

Making the ‘right’ choice based on experiments: regulatory decisions for food and health

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Received January 2011; final version accepted May 2011

Review coordinated by Thomas Heckeley

Abstract

This article shows how experiments revealing information about food quality and safety can contribute to regulatory debates on food and health. After detailing the motivations of regulation for the food sector, we underline the limits of theoretical welfare analysis. Despite challenges from behavioural economics, cost–benefit analysis using experimental results can complement theoretical analysis. In a brief review of laboratory and field experiments with food, we discuss their relative strengths and weaknesses and suggest an analytical approach of how to integrate experimental data into welfare analysis. An empirical application quantifies and compares the welfare impact of health information and a subsidy for fish.

Keywords: cost–benefit analysis, experimental economics, food choice, public policy, welfare analysis

JEL classification: D1, D6, I1

1. Introduction

Food-borne diseases, pesticide residues, obesity and nutrient deficiencies are among the numerous pathways in which food impacts health. There are still many open questions when designing public health campaigns, labels and information programmes, when taxing some nutrients at risk of overconsumption or when improving general education and school lunch programmes.

Experimental and behavioural economics may improve our understanding regarding agents’ reactions to regulatory decisions. Economic experiments apply experimental methods to study economic questions via controlled variation of conditions in a laboratory or in a field (Smith, 1982). Behavioural economics improves the theoretical foundation regarding economic decision-making by integrating knowledge from psychology and

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neuroeconomics and by using a variety of tools including economic experiments. By precisely studying agents' decisions, behavioural economics shows that people tend (1) to be impatient and inconsistent when making choices over time, (2) to lack self-control and often procrastinate on difficult decisions, (3) to make cognitive errors leading to a high sensitivity to low-probability and losses and (4) to be strongly influenced by frames and problem or product presentation. The deviation from rational decision-making sometimes leads to the suggestion that governments must intervene. However, even if people do not act rationally, there is no *a-priori* guarantee regarding the efficiency of regulation aiming at thwarting market failures and agents' bounded rationality. As a consequence, it is essential to ponder regulatory choices with cost–benefit analysis that helps measuring welfare impacts on economic actors and conducting an *ex-ante* assessment of regulations.

Taking a policy perspective, this paper seeks to address the following questions: What is the contribution of experimental economics in clarifying links between food and regulation? How may experimental results help the design of an optimal policy for improving food safety and nutritional quality? In this paper, we show that experiments provide valuable information for a welfare assessment of food regulation and for improving cost–benefit analysis. This paper details how heterogeneity and information measured by experiments can be used for guiding public policy. Experimental studies help public debates and regulatory decisions by providing quantified assessments of various regulatory tools while being upfront with the limits of these studies.

Our paper contributes to the literature by directly linking experiments eliciting willingness to pay (WTP) to regulatory debates and choices of regulatory instruments, which was overlooked by previous papers. Given the extent of the literature of behavioural, experimental and regulatory economics, this present framework does in our view not make it possible to broach all aspects of previous contributions. Regarding food economics, the reader could refer to complete overviews on both experimental methods by Alfnes and Rickertsen (2011) and behavioural economics by Just (2011).

This paper is organised as follows. After presenting the motivations of regulation and related issues, we show that estimations of WTP help evaluate policies *ex ante*, since economic theory alone cannot conclude which regulatory instrument should be preferred. Challenges for relevant cost–benefit analysis are reviewed. A brief review of experiments with food are presented by insisting on strengths and weaknesses related to laboratory and field experiments. A new analytical approach suggests how to take into account results of experiments in order to determine the welfare impact of different regulatory tools such as a label and/or a per-unit subsidy. An empirical application quantifies the welfare impact of health information and a subsidy for fish.

2. Motivation for and limits of food regulation

In the absence of government interventions, market failures or the absence of incentives to provide public goods lead to sub-optimal choices of food-

product attributes by firms or consumers (Hamilton *et al.*, 2003). More specifically, the absence of information leads to under-provision of product quality and safety (for a review on food safety, see Antle, 2001). Moreover, the absence of self-control and the excess of food consumption by some consumers entail obesity together with health problems and imply externalities towards taxpayers who finance public health and insurance programmes. Regarding dimensions linked to public goods, an intense use of pesticides negatively impacts environmental quality, farmers' health and consumers' health via pesticide residues in food.

The fact that consumers in the industrialised world take around 200 food-related decisions per day leads to a relative low consumer interest for each product taken individually and the related specific attributes (Wansink and Sobal, 2007). The lack of consumers' attention and awareness reinforces possible risks of market failures to provide satisfying levels of quality. Many food buying decisions do not involve a lot of attention but rather rely on habits and mindless routines (Grunert, 2005).

In their food choices, consumers are often influenced by external cues or extrinsic aspects such as package colours, appearance or ads for knowing what to eat or drink, which may defy a logic only based on health or environmental criteria (Wansink, 2006).¹ For instance, Roberto *et al.* (2010) show that children significantly prefer the taste of foods that have popular cartoon characters on the packaging compared with the same foods without characters. While many children select the product with cartoon characters, the effects are weaker for carrots than for gummy fruit snacks and graham crackers. The use of external cues or extrinsic aspects can be explained by the variety of attributes defining a food product and impeding mindful and conscious decisions by consumers.

The need of regulation depends on the priority given to different product attributes. Finn and Louviere (1992) develop the 'best–worst' scaling methodology to identify food safety attributes that matter for consumers. Lusk and Briggeman (2009) empirically show that safety, nutrition and taste are the most important characteristics, even if there is significant heterogeneity in the relative importance placed on these attributes. Food safety and nutrition can be characterised as vertical differentiation characteristics. This means that if products of differing quality are offered at the same price, all consumers will buy that product with the highest perceived level of quality. In other words, no rational person would knowingly choose an unsafe product over a safe product if the price is the same. This vertical differentiation property implies that regulation improving safety and nutrition is likely to be accepted by many consumers.²

1 Lange *et al.* (2002) and Combris *et al.* (2009) show significant differences regarding hedonic scales and WTP for a champagne that is first blind tasted and secondly tasted with the bottle and the brand revealed. Bushong *et al.* (2010) show that participants' WTP are significantly higher in the real displays of food than in the image or text displays for the same item.

2 Taste can be characterised as a horizontal differentiation characteristic, which means that, if different products are offered at the same price, consumers will choose among the goods

Products contain a multitude of characteristics imperfectly known by consumers, which raises the issue of how specific a regulation must be in order to be effective. Regulation is required to protect consumers and citizens and to guarantee that products provide satisfying attributes for consumers and/or contribute to public good dimensions. Despite market failures previously presented, there is *a priori* no certainty that regulation improves agents' situations because of additional distortions introduced by different public decisions. It is necessary to examine costs and distortions coming from different instruments and we briefly discuss these in the following.

First, safety and quality standards that impose a minimum level of safety/quality can take many forms, such as obligations to achieve a particular result as regards pesticide residues in products or specifications on processes, for example the cold chain or food irradiation to combat pathogens like salmonella. Standards also concern the authorisation of procedures for new products such as nanotechnologies or cloned meat. By guaranteeing a minimum level of quality and safety to consumers, standards make life easier for consumers who do not have to search for complex information about safety or quality (Swinnen and Vandemoortele, 2009). However, standards have the drawback of reducing the diversity of products on the market by eliminating poor qualities. As it is almost impossible to reach a zero-risk level, standards allowing residual risks are sometimes highly controversial.

Secondly, information, certification and labelling policies are more favourable to product diversity, because they allow the presence of various qualities bought by consumers in full knowledge of facts (Verbeke, 2005). These policies guarantee consumers' freedom of choice and sovereignty. The lack of attention and high risk of muddle among consumers regarding the significance of information may lead to inefficiencies. The risk of label proliferation as evidenced in the multiplication of allegations on health or the environment also limits their impact in guiding consumers.

Thirdly, taxation of products posing health risks or subsidies for healthy products acknowledge the price effect on consumer choice, since prices are affected by a tax/subsidy per unit sold. Furthermore, food stamps and free school lunch are subsidies dedicated to relatively poor populations. The revenue generated by taxes reducing purchases of risky products may be earmarked for financing subsidies for healthy products or other actions such as information campaigns. However, the low price elasticity of food demand limits the impact of price variations induced by a tax/subsidy on the quantities consumed.

Fourthly, after an accident or the outbreak of a food-related disease, *ex-post* instruments such as liability rules and product recall are useful for compensating victims and limiting the extent of the outbreak. They also provide an *ex-ante* incentive to producers to improve product safety. Loureiro (2008)

according to their individual preferences for the various characteristics inherent in the goods.

shows that strict liability allowing claims of punitive damages significantly decreases the number of food safety incidents in the USA. However, risk of producers' bankruptcies if the imposed compensation is too large compared with their assets limit the impact of these instruments.

An important question is whether or not these instruments improve welfare defined by the sum of producer profits, consumer surplus and taxpayer burden. As political decisions are complex and sometimes non-transparent, regulations observed in reality are not always socially optimal. Swinnen and Vandemoortele (2008, 2009) underline that regulatory choices are affected by various parameters including levels of income, consumer preferences, administrative costs, lobby pressure, media coverage, etc. Rigorous welfare analysis could help streamlining debates around food and improving regulatory efficiency.

In the context of under-provision of a quality attribute (and a fortiori with several attributes), there is no clear theoretical conclusion about the instrument(s) to select for maximising welfare. Information provision to consumers is pivotal in the welfare analysis (see Marette, 2007). On the one hand, information and labels enhance effective diversity and freedom of choice which is beneficial for society. When information is costless, perfectly broadcast and received by consumers, it dominates other instruments for improving welfare. This argument is raised by many free-market economists. On the other hand, prohibitive labelling costs, difficulties to recall information or a high risk of muddle among consumers regarding the significance of information ruin its efficiency and lead to the consideration of other tools as the socially optimal choice. In this case, the theoretical analysis advises to combine different types of instruments to limit their relative distortions.

Cost–benefit analysis is important to inform regulator's choices between taxes, standards and labels, since the socially optimal choice among tools depends on many parameters including consumers' reaction and preference heterogeneity. We now tackle potential limits of cost–benefit analysis.

3. Considerations regarding behavioural economics and cost–benefit analysis

Results of behavioural economics challenge the feasibility of cost–benefit analysis. Sugden (2009) underlines preference anomalies in environmental evaluation that may disqualify the validity of cost–benefit analysis. Basically preference inconsistencies discovered in behavioural economics (namely psychological attributes of the choice context, inconsistent time preferences and differences between private and social preferences, as defined by Robinson and Hammitt, 2011) question the validity of regulatory evaluations based on these inconsistent preferences.

Preference inconsistency annihilates the tautology of expressed preferences and actual well-being. With preference inconsistency, consumer choice does not necessarily correspond to the choice leading to the highest consumer welfare level, thus voiding choice as a normative criterion on which to base public policy. In light of missing alternative normative principles, some

behavioural economists have hence argued for a soft paternalism. Sunstein and Thaler insist on ‘libertarian paternalism’ that attempts ‘to steer people’s choices in welfare-promoting directions without eliminating freedom of choice’ (Sunstein and Thaler, 2003: 1159).

In this context of preference inconsistency, Bernheim and Rangel (2009) develop a framework evaluating multi-self Pareto optimality and Sugden (2005, 2009) argues that the principle of consumer sovereignty can be maintained. He pleads for using market simulations to inform policy advice on the ground that ‘the market gives effective sovereignty to those [preferences] that are revealed “at the point of consumption” [...]’ (Sugden 2009: 88). Sugden (2009) hence argues for using data from hedonic evaluations in cost–benefit analysis rather than contingent valuation data.

Smith and Moore (2010) criticise Sugden’s approach for not being useful in the context of most cost–benefit analysis, where no equivalent market data are available. In other words, market data do not exist for new products (as cloned beef) or public goods. Smith and Moore (2010) suggest that one way to dwarf the weight of some incoherent preferences is to consider additional constraints in the framework like the framing of the decision context, the lack of time by consumers for thinking about consequences of decisions, the limited ability to collect and understand information, etc.

Robinson and Hammitt (2011: 35) recommend that ‘researchers should continue to incorporate the results of behavioural research into the design of valuation studies where useful and relevant, with the goal of identifying well-informed, thoughtful preferences, regardless of whether stated- or revealed-preference methods are used’. Just and Payne (2009) refer to the interaction between consumers and firms in the food market, so that any possible intervention would not only have to take into account preference inconsistencies in consumer decision-making but also firms reaction thereto.

Many of the ‘human’ limits in decision-making are coming from difficulties to collect, understand and/or process the load of information (Ariely, 2000). In order to take into account additional constraints as mentioned by Smith and Moore (2010), regulatory assessment would consist in systematically integrating results from experiments (or surveys) and possible biases in consumer behaviour for helping the public debate. The empirical evaluation of consumers’ reaction to information is a crucial step for rigorous and convincing cost–benefit analyses. The following section shows that laboratory and field experiments provide different and useful insights on consumers’ reactions precious for welfare estimates.

4. Importance and limits of food experiments with revealed information

Experiments are useful for measuring the impact of information with high precision regarding the heterogeneity in consumers’

reaction. In this section, we mainly focus on laboratory and field experiments.³

4.1. Lab experiments

By gathering participants in a dedicated room, laboratory experiments precisely control the decision-making environment and eventually apply possible interventions or information scenarios. WTP can be measured via auctions such as the Vickrey auction, the Becker–Marshak–de Groot mechanism (see [Lusk and Shogren, 2007](#)) or choices among alternatives (see [Binswanger, 1980](#)).

Many laboratory experiments with food reveal information about one or several attributes and elicit individual WTP on well-informed, thoughtful preferences. In the case of food, knowledge about nutrients and safety attributes in different food products is highly imperfect for many consumers, which justifies laboratory experiments focusing on information revelation. Heterogeneity in consumer responses about the presence of an attribute in a product is efficiently revealed in the laboratory as shown by [Hayes *et al.* \(1995\)](#) for food safety. Many experiments in the last decade elicited consumers' WTP for new technologies with both health benefits and risks as studied by [Alfnes and Rickertsen \(2003\)](#) for hormones in beef, [Fox *et al.* \(2002\)](#) for irradiation, [Lusk *et al.* \(2003\)](#) for genetically modified organisms or [Marette *et al.* \(2009\)](#) for nanotechnologies.

The experimental literature on food generally shows that unfavourable information weighs more on choices than favourable information (see [Fox *et al.*, 2002](#)). [Marette *et al.* \(2008a\)](#) show that information about risk leads to a significant change in WTP, independent of the order mentioning risks or benefits of a product attribute. However, if benefits are mentioned before the risk, then beneficial attributes also impact WTP. Conversely, if the message on risk precedes the message on benefits, the major shift in the WTP only comes from the information on risk and additional information on benefits does no longer cause subsequent changes in product evaluation.

[Huffman *et al.* \(2007\)](#) also mention that the source of information matters. Trust in source validity is an important determinant of information relevance. [Hurley and Shogren \(2005\)](#) show that, in presence of risks, people seem to overestimate low probabilities and underestimate high probabilities, which makes the elicitation of WTP for different levels of risk difficult. WTP is likely to be relatively insensitive to risk magnitude (see [Hayes *et al.*, 1995](#); [Goldberg and Roosen, 2007](#)).⁴

The literature provides evidence of external validity of experiments with food, which allows to generalise the relationships found in one experiment to

3 We abstract from hypothetical choice experiments or contingent-valuation surveys. These methods are particularly tailored for eliciting WTP for new products not introduced on the market like cloned beef or nanotechnologies.

4 Other papers analyse the effect of framing. The reader is referred to [Cox *et al.* \(2006\)](#) for an analysis of framing effects of risk information on behavioural intentions.

other contexts as done in Section 5. It means that experimental results from the laboratory can be taken seriously by economic agents and public decision-makers. Some papers directly compare the results of a laboratory experiment with those of market data or field experiments in stores. [Shogren et al. \(1999\)](#) showed that laboratory evaluations and market shares coincide at high price valuations, supposedly selecting the truly interested consumers. [Lusk and Fox \(2003\)](#) and [Marette et al. \(2008c\)](#) have suggested that field valuations were larger than laboratory valuations. [Chang et al. \(2009\)](#) demonstrate a high level of external validity of non-hypothetical elicitation approaches in predicting retail sales. The relative proximity between laboratory and field experiments on food choice can be explained by (i) the similarity of stakes in both experiments (namely, purchased products are similar) and (ii) the absence of significant effects coming from differences between experienced and inexperienced participants. We can hence conclude that, for a given quality attribute or a specific question, a laboratory experiment is useful to elicit individual WTP based on well-informed, thoughtful preferences, even if decisions in real situations are never taken in a context similar to the laboratory.

4.2. Field and natural experiments

Field experiments examine interventions in a real-world context rather than in the laboratory.⁵ A treatment group is impacted by an intervention, while the control group is not affected by it. Field experiments randomise participants into treatment and control groups and compare outcomes between these groups via difference-in-differences estimations. Despite a limited level of control in the experimental treatment, they have the advantage of a more realistic choice environment in which food consumption decisions are observed. A natural experiment is a situation for which the assignment of intervention has been made by a decision-maker or by 'nature', and not by experimental design.

Field and natural experiments may test the impact of a recommendation or a label, even if quantified results depend on the context or the severity of health claims. In a seminal paper, [Jin and Leslie \(2003\)](#) showed that a grading system with letters A to D indicating food safety of restaurants significantly impacted the consumers' choice of restaurants in Los Angeles.⁶

The question of the efficiency of labels in real contexts is particularly salient for the traffic-light system in UK ([FSA, 2011](#)), the health check mark in Canada or the keyhole in Scandinavia. These kinds of labelling systems try to summarise complex health information in one or a few dimensions as different colours. These simple systems have the advantage to give

5 Embedded in an environment where participants naturally undertake their tasks, [Harrison and List \(2004\)](#) distinguish between framed field experiment where participants know that they participate to an experiment and natural field experiment where participants do not know that they are involved in an experiment.

6 Several papers underline that a relatively short message revealed to consumers is more efficient for changing consumer behaviour compared with a long and complex message (see [Wansink et al., 2004](#); [Verbeke, 2005](#)).

easy guidance to consumers. For consumers in a fast moving world, simple indications may increase attention and motivation when making purchasing. However, the regulator has to be careful when designing the guidelines for attributing the symbol. In addition, such an approach equates the nutritional needs of all consumer groups and does not allow flexibility in the communication to groups with specific needs (e.g. a particular low salt content).

New results suggest a relatively small impact of traffic lights systems on sales. Based on a natural experiment in the UK, [Sacks *et al.* \(2009\)](#) show a small effect on the sales of some products and the absence of an effect for others. In a field experiment in an Australian online grocery store, [Sacks *et al.* \(2011\)](#) show the absence of significant effects of traffic lights on sales. Based on in-store observations in UK supermarkets and questionnaires, [Grunert *et al.* \(2010\)](#) show that consumers' understanding of traffic lights was high, with a large proportion of respondents (80 per cent) being able to identify the healthiest product, while usage of these labels is mainly related to interest in healthy eating.

In a field experiment, [Wisdom *et al.* \(2010\)](#) show that providing daily calorie information on sandwiches in a fast-food restaurant reduces calorie intake, but does so only for non-overweight individuals. Such a message has a positive but limited social value for sensitive and educated people, whereas the decision-maker is thinking about overweight people who cluster in groups of low education.⁷ It points to the issue that even efficient information campaigns may increase inequality in health choices, rather than decreasing it. [Wisdom *et al.* \(2010\)](#) also show that making healthy choices convenient reduces calorie intake. This confirms the importance of arranging fruits and vegetables on visible or prominent shelves in the cafeteria, when consumers and kids use simple routines for choosing their food.

Even when information is provided in a real purchase context, the lack of time and attention or the difficulty in understanding and recalling health messages impedes the internalisation of health characteristics by consumers. As consumers' real purchases do not reflect consumer preferences under complete information and sufficient attention, additional social benefits may potentially come from regulation. As previously shown, laboratory experiments are useful to complement evidence from field experiments and elicit individual WTP based on well-informed, thoughtful preferences.

5. Regulatory tools and welfare analysis integrating experimental results

Experiments are useful for quantifying consumers' reaction to information about attributes and regulation. They provide hence important information to complete theoretical analyses mentioned in Section 2 leading to quantified

⁷ [Bollinger *et al.* \(2011\)](#) also show a significant but low impact of mandatory calorie posting on consumers' purchase decisions using detailed data from Starbucks. They find that average calories per transaction fall by 6 per cent.

welfare analysis. The following empirical framework integrates individual WTP estimates in a calibrated partial equilibrium model detailing price and cost effects of regulatory tools.

Even if we focus our attention on the integration of results from a laboratory experiment in the following analysis, the final part of this section will suggest how to integrate field results in a welfare analysis. Lusk and Marette (2010) show how this method can be extended to discrete choice models and surveys.

For the following estimation, we use some results of the experiment described in Marette *et al.* (2008a). The experiment dealt with health messages related to fish consumption. It was conducted in France with women of childbearing age, since fish is particularly important during pregnancy. Successive messages revealing risks (methyl-mercury) and benefits (omega-3s) of consuming sardines and tuna were delivered. The women were asked their willingness to exchange an endowment of one fish against a varying quantity of the other fish (see Binswanger, 1980; Masters and Sanogo, 2002). This mechanism is incentive compatible since the remitted products at the end of experiment were randomly selected out of the multiple choices by participants.

Here, we only focus on the WTP change for sardines following the message on omega-3. The participants significantly increased their WTP for sardines, when information about their high content of omega-3 is revealed. The average WTP shifts from EUR 1.6 to EUR 2.3 for a can of sardines. As this WTP increase is statistically significant, the WTP shift can be used for measuring the welfare impact of various regulatory measures. We compare two approaches with the measurement of welfare effects using WTPs from the same experiment.

5.1. Approach 1: direct use of individual WTP estimates

Approach 1 directly uses individual estimates of WTP (see Lusk *et al.*, 2005; Huffman *et al.*, 2007; Rousu *et al.*, 2007; Lusk and Marette, 2010). It hence explicitly acknowledges the full heterogeneity of consumer preferences. Let $WTP_{i,0}$ and $WTP_{i,1}$ indicate individual i 's willingness-to-pay for a product before and after the revelation of information, respectively.

For the can of sardines used in the experiment (see Marette *et al.*, 2008a), we denote the price of this can as P_A and we directly introduce the per-unit subsidy s that is passed into the price. For a can of sardines purchased at a price $P_A - s$, consumer i derives utility $WTP_{i,0} - (P_A - s)$ under the absence of information and zero in the case of non-purchase (i.e. the utility of non-purchase is normalised to zero). The consumer chooses the option generating the highest utility, namely

$$CS_{i,0}(s) = \max\{WTP_{i,0} - (P_A - s), 0\} \quad (1)$$

However, equation (1) does not give a full welfare estimate, as the health benefit of the product will be obtained by consumers of the product, but

will not be measured in their non-informed valuation, $WTP_{i,0}$. The welfare should also take into account the effect of ignorance, $J_i(WTP_{i,1} - WTP_{i,0})$ where J_i is an indicator variable taking the value of 1 if individual i is predicted to have chosen the product at $P_A - s$ without the information. The cost of the per-unit subsidy linked to the purchase by participant i is $J_i s$ and the 'cost for taxpayers' is given by the sum of $J_i s$ over the number of participants. For a participant i , the total welfare without information is

$$\overline{CS}_{i,0}(s) = \max\{WTP_{i,0} - (P_A - s), 0\} + J_i(WTP_{i,1} - WTP_{i,0}) - J_i s \quad (2)$$

The effect of ignorance should be accounted for, since it corrects the non-informed valuation, $WTP_{i,0}$, when the consumer purchases the good without information and thus receives the benefit without fully valuing it in the WTP estimate.

With a per-unit subsidy, s , some consumers may change their purchasing decisions because of the price decrease, despite not having additional information. Compared with the absence of subsidy, the average variation in per-unit welfare is equal to $\sum_{i=1}^L [\overline{CS}_{i,0}(s) - \overline{CS}_{i,0}(0)]/L$, by taking into account the L participants to the experiment. The optimal subsidy s^* maximising this variation is determined numerically.

When the information about omega-3 is revealed without subsidy, WTP may change and the consumer chooses the option generating the highest utility, namely

$$CS_{i,1} = \max\{WTP_{i,1} - P_A, 0\}. \quad (3)$$

In the latter case, there is no effect of ignorance since all the information is revealed. The welfare variation linked to the information provision is defined by $CS_{i,1} - \overline{CS}_{i,0}(0)$. The difference is not zero when the participant who did not purchase the good without information (with $\overline{CS}_{i,0}(s) = 0$) decides to purchase the good when the information is revealed (with $CS_{i,1} > 0$). By taking into account the L participants, the average variation in the per-unit welfare is equal to $\Delta CS = \sum_{i=1}^L [CS_{i,1} - \overline{CS}_{i,0}(0)]/L$. This variation is shown on the left chart of Figure 1, where the ordered WTP before the revelation of information, $WTP_{i,0}$, are represented, and the corresponding WTP after the revelation of information, $WTP_{i,1}$, are represented by bold segments.

5.2. Approach 2: use of average WTP

Approach 2 relies on a combination of an elasticity of demand obtained from times-series econometrics and the average WTP value obtained from the experiment (see Roosen, 2001; Marette *et al.*, 2008a, 2008b). Heterogeneity in consumer preference can be acknowledged by separating demand into different market segments. The demand of each consumer $i = \{1, \dots, N\}$

over a period is derived from a quasi-linear utility function that consists of the quadratic preference for the market good of interest and is additive in the numeraire good, w_i :

$$U_i(q_i, w_i, I) = aq_i - \frac{\bar{b}q_i^2}{2} + Ie_iq_i + w_i, \quad (4)$$

where q_i is the consumption of sardines. The parameters $a, \bar{b} > 0$ allow capturing the immediate satisfaction from consuming products. The positive effect coming from omega-3 is captured by the term Ie_iq_i with the per-unit benefit e_i . Parameter I represents the consumer's knowledge regarding the benefit of omega-3. If consumers are not aware of the characteristic, then $I = 0$. However, the characteristic is accounted for in the welfare via the non-internalised benefit.

The maximisation of utility defined by (4) with respect to q_i , subject to the budget constraint with a sardines price $P - s$ (where P is the average baseline price over the period and s is the per-unit subsidy), gives the individual demand $q_i(P - s, e_i) = \text{Max}[0, (a + Ie_i - P + s)/\bar{b}]$.

Individual demands are aggregated by subgroups. A proportion $\beta = N_1/N$ of consumers are concerned by the benefit of omega-3, with $e_i = e$ for every $i = 1, \dots, N_1$ (β and e are given by the experiment). The proportion $(1 - \beta) = 1 - N_1/N$ of consumers is indifferent with regard to the omega-3 with $e_i = 0$ (corresponding to $\text{WTP}_{i,1} = \text{WTP}_{i,0}$ via the experiment). With $b = \bar{b}/N$ for the concerned consumers, the aggregate demand of this group is $Q_1^D = \sum_{i=1}^{N_1} q_i(P - s, e) = \text{Max}[0, \beta(a + Ie - P + s)/b]$ and the inverse demand is $P_1^D(Q, I, s) = a + Ie + s - (b/\beta)Q$. For the indifferent consumers, the aggregate demand is $Q_2^D = \sum_{i=1}^{N-N_1} q_i(P - s, 0) = \text{Max}[0, (1 - \beta)(a - P + s)/b]$.

It is assumed that the supply is perfectly elastic at price P (which implies constant returns to scale and zero profits for producers). With R denoting income, the consumer surplus for the concerned consumers is given by $\beta(a + Ie - P + s)^2/(2b) + R$. The regulator also takes into account the effect of ignorance defined by $+(1 - I)eQ_1^D$ and the cost of the subsidy $s(Q_1^D + Q_2^D)$. The consumer's surplus for indifferent consumers is given by $(1 - \beta)(a - P + s)^2/(2b) + R$. The sum of surplus of indifferent and concerned consumers, the cost of subsidy and effect of ignorance leads to welfare $W(I, s)$.

The label informing consumers changes I to $I = 1$. The welfare variation over a period linked to the information revealed to consumers is given by $W(1, 0) - W(0, 0)$. This variation is shown on the right-hand side chart of Figure 1 with $\beta = 1$ and we arbitrarily set $P = P_A$ only for facilitating the graphical comparison. Alternatively, with no information and $I = 0$, a subsidy $s^* = \beta e$ maximising welfare $W(0, s)$ is selected. The welfare variation linked to the choice of per-unit subsidy is given by $W(0, s^*) - W(0, 0)$. The parameter a and b are determined by classical calibration methods taking

Table 1. Absolute and percentage changes in welfare for different regulatory tools compared with the baseline scenario (without regulation).

Scenarios	Approach 1	Approach 2
Per-unit subsidy (€/kg)	$s^* = 7.38$	$s^* = 4.05$
Per-unit welfare variation (€/kg)	0.03	0.36
Aggregate welfare variation (€)	443,006 (+0.3 per cent)	4,212,258 (+2 per cent)
Label received and read by all consumers		
Per-unit welfare variation (€/kg)	1.62	0.76
Aggregate welfare variation (€)	18,661,500 (+13.3 per cent)	8,775,539 (+5 per cent)

Note: Under Approach 1, a can used for the experiment weighed 80 g. The per-unit welfare per kg consisted in the estimated welfare per can multiplied by 12.5 = 1/0.08. The aggregate welfare variation for the year 2002 consisted in multiplying the welfare per kg by the quantity purchased over the year 2002. Under the Approach 2, the per-unit welfare consisted in dividing the aggregate welfare variation for the year 2002 by the quantity purchased over the year 2002.

into account the consumption $\hat{Q}$ of the whole French population.⁸ The welfare variation over a period under Approach 2 is related to variations in per-unit welfare under Approach 1, via the multiplicative factor considering the observed number of units $\hat{Q}$ sold over the period.

Parameter e is determined by WTP data coming from the experiment using values $WTP_{i,0}$ and $WTP_{i,1}$ indicating, as above, individual i 's WTP for the product before and after the revelation of information. The relative variation in WTP based on the experiment provides a measure of the inverse demand shift, $\delta = E[(WTP_1 - WTP_0)/(WTP_0)]$, where E denotes the expected value estimated by the sample mean over the concerned participants (with $WTP_{i,1} > WTP_{i,0}$). Extending the point estimates of WTP using the inverse demand curve $P_1(\hat{Q}, I, 0)$ for concerned consumers can conceptually be used to derive an estimate of the inverse demand shift for the whole population leading to $[P_1(\hat{Q}, 1, 0) - P_1(\hat{Q}, 0, 0)]/P_1(\hat{Q}, 0, 0) = \delta$. The price $P_1(\hat{Q}, 0, 0) = P$ and the equality $P_1(\hat{Q}, 1, 0) - P_1(\hat{Q}, 0, 0) = e$ leads to an estimated value $\tilde{e} = \delta P$.

5.3. The estimation

Table 1 shows consumer welfare changes linked to both instruments for the sardine market for the year 2002. It shows a positive net welfare gain from intervening for both approaches and both instruments. Caution must be

8 Using existing data on the quantity $\hat{Q}$ of the product sold over a period, the average price P observed over the period, and the direct price elasticity $\hat{\varepsilon}$ obtained from time-series econometric estimates, the calibration leads to estimated values for the demand equal to $1/\hat{b} = -\hat{\varepsilon}\hat{Q}/P$ and $\hat{a} = \hat{b}\hat{Q} + P$. Details about the parameters used for the calibration are given by information about sardines in Table 2 in [Marette et al. \(2008c\)](#).

taken, though, because the administrative costs not accounted for here would need to be subtracted from the aggregate welfare variation for a complete cost–benefit analysis.

Under the assumption of costless implementation, the label read and received by all consumers is socially optimal, whichever of the approaches used in the assessment. The label guarantees product diversity and freedom of choices, while the subsidy pushes consumers who would not purchase sardines because of their high price, even when knowing the benefit linked to them. In this case, the subsidy is welfare dominated by the label, since some consumers do not value omega-3 (with a constant WTP whatever the information). The subsidy increases their sardine purchases without reaping any additional benefit. This leads to a cost to society. The subsidy impact is also limited since the demand elasticity is relatively low (under Approach 2), leading to a costly, but relatively low-quantity adjustment for increasing consumption. However, the comparison of the subsidy and the label in Table 1 assumes that all concerned consumers read and understand the provided information.

The previous simulation is oversimplified for fully characterising consumer choice. In particular, the dominance of the label over the subsidy in Table 1 is linked to the *extreme* assumption of a label perfectly known and understood by all consumers and available in every supermarket, which is unlikely to occur in real situations where credible information is hard to convey. Based on a field experiment, Roosen *et al.* (2009) show the difficulties in recalling fish species when the information is conveyed by a message or a medical recommendation.

When some consumers are not informed by the label/recommendation (or do not understand it), the social benefit exhibited in the last line of Table 1 decreases. Additional simulations with Approach 2 show that, if more than 48 per cent of consumers are aware of omega-3 and internalise the benefit, the label leads to a higher welfare compared with the subsidy. Furthermore, for a proportion $\gamma < 1$ of aware consumers, the optimal policy consists in combining the label and a subsidy equal to $4.05 \times (1 - \gamma)$. The laboratory experiment is hence useful for quantifying the effect of combined instruments. The percentage of aware consumers can also be measured with results from a field experiment (see Marette *et al.*, 2011, for a combination of both laboratory and field experiments).⁹

Without the label available, the subsidy is socially preferred compared with the absence of intervention (see first lines of Table 1). Column 1 (Approach 1) shows that the welfare impact of the subsidy is relatively small and that therefore the results are sensitive to the validity of the demand curve coming from the laboratory. The effect is small, because it is based on a few concerned

9 For many food topics, the simple methodology could be extended by considering alternative welfare measures and other regulatory tools. Disdier and Marette (2010) use results from a laboratory experiment for calibrating the damage e introduced in equation (4) with results from a natural experiment linked to the reinforcement of a standard for limiting anti-biotic residues for crustaceans in the European Union.

participants (and their individual WTP) who need a large subsidy ($s^* = 7.38 \text{ €/kg}$) to react and purchase. With more credibility coming from demand analysis on time-series data using many data points, column 2 gives a per-kg subsidy of $s^* = 4.05 \text{ €/kg}$ that can be imposed on canned sardines in France.

The method leading to Table 1 has limitations, since substitutes were omitted. The results of Table 1 could be extended to other instruments of market intervention such as fortification of other foods with omega-3. Subsidies of healthy fish could also be combined with taxes on fish at risk of excessive contamination. Marette *et al.* (2008c) develop a tax-subsidy programme maximising welfare based on the same experimental results with the tax revenue earmarked to finance the subsidy. Moreover, a safety standard capping the mercury content in some fish could also be taken into consideration and studied.

Despite such limitations coming from experiments and related welfare estimations, the computed effects of the instruments are informative simulations that provide credible suggestions for policy. The chosen instruments are driven by consumers' preferences and welfare maximisation aimed at limiting distortions linked to instruments.

6. Conclusion and outlook on future research

Making the 'right' choice in food regulation related to health is a thorny issue. Regulators can help individual consumers to make the right choices by internalising health risks and benefits of consumption choices. This paper showed that experiments may be used for cost-benefit analysis of regulatory options and that experimental results may help by comparing various regulatory scenarios. It showed how ambiguity in risk-benefit information may be evaluated by consumers and it referred to the importance of source credibility when evaluating information.

The integration of experimental results into cost-benefit analysis is challenged by their ability to measure consumers' true preferences. Experiments in behavioural economics have shown that choices may be influenced by perceptual distortions, cognitive biases and rules of thumb (Just, 2006). Such effects may be taken into account when modelling firms' response to market interventions (Just and Payne, 2009).

The methodology developed in the previous section can be used by administrations, parliaments or regulatory agencies for forecasting the consequences of their regulatory decisions. It could also help to develop procedures for regulatory assessments with evidence-based policy approaches (e.g. OECD, 2010).

The methodology of the previous section seems particularly tailored to the obesity challenge where many instruments could be selected. Mazzocchi *et al.* (2009) advise the combination of fat taxes and thin subsidies. It would be possible and challenging to calibrate household production functions with data from behavioural experiments for studying policies fighting obesity. This type of calibration could integrate precise econometric observations about calorie intakes (see Loureiro and Nayga, 2005; Nayga, 2008; Bhargava, 2010). In particular, the fact that fat intake is higher during the weekend than during the week

(Bhargava, 2010) and the fact that TV viewing significantly influences children obesity (Chang and Nayga, 2009) may lead to study a policy that subsidises gyms, sport clubs or educational programmes for relatively poor kids during the weekend. These programmes could be financed by a tax on fat products.

Regarding future regulatory debates, the following topics are likely to be at the forefront of the public agenda. First, complete cost–benefit analysis for food safety programmes could be enriched by adding options like irradiation (Fox *et al.*, 2002) or food safety vaccination. Alternatively, WTP by particular consumers as the ones suffering food allergies could be compared with segregation costs for offering food that can be guaranteed to be free from a certain allergen. Secondly, field experiments could be used for implementing programmes for reducing pesticides use by farmers in order to reduce pesticide residues in fruits and vegetables and to enhance health in rural areas. Beyond issues of health, new food products based on controversial technologies such as nanotechnologies and cloning are likely to invade markets and raise debate. Welfare analysis could streamline the debate about the relevance of these products and the possible labels providing diversity on the market. Other questions coming from carbon footprint, food miles and land use are likely to be prominent over the next years. One challenge consists in developing credible and readable labels making sense for consumers and avoiding label proliferation. Experimental methods may contribute to ward off such problems. Eventually, the distribution of WTP could be used to show and explain the health-income gradient in the value of health information and derive implications for policy also with regard to equity issues.

Despite the advances in methodology for regulatory assessment, challenges equally remain for data collection. Many health issues require the analysis of long-term behavioural changes while experimental approaches are often short term and, at best include a surveillance for a couple of months. Secondly, the vast variety of food products available in grocery stores makes it important to consider the number of substitutes available to consumers and the difficulty in having a sustained change in behaviour. The same effect requires robust measures on the elasticity of substitution among food products in a similar product category. Eventually, further integration of data sources from laboratory with field experiments and with actual market data is necessary to improve the validity of results.

Acknowledgements

We gratefully acknowledge the helpful comments by two reviewers and the coordinating editor. The usual disclaimer applies.

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