1-\sigma)S_2) = (\alpha/(1-\sigma))S_1 S_2$ and, similarly $(\partial S_2/\partial p_1) S_1 - (\partial S_1/\partial p_1)S_2 = -(\partial S_2/\partial p_2)S_1 + (\partial S_1/\partial p_2)S_2 = (\alpha/(1-\sigma))S_1 S_2$, which gives $p_1 - c_1 = p_2 - c_2 = 1/\alpha(1 - S_1 - S_2)$.

It is easy to verify that under another nesting structure, the $p - c$ for the products produced by a manufacturer will be (except in a special case) different from one another. Assume that product 1 falls into nest A, while 2 belongs to B. While the own-price derivatives are the same as those presented above, the cross-price ones formulas are the same as the MNL, since the two products belong to different nests, i.e. $(\partial S_1/\partial p_2) = (\partial S_2/\partial p_1) = \alpha S_1 S_2$. Then, in this case, one has

$$\frac{\partial S_1}{\partial p_1}\frac{\partial S_2}{\partial p_2} - \frac{\partial S_2}{\partial p_1}\frac{\partial S_1}{\partial p_2} = \frac{\alpha^2}{(1-\sigma)^2} S_1 S_2 (1 - \sigma S_{1|A} - (1-\sigma)S_1)$$

$$(1 - \sigma S_{2|B} - (1-\sigma)S_2) - \alpha^2 {S_1}^2 {S_2}^2 = \frac{\alpha^2}{(1-\sigma)^2} S_1 S_2 [(1 - \sigma S_{1|A})(1 - \sigma S_{2|B})$$

$$- (1 - \sigma S_{1|A})(1-\sigma)S_2 - (1 - \sigma S_{2|B})(1-\sigma)S_1)]$$

and

$$-\frac{\partial S_2}{\partial p_2} S_1 + \frac{\partial S_1}{\partial p_2} S_2 = \frac{\alpha}{1-\sigma} S_1 S_2 (1 - \sigma S_{2|B} - (1-\sigma)S_2) + \alpha S_1 S_2^2$$
$$= \frac{\alpha}{1-\sigma} S_1 S_2 (1 - \sigma S_{2|B})$$

Thus, the expression for $p_1 - c_1$ and $p_2 - c_2$ will be, respectively

$$p_1 - c_1 = \frac{(1-\sigma)(1-\sigma S_{2|B})}{\alpha[(1-\sigma S_{1|A})(1-\sigma S_{2|B}) - (1-\sigma S_{1|A})(1-\sigma)S_2 - (1-\sigma S_{2|B})(1-\sigma)S_1)]};$$

and

$$p_2 - c_2 = \frac{(1-\sigma)(1-\sigma S_{1|A})}{\alpha[(1-\sigma S_{1|A})(1-\sigma S_{2|B}) - (1-\sigma S_{1|A})(1-\sigma)S_2 - (1-\sigma S_{2|B})(1-\sigma)S_1)]};$$

which will coincide only in the special case $S_{1|A} = S_{2|B}$.

Appendix 2

Table A1. Selected first-stage coefficients – overidentifying instruments

	First-stage equation (endogenous variable)	
Instrumental variable	Price	$\text{Ln}(s_{j\|g})$
Sugar price	0.0309*** (0.0093)	0.0025*** (0.0007)
Average volume per unit	0.9948*** (0.0469)	−0.1778*** (0.0035)
Fruit price × fruit	0.0134 (0.0147)	−0.0023* (0.0013)
Nuts price × flavour	−0.0919** (0.0355)	0.0015 (0.0023)
Weighted conditional distribution share	4.4191*** (0.0651)	0.0873*** (0.0038)
Commercial electricity price	−0.0025*** (0.0004)	−0.0002*** (0.0000)

Note: *, **, and *** represent 10, 5 and 1% significance levels. Standard errors are in parentheses.