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Quality, Market Mechanisms and Regulation in the Food Chain

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Quality, Market Mechanisms and Regulation in the Food Chain

Abstract: This paper focuses on questions related to the regulation of quality in the food chain. The paper first recalls the new challenges related to quality in the food chain, with an emphasis on the issue of sustainability. This first part underlines that the numerous dimensions related to sustainability make the regulation necessary but difficult. Then the paper introduces a partial equilibrium model calibrated with empirical data, for helping evaluate which regulatory instrument should be socially preferred *ex ante* on a case-by-case basis. An application to the milk market focuses on linseed for feeding dairy cows, which reduces methane emissions and increases the omega-3 content of milk. Simulations compare the impact of the exclusive use of one label signaling omega-3, versus the impact of a minimum-quality standard imposing linseed in the diet of all dairy cows. Both instruments would have a positive impact on consumers' surpluses and some producers' profits. This application shows that details about the influence of regulatory tools on surpluses may be given on a case-by-case basis.

Keywords: Market regulation, quality, sustainability, experiment, welfare estimation.

JEL codes: D82, C91.

1. Introduction

There are still many open questions when designing public policy for improving food quality (Unnevehr et al., 2010). Food-borne diseases, pesticides use, various pollutions coming from agriculture, nutrient deficiencies, malnutrition, obesity, animal welfare (…) are among the numerous pathways in which food impacts consumers' welfare, public health and environment. The choice of regulatory instruments for improving quality is difficult, since the regulator should choose among many instruments, such as mandatory norms and standards, labels and information programs, taxes and/or subsidies depending on products quality (Hahn and Tetlock, 2008). These regulatory questions are particularly acute for the sustainability of the food sector, since many public debates now turn to questions related to the long-term viability and the public impact of the food sector (FAO, 2010).

The paper focuses on questions related to quality/sustainability regulation in the food chain. The paper first recalls the new challenges related to quality in the food chain, with an emphasis on sustainability. It underlines that the numerous dimensions related to sustainability make the regulation necessary but difficult. The paper also underscores that the theory cannot directly conclude which instrument should be socially preferred.

In such a context, estimations of willingness-to-pay (WTP) and econometric estimations are useful for complementing the theoretical analysis and evaluating policies *ex ante,* on case-by-case basis. In particular, calibrated models with empirical estimations try to combine different sources of data to understand and predict possible responses to policy changes, aiming at improving quality and sustainability of products. We introduce a partial equilibrium model calibrated with empirical data, for helping evaluate which regulatory instrument should be socially preferred *ex ante* on a case-by-case basis.

An application to the milk market focuses on linseed for feeding dairy cows, which reduces methane emissions and increases the omega-3 content of milk. By mixing up an environmental dimension and a heath dimension, linseed for feeding dairy cows directly pertain to the sustainability of the milk sector. The calibrated model uses willingness to pay for milk elicited in a lab. Indeed, lab experiments provide many details about the way participants receive information, since the organizer precisely controls messages revealed to participants. From elicited WTP, simulations were conducted for estimating variations in surpluses related to different policy. More precisely, simulations compare the impact of the exclusive use of one label signaling omega-3, versus the impact of a minimum-quality standard (MQS) imposing linseed in the diet of all dairy cows. The integration of estimated marginal cost in profit functions of supply chains leads to endogenous market prices of products, following the choice of one regulatory instrument. We show that both instruments would have a positive impact on consumers' surpluses and some producers' profits. Eventually, we insisted on the limits of these simulations.

This paper adds to the literature by focusing on some overlooked questions resulting from regulation. The application with milk products shows that interesting details, like the impact of regulatory tools on sustainability, may be tackled for helping public debates. This papers differs from general equilibrium models like Fapri (see Fapri, 2016) or Globiom (see Globiom, 2016), in which regulatory tools for improving quality are not studied with such a level of precision.

This paper also contributes to the literature on welfare estimates with WTP elicited in the lab. In particular, we expand the choice of regulatory instruments with a label policy and a MQS, which may increase the role of experimental data. We also detail the endogenous prices competition following the choice of a regulatory instrument. This differs from previous contributions by Lusk et al. (2005), Lusk and Marette (2010), Marette et al. (2008 and 2011),

Rousu et al. (2007) and Rousu and Lusk (2009), only focusing on the impact of information and only using fixed market prices.

This paper is organised as follows. The next section first recalls the new challenges related to quality in the food chain, with an emphasis on sustainability. After presenting the motivations of regulation, we show that an empirical application helps evaluate policies *ex ante*, since economic theory alone cannot conclude which regulatory instrument should be preferred. An empirical application quantifies the welfare impacts of the exclusive use of one label signaling omega-3, and one minimum-quality standard imposing linseed in the diet of all dairy cows. The final section concludes.

2. New challenges linked to the sustainability of the food sector

Quality of foods encompasses many dimensions. In the food sector, the concept of sustainability has recently gained momentum, and this term can be seen as a "holistic" concept, gathering all the private and public dimensions related to the quality, defined in a broad sense (see Krystallis et al., 2012). The sustainability questions have recently emerged on the agenda of firms, non-governmental organizations (NGOs) and governments.

Sustainability mixes up many dimensions such as security of the supply of food, health, nutrition, safety, affordability, organoleptic characteristics, strong food industry in terms of jobs and growth, durability of the farm sector with "reasonable" land use, animal welfare, relative naturalness of the production, and obviously many environmental characteristics such as climate change, quality of air, soil and water, biodiversity, absence of dangerous residues (Tobler et al., 2011). Passionate debates around these topics suggest a complex balance between private and public interventions for reaching sustainability, integrating all these dimensions. The three following examples underline the complex links

between different dimensions including environmental, public health and social dimensions.

2.1. *Farmed tropical shrimps*

The environmental impact of farmed shrimp production is particularly acute, since the expansion of farmed tropical shrimps implies many problems (see Debaere, 2010). In particular, natural-coastal habitat has been destroyed to create ponds for shrimp production. Shrimp farming has destroyed mangroves areas in some Asian countries. These mangroves are particular vital for wildlife protection and also serve as a natural barrier against storms. The supply of water to shrimp farms have contaminated some coastal-land areas with salt water. Eventually, the high concentration of shrimps in ponds leads to serious pollutions, with possible outbreaks of disease such as salmonella for shrimps and ultimately for consumers (WWF, 2014). Producers use antibiotics for thwarting pollution and foodborne diseases, which led to health regulations with bans of some dangerous antibiotics (Disdier and Marette, 2010). One solution for improving the sustainability of this process consists in developing organic shrimps that reduce both concentration in ponds and use of antibiotics, even if this organic process significantly increases the cost of products (Disdier and Marette, 2012). For other goods like avocado and quinoa, the booming demand also entails many problems regarding the land use by farmers and the management of natural resources (May, 2016).

2.2. *The palm oil controversy*

Palm oil is increasingly used in many products sold in supermarkets (Friends of the Earth, 2005). Its production, mainly in Malaysia and Indonesia, has become a sensitive topic, with NGOs intensive campaigns against its use (e.g., Greenpeace, 2007). Researches have highlighted environmental damage related to palm oil production, as the destruction of rainforests in Southeast Asia and their replacement by gigantic palm groves, with numerous

detrimental consequences for biodiversity, endangered species, such as orangutans, and greenhouse gas emissions. The health impact of palm oil, which has a high concentration of saturated fat compared to alternative oils, is another issue generally overlooked by NGOs and the media. Eventually, the issue of land use also matters when focusing on the production of alternative oleaginous crops (e.g., groundnut, cotton, sunflower, soy or rapeseed oil). Indeed, to supply the same amount of oil, one would need to plant 5 to 10 times as much land with other oleaginous plants compared to palm groves (Economist, 2010). This makes the palm oil relatively efficient in terms of yields per hectare compared to other oleaginous crops (Disdier et al., 2013). Consumers are faced with difficulties to consider all these previous issues.

2.3. *Linseed for ruminants*

Because of enteric fermentation, ruminants are emitting a lot of methane that is one important greenhouse gas (FAO, 2012). As the methane lifespan is only twelve years, reducing the related emissions would have a rapid effect on the atmosphere (FAO, 2012). Adding oilseed lipid supplements from linseed, rapeseed, soybeans, or sunflower to the diet of dairy cows significantly reduces the production of methane. Linseed appears as the most efficient supplement leading to configurations with a 20% or 30% reduction in methane emissions (Nguyen et al., 2012). Beyond the reduction of emissions, linseed in dairy cows diet also leads to milk with a higher content in omega-3 polyunsaturated fatty acids protecting the cardiovascular system for consumers (Glasser et al., 2008). Eventually, growing more linseed for supplementing milk offers other advantages regarding the land use. In particular, linseed is tailored to crop rotations as a break crop for cereal production (Chan, 1996).[1] Despite these advantages coming from linseed, a vast majority of bottles sold in the world

[1] Because of cow feeding in pasture, organic milk also reaches a higher level of omega-3 compared regular milk coming from cows mainly fed a diet with corn in barns.

offer milk from cows fed a diet without linseed, namely with corn or other fodders (Marette and Millet, 2014).

2.4. *Sustainability and market mechanisms*

These three previous examples lead to important remarks regarding the link between market mechanisms and regulation. First, with many food productions, environmental and public health characteristics are interdependent and cannot be considered separately. Second, as environmental characteristics are related to nutrition characteristics, there is a complexity in trade-offs related to the production for reaching a satisfactory level of sustainability. Third, consumers cannot take into account all criteria and trade-offs linked to sustainability, which limits their ability to influence the market for providing incentives towards sustainable products. Fourth, supply chains are not always organized for promoting new sustainable practices. This question of supply chains particularly matters for food multinationals, since being publicly perceived as "unsustainable" companies could lead to financial losses and/or a negative reputation. Fifth, because of all previous points, market failures and absence of incentives to provide all public/private characteristics lead to sub-optimal provision of quality/sustainability by sellers of a supply chain. Sixth, regulation is necessary, but the numerous dimensions related to sustainability make this regulation extremely difficult and potentially doomed to failures.

These previous points lead to the following question: is a relevant and coherent regulation possible with so many dimensions at stake for defining sustainability? As it is almost impossible to reply to such a broad question, the rest of this paper will try to offer some arguments for "streamlining" the debate. The next section will search in the economic and theoretical contributions for understanding the tools that could be selected, in order to improve quality and sustainability.

3. The regulatory tools for improving quality and the economic analysis

Market failures and the absence of incentives to provide public/private goods lead to sub-optimal choices of quality/sustainability by a supply chain. Regulation is then required to guarantee that products provide satisfying attributes for consumers. However, there is no certainty that regulation improves agents' situations, because of costs and distortions coming from regulatory instruments. Despite the abundance of theoretical works, no single instrument is clearly superior for improving welfare and guiding policy choices (Goulder and Parry 2008). We may distinguish three categories of regulation, for which advantages and distortions can be underlined.

(1) *The norms and MQS* impose on producers a minimum level of quality/safety and they can take many forms, such as obligations to achieve a particular result, like pesticide residues in products, or specifications on processes, like some crop rotations bringing natural sources of nitrogen rather than chemical fertilizers. A MQS also concerns the authorization procedures for new products such as genetically modified organisms or meat from cloned animals. By guaranteeing a minimum level of quality/sustainability to consumers, standards make trade easier (Disdier and Marette, 2010). However, MQS have the drawback of reducing both the diversity of products, by eliminating poor qualities, and the competition, by limiting entry to the market for some firms (Ronnen, 1991, and Marette, 2007).

(2) *Information and labelling policies* are more favourable to product diversity because they allow the presence of various qualities bought by consumers under full knowledge of food characteristics (Bonroy and Constantatos, 2015). Labels are sometimes compulsory, as in the case of informative messages on nutrition. These information policies aim at guaranteeing the consumers' freedom of choice. The main limit of labels comes from

the imperfect recall by consumers and their possible confusion between good and bad characteristics related to products, as soon as the information given is technical or complex. Furthermore, a tendency toward the proliferation of labels is observed, with in particular, the multiplication of claims on health, environment and/or sustainability, which may limit the impact of labels for helping consumers (Marette, 2010).

(3) The mechanism *of taxation and/or subsidy* is a regulatory alternative based on a price impact on the consumers' choices, since prices are affected by a tax/subsidy per unit sold (Marette et al., 2008). If taxes aim at limiting the purchases of dangerous or unsustainable products, the revenue that they generate creates a tax resource available for subsidising sustainable products or other actions such as information campaigns. Such a process results in double profit, called double dividend. But the low elasticity of food demand in relation to prices limits the impact of price variations induced by tax/subsidies on the quantities consumed.

As shown by Hahn and Tetlock (2008), Goulder and Parry (2008) and Disdier and Marette (2012), economic analyses do not give any definitive conclusions on the optimal use of these tools. The combination of tools often limits some of the drawbacks presented above, even if the unnecessary redundancy of tools is a burden for the society. It is then important to examine the regulatory costs linked to each type of tools, which may affect the supply chain's competitiveness as well as its long-term viability, in particular for small and medium-sized firms. Regarding the supply chain and the contractual relationships, there is a lack of analysis studying the share of regulatory costs inside the supply chain and the consequences on entry/exit. Among the exceptions, Bonroy and Lemarié (2012) theoretically study the downstream labeling and the upstream price competition, and they underline the complexity of contractual links among producers of a supply chain.

Regarding producers, the industrial organization particularly raises the issue of the link between competition and regulation. For firms, the regulatory requirements usually lead to an increase in variable costs and so-called sunk (non-recoverable) costs. Variable costs directly depend on production and are passed on to consumers via prices. Conversely, once the investment has been made, sunk costs like the purchase of specific equipment for refrigeration, or staff training expenses do not directly depend on production. They do not directly affect prices but influence the competition structure when the producers' margins do not cover these sunk costs. Shaked and Sutton (1987) and Sutton (1991) underscored the importance of endogenous sunk costs on concentration. Counterintuitively, they showed that concentration increases as market size increases, which is particularly the case with the process of trade liberalization or the emergence of a monetary union. If quality, R&D and information are produced at a fixed/sunk cost, a firm by selecting a relatively high level of quality can potentially drive competitors with lower-quality products out of a market. Existing producers may choose not to pass on the fixed/sunk cost to consumers via prices, thus eliminating potential rivals.

Regulation may reinforce the firms' concentration via its impact on sunk costs presented in the previous paragraph. Very few works have raised questions about the possibility of preventing the reduction in competition induced by regulation in the presence of endogenous sunk cost. Crespi and Marette (2009) show that the generic advertising policies of the type "eat fruit and vegetables" allow the advertising costs to be shared among producers, and competition to be maintained (the same mechanism applies to pooled R&D expenses). By pooling the sunk cost of generic advertising among producers, generic advertising counteracts the phenomenon inherent to the reduction in competition linked to quality, safety or advertising expenses when these are sunk. Industry-funded check-off programs of generic advertising affect firms' strategies and can be procompetitive. The

check-off's crowding-out effect reduces the ability of a firm to use its private expenditures to avoid a rival's market access. Even if an empirical measure is difficult, this effect of maintaining (or destroying) a competitive structure must be taken into account by models, when a regulatory choice is decided.

There are a few theoretical works to help the public decision-maker when faced with a particular food question. The theory cannot directly conclude which instrument should be socially preferred. As shown by Roosen & Marette (2011) and Disdier and Marette (2012), empirical works are useful for complementing the theoretical analysis and evaluating policies *ex ante*, on case-by-case basis.

4. An empirical application: the regulatory tools and the welfare analysis integrating experimental results

This section provides one example of an applied welfare estimate, even if other types of calibrated models are possible (see Roosen & Marette, 2011).[2] This section analyses the integration of individual estimates of willingness-to-pay (WTP), using a partial equilibrium approach to provide a welfare analysis for choosing regulatory instruments on a case-by-case basis. Experiments are useful for quantifying consumers' reaction to information about attributes and regulation, leading to quantitative welfare analysis.

This application to the milk market studies linseed for feeding dairy cows, which reduces methane emissions and increases the omega-3 content of milk, as explained in the

[2] Roosen and Marette (2011) compared the approach of this paper with an alternative approach based on a calibrated model combining elasticities of demand obtained from times-series econometrics and average WTP value obtained from the experiment. Rousu et al. (2014) introduce a new approach with a Hicksian surplus measure that couples variations in WTP coming from information under a non-hypothetical experimental auctions, with time-series revealed preference demand estimates.

subsection 2.3 above. We now turn to a brief description of the protocol of the experiment (see also Marette, 2014).

5.1. The experiment

We conducted an experiment in Dijon, Burgundy, France, in multiple one-hour sessions in June 2012. The sample consisted of 114 people aged between 18 and 69 years and representative for age and socio-economic status of the population in Dijon.

Our experiment focused on bottles of milk. We offered 3 liters sold by the brand *Candia* and called *GrandLait* and 3 liters sold by the supermarket brand *Carrefour* since these supermarkets are located in Dijon. The choice of the *GrandLait Candia* is motivated by its use of linseed for feeding cows leading to more omega-3 compared to conventional milk, as the *Carrefour* one. A label *Filière Nutrition, Oméga-3 Naturels* posted on the bottle *GrandLait Candia* indicates the high-content in omega-3. The size of this label *Filière Nutrition, Oméga-3 Naturels* posted on the bottle is relatively small (length: 2 cm, width: 1.5cm). Two sentences linked to this label mention an improved diet for cows leading to more omega-3. Three other labels of a similar size were posted on this bottle. These labels indicating specific characteristics were entitled *Saveur de l'Année 2012*, *AgriConfiance* and *La Route du Lait*. The size of these labels was also relatively small (length: 2 cm, width: 1.5cm).

To elicit participants' WTP, our experiment used the BDM procedure (for Becker, DeGroot and Marschak, 1964). Further information was revealed to participants, and a willingness to pay (WTP) was elicited after each message for both types of milk. The question was: "What is the maximum price you are willing to pay for the following bottles of milk?" The question was repeated for each product. The initial explanations made clear that

one of the elicited WTPs would be randomly selected at the end of this experiment for determining whether participants will have to buy milk (i.e., performance-based financial incentives).

The BDM procedure implemented at the end of the experiment works as follows.[3] If the selected WTP is smaller than the randomly drawn price, the participant will receive the €15 indemnity without purchase. If the WTP is higher than the price, the compensation is equal to €15 less the price randomly drawn, and the participant receives the milk bottles (3 liters). The purchasing price was randomly selected among "prices" uniformly distributed between €0.1 and €5 with an increment of 10 cents. In the explanations, we did not reveal the distribution of prices between €0.1 and €5 and no participant asked any question about this range of prices. However, with the candy bar example given in the initial instruction, we insisted on the fact that, with the BDM procedure, the dominant strategy for a participant really consists in reporting her/his "true" WTP.

The timing of the experiment was the following. The session started with the initial instructions to explain the BDM mechanism. They received general instructions and signed a consent form. Based on different types of information revealed to participants, several rounds of WTP elicitation with the BDM procedure were successively carried out.

In the initial round (round #0) of the experiment, only the *Carrefour* milk from cows fed a diet without linseed was made available to the participants, since milk without linseed is dominating the French market (with a market share in volume equal to 95%). Participants had two minutes for observing the bottle. We simply informed participants that 3 bottles of 1 liter were sold between €2 and €2.5 in supermarkets in Burgundy. No more price information was

[3] With a candy bar example given with the initial instructions, we carefully explained that a purchasing price will be drawn at random at the end of the experiment, and purchasing choices will be enforced by comparing this purchasing price to one of the WTP randomly selected (namely, by following the BDM procedure).

given in the subsequent rounds. Consequently, round #0 only elicited participants' WTP for 3 liters of milk from cows fed a diet without linseed.

The *GrandLait Candia* milk from cows fed with linseed was introduced before round#1 with two additional minutes for observing the new bottle. Participants observed this new bottle with the posted labels, but we did not insist on these labels in our talk. Then this round #1 elicits WTP for both products, namely for 3 liters of *Carrefour* milk and 3 liters of *Candia* milk from linseed fed cows.

In round #2, a simple message was revealed. The experiment was conducted in two treatments, varying the order of messages provided to two subgroups of participants. 54 participants first received messages on omega-3 (and after, other messages on the environment), while 57 participants first received messages on the environment and the methane emissions (and after, other messages on the omega 3).

As information on omega-3 is at the core of this section, we restrict our attention to the 54 participants who first receive the message on the omega-3 without any other previous messages. Regarding round#2, the following additional message was communicated to the subgroup of 54 participants as following: "One liter of milk *GrandLait Candia* has 3 times more omega-3 than a liter of milk *Carrefour*. The presence of omega-3 in milk *GrandLait Candia* comes from feeding cows with linseed." New WTP were elicited for both products. Other rounds eliciting WTP are not disclosed in this paper. Our analysis will focus on two bids (WTP1) for each product before receiving the message on the omega-3 content, and two bids (WTP2) for each product after receiving this message.

At the end of the experiment, participants completed an exit questionnaire on different issues, including their judgments on the labels posted on the bottle *GrandLait Candia* with a high content in omega 3. Bottles were still on the participants' tables, which allowed them to

recheck the labels if they wanted. The experiment concluded by randomly selecting one type of milk (*Carrefour* or *GrandLait Candia*) and one of the elicited WTP, which were used to determine whether participants had to purchase the bottles.

5.2. Impact of the simple message on WTP and perception of participants regarding the labels

The omega-3 message is valued by some consumers and leads to significant change in WTP. For each product, a Wilcoxon test for comparing paired samples confirms a significant difference at 1% between WTP in rounds #2 and #1. After the revelation of the message, the average WTP for the milk *GrandLait Candia* significantly increases, while the average WTP for the conventional milk *Carrefour* significantly decreases (see also Marette, 2014).

Table 1. Participants' opinion about the labels from the exit questionnaire

Labels posted on the bottle *GrandLait Candia*	% of participants noticing the label at round #1 [a]	% of participants considering the label as useful [b]
Nutrition for a sector, Omega-3	25.4 %	94.1 %
Flavor of the year 2012	76.4 %	50.9 %
Agri-Trust	41.1 %	78.4 %
Road of Milk	27.4 %	23.5 %

Note: Table 1 summarizes the replies from 51 participants, since 3 participants did not reply to these questions.
[a] The exact question was: "When we gave you the bottle *GrandLait Candia* in round #1, did you notice the following labels?" [b] The exact question was: "On the bottle *GrandLait Candia*, do you think that the following labels are useful?" We did not ask additional questions about which characteristic could be deemed as useful.

At the end of sessions, the exit questionnaire asked several questions about the labels. Table 1 details questions on the four labels posted on the bottle *GrandLait Candia* with a high content in omega 3. Table 1 clearly indicates that some labels were not noticed at the

time the bottle was given to participants (in round #1). The first column shows that the label *Nutrition for a sector, Omega-3* has the lowest rate of "recognition", namely 25.4 % of participants. Table 1 also shows that participants favor this label *Nutrition for a sector, Omega-3* indicating a high omega-3 content, deemed as useful by 94.1% of participants (second column). The 25.4 % of participants who initially noticed this label *Nutrition for a sector, Omega-3* suggests that some significant improvements for signaling the high omega-3 content are possible, via regulatory interventions that are now studied.

5.3 Simulations regarding the exclusive use of one label signaling the omega-3 content or the MQS

Before studying the impact of two regulatory tools, we first introduce the baseline scenario without regulation. With the following methodology, (1) consumers' choices are inferred from participants' WTP elicited in the experiment, and (2) the market equilibrium is not an experimental finding but rather an induced outcome coming from the model.

Baseline scenario

In the baseline scenario representing the market situation in France at the time of the experiment, four labels were printed on the bottle *GrandLait Candia*. For this baseline scenario, the round#1 is the closest one to the market situation. For the surplus determination, it is assumed that a participant purchases a good if her/his WTP in round#1 for a good is higher than the price observed on average in the supermarkets in France, namely if $WTP1_{II,i} > P_{II}$ for 3 liters of the product *II={Conv,Omeg}* (see Rousu et al., 2007). The indexes *Conv* and *Omeg* are respectively related to the conventional milk *Carrefour* and the *GrandLait* with a high content in omega-3. At the time of the experiment, the observed

average prices for 3 liters were $\overline{P}_{Conv} = €2.1$ and $\overline{P}_{Omeg} = €2.9$, and these average market prices are fixed in the baseline scenario. A participant *i* chooses the product that generates the highest utility, and thus the surplus for the baseline scenario is:

$$CS_A^i = \max\{WTP1_{Conv,i} - \overline{P}_{Conv}, WTP1_{Omeg,i} - \overline{P}_{Omeg}, 0\}. \quad (1)$$

In round#1, participants simply observed products with a limited knowledge. The lack of information leads to decisions the participants could subsequently regret if information was revealed. If the information on omega-3 was revealed as in round#2 with $WTP2_{II,i}$, some participants would not buy the product, start to purchase a product or change the products they were purchasing. For a participant *i*, the effect of ignorance was linked to the absence of information about the omega-3 is $D_{II,i} = J_{II,i}[WTP2_{II,i} - WTP1_{II,i}]$, where $J_{II,i}$ is an indicator variable taking the value of 1 if, at round#1, participant *i* is predicted to have chosen the product *II* at the market price P_{II}, with $WTP1_{II,i} > P_{II}$ (and 0 otherwise). This effect of ignorance is added to the surplus given by (1) leading to the complete surplus:

$$\begin{aligned} CS_B^i = {} & \max\{WTP1_{Conv,i} - \overline{P}_{Conv}, WTP1_{Omeg,i} - \overline{P}_{Omeg}, 0\} \\ & + J_{Conv,i}[WTP2_{Conv,i} - WTP1_{Conv,i}] + J_{Omeg,i}[WTP2_{Omeg,i} - WTP1_{Omeg,i}]. \end{aligned} \quad (2)$$

With our simple specification, the different actors in the supply chain (farmers, processors, retailers etc.) are grouped into a single production stage representing the supply of a given product. For each product, the supply chain's profit depends on the number of participants choosing the conventional milk, which is the case for consumers with a net surplus, $\Omega_1^i > 0$, where $\Omega_1^i = WTP1_{Conv,i} - \overline{P}_{Conv} - \max\{WTP1_{Omeg,i} - \overline{P}_{Omeg}, 0\}$, and the number participants choosing the milk with omega-3, with a net surplus $\Delta_1^i > 0$, where $\Delta_1^i = WTP1_{Omeg,i} - \overline{P}_{Omeg} - \max\{WTP1_{Conv,i} - \overline{P}_{Conv}, 0\}$. We also consider the total marginal cost

over all the supply chain equal to c_{Conv} for 3 liters of conventional milk and to c_{Omeg} for 3 liters of milk with omega-3. The estimated profit for each supply chain over the 54 participants is:

$$\begin{aligned} \pi_{1,Conv} &= (\overline{P}_{Conv} - c_{Conv}) \sum_{i=1}^{I=54} K\left(\Omega_1^i\right) \\ \pi_{1,Omeg} &= (\overline{P}_{Omeg} - c_{Omeg}) \sum_{i=1}^{I=54} K\left(\Delta_1^i\right) \end{aligned}, \quad (3)$$

with $K(z)$ equal to 1 if $z > 0$ and 0 otherwise. The marginal cost are given by Bonnet and Bouamra-Mechemache (2016) who computed both retailers' and manufacturers' margins. The total marginal cost estimates for retailers and manufacturers are equal to €0.47 per liter for conventional fluid milk (and c_{Conv} = €1.41 for 3 liters of conventional milk), and €0.55 per liter for organic milk (and c_{Omeg} =€1.65 for 3 liters). We assume that the marginal cost for the *GrandLait Candia* is equal to c_{Omeg}, since this production process of production is very close to the organic-milk process. The welfare taken into account by the regulator is given by the sum of consumers' surpluses and profits given in (2) and (3). We now turn to the impact of each regulatory tool.

Exclusive label

Under this first scenario, we assume that the regulator (1) uses generic advertising for informing all consumers about the label *Nutrition for a sector, Omega-3* (with precise explanations) and/or (2) provide enough incentives to the producers/supply chain for only developing and promoting the label *Nutrition for a sector, Omega-3*. The cost of the generic information is incurred by the regulator and not detailed in this analysis. Only this label *Nutrition for a sector, Omega-3* indicating a high-content in omega 3 would be printed on the front of the bottle *GrandLait Candia* and/or recognized by consumers because of the generic

advertising. This label could even be posted with a greater size compared to the actual size. It is assumed that all producers of conventional milk continue producing conventional milk.[4] This new marketing strategy would be very close to the message revealed in round #2 to the subgroup of 54 participants. WTPs elicited after the short message on omega-3 can be used as a credible approximation of consumers' reaction to a single *Nutrition for a sector, Omega-3* label. The market prices P_{Conv} and P_{Omeg} are now endogenous.

The impact of this exclusive label is measured by considering the WTP following the message released at round#2. Because the message is revealed to all participants, the effect of ignorance disappears, and the complete surplus is:

$$CS_C^i = \max\{WTP2_{Conv,i} - P_{Conv}, WTP2_{Omeg,i} - P_{New}, 0\}. \quad (4)$$

Compared to the baseline scenario with the complete surplus given by (2), the average relative variation in surplus following the introduction of the exclusive label is equal to $\Delta CS = \sum_{i=1}^{I=54} [CS_C^i - CS_B^i] \Big/ \sum_{i=1}^{I=54} CS_B^i$.

For each product, the supply chain's profit depends on the number of participants choosing the conventional milk which is the case with a gain $\Omega_2^i > 0$, where $\Omega_2^i = WTP2_{Conv,i} - P_{Conv} - \max\{WTP2_{Omeg,i} - P_{Omeg}, 0\}$, and the number of participants choosing the milk with omega-3, with a gain $\Delta_1^i > 0$, where $\Delta_2^i = WTP2_{Omeg,i} - P_{Omeg} - \max\{WTP2_{Conv,i} - P_{Conv}, 0\}$. The profit for each supply chain is

$$\begin{aligned} \pi_{2,Conv} &= (P_{Conv} - c_{Conv}) \sum_{i=1}^{I=54} K\left(\Omega_2^i\right) \\ \pi_{2,Omeg} &= (P_{Omeg} - c_{Omeg}) \sum_{i=1}^{I=54} K\left(\Delta_2^i\right) \end{aligned} \quad (5)$$

[4] The other labels could also be withdrawn for promoting the clarity of this label *Nutrition for a sector, Omega-3,* which would make clear the presence of omega-3 because consumers focus on one logo.

with $K(z)$ equal to 1 if $z > 0$ and 0 otherwise. Each supply chain maximizes its profit by considering the price of the other supply chains as given. The optimal prices P^*_{Conv} and P^*_{Omeg} are given by a groping process, since all participants' WTP are discrete values. We assume that the groping process started with a first choice of ${P_{Omeg}}^1 \neq \overline{P}_{Omeg}$ with ${P_{Omeg}}^1$ maximizing $\pi_{2,Omeg}$ given by (5). For a price ${P_{Omeg}}^1$, the other supply chain selects a price ${P_{Conv}}^1$ maximizing ${\pi_{2,Conv}}^*$ given by (5). For this price ${P_{Conv}}^1$, the other supply chain adjusts its price by selecting ${P_{Omeg}}^2$ that maximizes the profit $\pi_{2,Omeg}$ (…). When no individual deviation is beneficial, the process stops with P^*_{Conv} and P^*_{Omeg} leading to ${\pi_{2,Conv}}^*$ and ${\pi_{2,Omeg}}^*$.

The average variations of profits following the introduction of the exclusive label are $\Delta\pi_{Conv} = \left({\pi_{2,Conv}}^* - \pi_{1,Conv}\right)\Big/\pi_{1,Conv}$ and $\Delta\pi_{Omeg} = \left({\pi_{2,Omeg}}^* - \pi_{1,Omeg}\right)\Big/\pi_{1,Omeg}$.

MQS imposing linseed in the diet of all dairy cows

A quality standard would impose linseed intake in the diet of all dairy cows in all farms. The simulations take into account the following key factors.

The MQS is imposed without any additional information revealed to consumers via generic advertising. The regulator puts resources in the management of the certification, rather than in generic advertising. The existing certification process *Filière Nutrition, Bleu-Blanc-Coeur* could be extended to all farmers (*Blanc Bleu Coeur* Association, 2012).[5] Even if the "new conventional" products could show the label signaling the Omega-3, very few consumers would notice it, as shown in the first column of table 1, and, for many consumers, the value of this label would be likely depreciated because all producers would use it. Even if no additional information is revealed, the MQS modifies the effect of ignorance accounted

[5] In essence, this mandatory linseed supplementation is close to the mandate for ethanol and biodiesel that are blended with gasoline for automobiles in many countries.

for in the complete surplus. The standard increases the complete surplus of "ignorant" consumers, because of the improvement in the quality of the conventional product. A new WTP for the "conventional" product with linseed is included in the effect of ignorance.

The MQS is costly for producers since linseed is more expensive than other ingredients of the conventional diet of cows. This standard leads to an increase of the marginal cost c_{Conv} of bottles of milk from cows actually fed without linseed and turning to linseed because of the mandatory regulation. We assume that the standard leads to either a 5% increase of the total marginal cost, with the new marginal cost equal to $1.05\times c_{Conv}$, or to a 10% increase of the marginal cost, with the new marginal cost equal to $1.1\times c_{Conv}$.[6]

This instrument changes the nature of the whole *conventional* milk that becomes a new product with linseed. In this case, the WTP premium ($WTP2_{Omeg,i} - WTP1_{Omeg,i}$) observed for milk with linseed after the release of information on the impact of linseed can be applied to the conventional milk. However, a statistically significant difference was observed in round#1 between $WTP1_{Omeg,i}$ and $WTP1_{Conv,i}$. This small difference is such that $\delta = E[WTP1_{Conv}] / E[WTP1_{Omeg}] = 0.89$. It means that, in stage #1, the milk *Candia* from cows fed with linseed differs from the *conventional* milk because of the taste, the brand, and other characteristics indicated by different labels. Even if the premium $WTP2_{Omeg,i} - WTP1_{Omeg,i}$ linked to the message on the impact of linseed is applied to the conventional milk enriched with linseed because of the standard, we correct the new WTP of the new conventional product by the parameter δ. It means that the WTP difference between both products is the

[6] We found an extra-cost of €0.016 per liter of milk linked to 0.6 kg of linseed per cow and per day and including the certification cost (see table "Lait" p.17 in the *Blanc-Bleu Coeur* Association, 2012). As we offered 3 liters, the extra marginal cost is € 0.05 for bottles of conventional milk impacted by the MQS, which corresponds to an increase of 3.5% compared to the marginal cost c_{Conv} = €1.41. This increase of 3.5% is a lower bound of the possible increase, since the linseed price would increase if the linseed use was mandatory.

same in stages #1 and #2. Thus the WTP for the "new conventional" milk coming from cows fed a diet with linseed is equal to $WTP2_{Conv\_with\_Lin,i} = \delta \times WTP2_{Omeg,i}$.

As the MQS does not reveal any information, participants take their decisions as in round#1 and as described with equation (1), except that prices are endogenous with P_{Conv} and P_{Omeg} replacing $\overline{P}_{Conv}$ and $\overline{P}_{Omeg}$. The new value $WTP2_{Conv\_with\_Lin,i} = \delta \times WTP2_{Omeg,i}$ is accounted for in the effect of ignorance, $\overline{J}_{Conv,i}[WTP2_{Conv\_with\_Lin,i} - WTP1_{Conv,i}]$, where $\overline{J}_{Conv,i}$ is an indicator variable taking the value of 1 if participant *j* is predicted to have chosen the conventional product at the new market price.

Under a MQS, participants have no additional information compared to the baseline scenario, which leads to choices equivalent to the ones of equation (1). However, the effect of ignorance changes with the MQS compared to the baseline scenario. For a participant *i*, the complete surplus integrating the effect of ignorance with a MQS is:

$$\begin{aligned} CS_D^i = & \max\{WTP1_{Conv,i} - P_{Conv}, WTP1_{Omeg,i} - P_{Omeg}, 0\} \\ & + \overline{J}_{Conv,i}[WTP2_{Conv\_with\_Lin,i} - WTP1_{Conv,i}] + J_{Omeg,i}[WTP2_{Omeg,i} - WTP1_{Omeg,i}] \end{aligned}. \quad (6)$$

For each product, the supply chain's profit depends on the number of participants choosing the conventional milk which is the case with a net surplus $\Omega_3^i > 0$, where $\Omega_3^i = WTP1_{Conv,i} - P_{Conv} - \max\{WTP1_{Omeg,i} - P_{Omeg}, 0\}$, and the number of participants choosing the milk with omega-3, with a net surplus $\Delta_3^i > 0$, where $\Delta_3^i = WTP1_{Omeg,i} - P_{Omeg} - \max\{WTP1_{Conv,i} - P_{Conv}, 0\}$. Compared to the profits indicated by equation (3), the total marginal cost over the entire supply chain increases of 5% or 10%, leading to a new marginal cost equal to $1.05 \times c_{Conv}$ or $1.1 \times c_{Conv}$ for 3 liters of new

conventional milk with linseed. By only reporting the case with $1.1\times c_{Conv}$, the estimated profit for each supply chain over the 54 participants is:

$$\begin{aligned}\pi_{3,Conv} &= (P_{Conv} - 1.1\times c_{Conv})\sum_{i=1}^{I=54} K\left(\Omega_3^i\right) \\ \pi_{3,Omeg} &= (P_{Omeg} - c_{Omeg})\sum_{i=1}^{I=54} K\left(\Delta_3^i\right)\end{aligned}, \qquad (7)$$

The optimal prices P_{Conv}^* and P_{Omeg}^* are given by the groping process similar to the one detailed after the equation (5). The variations of surpluses and profits are given by formulas similar to the ones related to the exclusive label, namely ΔCS, $\Delta\pi_{Conv}$ and $\Delta\pi_{Omeg}$, presented above.

The variations of surpluses and profits were estimated on an *Excel* spreadsheet. Table 2, shows the impact of the exclusive label given in the second column, and the impact of the MQS, given in the third and fourth columns for two possible changes in the marginal cost of the conventional milk, $1.05\times c_{Conv}$ and $1.1\times c_{Conv}$. Table 2 shows significant economic benefits coming from both regulatory instruments, with the welfare variations at the bottom of table. With a regulator who maximizes the welfare, the choice of the instrument leading to the highest welfare depends on the MQS marginal cost. When the increase of the marginal cost is relatively low, $1.05\times c_{Conv}$ in the third column, the welfare variation with the exclusive label is lower than the one with the MQS, despite the reduction of products diversity coming from the MQS. In this case it is socially optimal to select the MQS, leading to a quality increase of the conventional milk with a very low impact on both marginal cost and profit of the supply chain with the new conventional milk. Conversely, when the increase of the marginal cost is relatively high, $1.1\times c_{Conv}$ in the fourth column, the welfare variation with the exclusive label is higher than the one with the MQS, implying a reduction of products diversity.

The comparison between instruments in table 2 reveals important differences in gains among participants. The exclusive label provide a high variation in benefits to the supply chain offering milk with linseed (+40%), since this supply chain may charge a higher price based on WTP positively influenced by the exclusive label. This relative high-price increase (+17.2%) of the high-quality milk with linseed explains the relatively low increase in the consumers' surplus (+12.7%). Because of this relative high price for the milk with linseed, some consumers/participants switch to the conventional milk, which explains the positive profit variation for the supply chain of conventional milk despite the price decrease of conventional milk.

Table 2. Relative variations (%) in profit and surplus coming from the exclusive label or the MQS

	Exclusive label	**MQS with** $1.05\times c_{Conv}$	**MQS with** $1.1\times c_{Conv}$
Price variation of milk without linseed	- 4.7%	- 4.7%	- 4.7%
Price variation of milk with linseed and label(s)	17.2 %	3.4 %	3.4 %
Profit variation for supply chain offering conventional milk, initially without linseed	1.1 %	- 0.7%	- 14.2%
Profit variation for supply chain offering milk with linseed	40 %	8 %	8 %
Consumers' surplus variation	12.7 %	37.6 %	37.6 %
Welfare variation[1]	10.3 %	15.8%	9.4 %

Note: [1]The welfare is given by the sum of consumers' surplus and profits.

Compared to the exclusive label, the MQS tends to relatively favor consumers compared to producers. As consumers do not change their demand with the MQS, the

changes in prices are small, which limits the gains for producers.[7] Even if no additional information is revealed, the MQS modifies the effect of ignorance in the complete surplus given by (6), with the WTP increase for the new conventional product with linseed. The standard increases the complete surplus of "ignorant" consumers because of the quality improvement of the product.

5.4. Limitations of the methodology and extensions

Because of flaws linked to lab experiments, and also because profits and surpluses of table 2 are inferred with simulations, there is no definitive conclusion. The reader should keep in mind that the results come from lab experiments and questionnaires that are criticized by some economists. Because of possible biases coming from lab experiments, the results of this section only provide suggestions that could help debates and future research. Moreover, many simplifications were made with the model represented by equations (1) to (7).

Several extensions are necessary for confirming the results of table 2. First, the supply chain can/should be taken into account in this partial equilibrium model. By using real purchase data it is possible to develop a structural econometric model of demand and supply that takes into account the relationships between manufacturers and retailers (see Bonnet and Bouamra-Mechemache, 2016). This structural econometric model allows to distinguish between processors and retailers margins, which is promising for understanding vertical relationships. For instance, the different actors and margins in the supply chain could be integrated in an alternative calibrated model, combining elasticities of demand obtained from time-series econometrics and average WTP obtained from the experiment (see Roosen and Marette, 2011).

[7] The optimal prices are the same for both configurations of marginal costs related to MQS, since the WTP determining the demand in (7) are discrete values.

Second, sunk costs could/should be integrated by considering profits over a whole population. In other words, we could extrapolate the profits coming from (3), (5) and (7) and linked to the *54* participants to the overall population of France by considering the average yearly consumption. This would lead to yearly gross-profits from which sunk costs related to quality effort could be subtracted. Boland et al. (2014) provide a precious methodology for evaluating sunk costs and values of assets in the industry. The evaluated sunk costs related to the milk quality could be integrated in the previous profits estimate. Eventually, the regulator should also take into account all administrative/regulatory costs overlooked in this section, but essential for getting a complete costs-benefits analysis.

Third, the analysis should consider some configurations for which the regulation targets several goods and/or several characteristics related to goods. WTP for a good/characteristic may vary depending on whether it is evaluated on its own, or as part of a "broad basket" of goods/characteristic, which ultimately raises the question of the stability of WTP.[8] Kahneman and Knetsch (1992) underlined the sub-additivity effect that occurs, when the estimated WTP for the improvement of one characteristic plus the estimated WTP for another characteristic is greater than the "common WTP", when participants are asked to value the two characteristics together. An interesting extension would consist in diversifying the contexts in which WTP for one and/or several characteristics are estimated, for understanding the sensitivity of WTP elicitations.

[8] The stability of WTP is questionable even when only one product is considered. Marette et al. (2017) show that the WTP for a given type of product are particularly sensitive to the order of different mechanisms and to the period of the experiment. Conversely, for a product, the variations of WTP coming from explanatory messages about private or public attributes are particularly stable over the order of different mechanisms and the period of experiments. In other words, as marginal WTP for characteristics are stable, they can be credibly integrated in costs-benefits analyses.

6. Conclusion

Despite shortcomings, we have been able to shed lights on one important question related to quality and sustainability regulation. The application to the milk market focused on linseed for feeding dairy cows, which reduces methane emissions and increases the omega-3 content of milk. Simulations compared the impact of the exclusive use of one label signaling omega-3, versus the impact of a minimum-quality standard imposing linseed in the diet of all dairy cows. Both instruments would have a positive impact on consumers' surpluses and some producers' profits.

The integration of experimental results in calibrated models helps to assess *ex ante* the impacts of regulatory measures, that is to say, before the effective implementation of food, environmental or health policies. The experimentation results are a basis to anticipate consumers' reactions and so the calibrated models help to anticipate the price adjustments on markets and provide useful results to the public decision-maker. Applied welfare estimations are useful for evaluating policies *ex ante* (or *ex post*) on a case-by-case basis and helping public debates. These methods can be applied to costs-benefits analyses showing the consequences of the various public choices.

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