# Firms' strategies in food innovation and reformulation and their responses to regulatory nutritional policies

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To deal with health issues related to food consumption, governments are implementing partnerships with the food industry to generate changes in the quality of foods, based for instance on the decrease in salt or fat contents. Some governments employ also more coercive policies, based on the ban of some ingredients, the implementation of quality standards, or advertising regulations. Are these policies focused on the supply side more promising than policies focused on consumers? Are market incentives sufficient to induce voluntary changes by firms or is public regulation of food quality needed to reach public health objectives? The goal of this task will be to deal with these questions, by combining conceptual models and empirical data collection.


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# DELIVERABLE SHORT SUMMARY FOR USE IN MEDIA

Policies focused on food quality are intended to facilitate healthy choices by consumers, even those who are not fully informed about the links between food consumption and health. Decreasing the salt and fat content in foods and increasing the whole grain content are good examples of food composition changes being made to address health-related issues. In this context, public health agencies and policy makers urge the food industry to favor a better food environment through changes in the quality and variety of foods and through changes in advertising and marketing, and some governments are partnering with the food industry and the retail sector to generate changes on the supply side.

Are policies focused on the supply side more promising than policies focused on consumers? Which public health benefit can we expect from their implementation? Are market incentives sufficient to induce voluntary changes by firms or is public regulation of food quality needed to reach public health objectives?

In the first study, we review the available literature in the field of nutrition and public health in order to evaluate the potential impact of food reformulation on health outcomes, as well as the magnitude of reformulation efforts really implemented by the food industry. In addition, we use French data to quantify and compare the relative contribution of changes implemented on the supply side (food reformulation effect) and changes on the demand side (variation of purchases in the different food groups) on the quality of the average consumer's diet.

The results show that the modification of the nutritional quality of foods may potentially induce significant health benefits even in the absence of positive changes in consumers' diet patterns. Although food reformulation alone would not be sufficient to dramatically reduce the prevalence of chronic diseases related to food consumption, it can play an important role in that direction. Food reformulation initiatives, currently implemented by the food industry as part of voluntary agreements negotiated with public authorities, are often significant and have positive effects on food quality. However, as this process is not yet generalized and adopted by the whole food sector, at the moment, the effects on consumers' intakes remain limited. This statement leads to questions on the generalization of food reformulation efforts, and the possible effects of public policies aiming at enhancing the nutritional quality of the food supply.

The second study aims at better understanding firms' strategic reactions to nutritional policies targeting food quality improvements and deriving a set of optimal policies. To reach this goal, we propose an economic model of product differentiation, which takes into account both taste and health characteristics of food products, and we use it to assess the health and welfare impact of taxation and Minimum Quality Standard (MQS)-based policies.

We show that firms respond differently to tax- and MQS-based instruments, leading to different impact on market and public health outcomes. We find that only the MQS policy and the linear excise tax on the low-quality product are effective in a general sense. The choice, however, between the two depends on the priorities of the regulator and on consumers' resistance to move away from their initial taste preferences.
Finally, we show that policies intended to change the food market environment allow for greater health benefits and welfare than policies based solely on information campaigns.

# TEASER FOR SOCIAL MEDIA

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# ABSTRACT

Given the modest impacts of information-based policies, public health agencies are now considering other policies to modify the market environment to facilitate healthier food choices, even by non-health-sensitive consumers. A broad range of instruments have been considered, from price policies to nutrition-related standards.

Policies focused on food quality are intended to facilitate healthy choices by consumers, even those who are not fully informed about the links between food consumption and health. Decreasing the salt and fat content in foods and increasing the whole grain content are good examples of food composition changes being made to address health-related issues. In this context, public health agencies and policy makers urge the food industry to favor a better food environment through changes in the quality and variety of foods and through changes in advertising and marketing, and some governments are partnering with the food industry and the retail sector to generate changes on the supply side.

Are policies focused on the supply side more promising than policies focused on consumers? Which public health benefit can we expect from their implementation? Are market incentives sufficient to induce voluntary changes by firms or is public regulation of food quality needed to reach public health objectives? The goal of Task 3.3 is to answer these questions through two studies.

In the first study, we review the available literature in the field of nutrition and public health in order to evaluate the potential impact of food reformulation on health outcomes, as well as the magnitude of reformulation efforts really implemented by the food industry. In addition, we use French data to quantify and compare the relative contribution of changes implemented on the supply side (food reformulation effect) and changes on the demand side (variation of purchases in the different food groups) on the quality of the average consumer's diet.

The results show that the modification of the nutritional quality of foods may potentially induce significant health benefits even in the absence of positive changes in consumers' diet patterns. Although food reformulation alone would not be sufficient to dramatically reduce the prevalence of chronic diseases related to food consumption, it can play an important role in that direction. Food reformulation initiatives, currently implemented by the food industry as part of voluntary agreements negotiated with public authorities, are often significant and have positive effects on food quality. However, as this process is not yet generalized and adopted by the whole food sector, at the moment, the effects on consumers' intakes remain limited. This statement leads to questions on the generalization of food reformulation efforts, and the possible effects of public policies aiming at enhancing the nutritional quality of the food supply.

The second study aims at better understanding firms' strategic reactions to nutritional policies targeting food quality improvements and deriving a set of optimal policies. To reach this goal, we propose an economic model of product differentiation, which takes into account both taste and health characteristics of food products, and we use it to assess the health and welfare impact of taxation and Minimum Quality Standard (MQS)-based policies.

We show that firms respond differently to tax- and MQS-based instruments, leading to different impact on market and public health outcomes. We find that only the MQS policy and the linear excise tax on the low-quality product are effective in a general sense. The choice, however, between the two depends on the priorities of the regulator and on consumers' resistance to move away from their initial taste preferences. Finally, we show that policies intended to change the food market environment allow for greater health benefits and welfare than policies based solely on information campaigns.

# INTRODUCTION

To address public health issues related to poor dietary habits, governments and public health agencies have been implementing policies intended to promote preventive behaviors by information campaigns and food product labeling. Reviews of these policies show that they have some positive impact that, however, remains small, at least in the medium term (Brambila-Macias *et al.*, 2011). In addition, these policies are suspected to increase health inequalities, with less-educated individuals responding less to information policy (Etile, 2013). Given the modest impacts of information-based policies, public health agencies are now considering other policies to modify the market environment to facilitate healthier food choices, even by non-health-sensitive consumers. A broad range of instruments has been considered, from price policies to nutrition-related standards (Brambila-Macias *et al.*, 2011).

Policies focused on food quality are intended to facilitate healthy choices by consumers, even those who are not fully informed about the links between food consumption and health. Decreasing the salt and fat content in foods and increasing the whole grain content are good examples of food composition changes being made to address health-related issues. In this context, public health agencies and policy makers have urged the food industry to favor the development of a better food environment through changes in the quality and variety of foods and through changes in advertising and marketing (WHO, 2012a), and some governments are partnering with the food industry and the retail sector to generate changes on the supply side.

Are policies focused on the supply side more promising than policies focused on consumers? What public health benefit can we expect from their implementation? Are market incentives sufficient to induce voluntary changes by firms, or is the public regulation of food quality needed to achieve public health objectives? The goal of Task 3.3 is to answer these questions through two subtasks addressing complementary questions:

(i) **Subtask 1**: What public health benefits can we expect from voluntary food reformulation initiatives?

An initial response of the food industry to the health and nutrition challenge has been to launch new products based on nutrition and health claims and innovative foods, such as functional foods, targeting health-conscious consumers. Market incentives exist for such a strategy and depend on the number of health-conscious consumers (which is influenced by public information campaigns) and their willingness-to-pay (WTP) for healthier and innovative foods. In France, for instance, approximately 20 percent of food products have a nutritional claim.

A second strategy is to improve the nutritional quality of the current supply (the remaining 80 percent). Individual and collective private initiatives have been pursued to

improve the nutritional quality of existing products. As an example, the Healthy Weight Commitment Foundation (HWCF) voluntarily pledged to collectively remove 1 trillion calories from their products by 2012 (against a 2007 baseline) and 1.5 trillion calories by 2015 (Slining et al. 2013). Other voluntary approaches rely on bilateral agreements between regulatory agencies and firms. In the United Kingdom, the partnership between the food industry and the government for salt reduction was based on negotiated reformulation targets signed by 75 organizations in 2010 (Wyness et al., 2011). In France, in the framework of the National Program for Health and Nutrition implemented by the government, 39 firms or groups of firms signed such commitments between 2008 and 2016.

In this deliverable, we only consider the second strategy related to the food reformulation of 'generic' products (without any nutritional or health claims), and our analysis aims at determining the public health impact of these actions in leading to changes in the nutritional quality of foods available on the market.

Recent studies have investigated the impact of food reformulation initiatives on consumers' intakes and public health. Some of them have dealt with the potential impact of the adoption of quality standards on consumers' diets (Van Raaij *et al.*, 2008; Buttriss, 2013). For instance, one study (Roodenburg *et al.*, 2011) assessed the impacts on diets if all food products complied with the International Choices Programme (ICP) (Dötsch-Klerk *et al.*, 2015; Vyth *et al.*, 2009; Vyth *et al.*, 2010). Roodenburg *et al.* (2013) and Vyth *et al.* (2012) modeled the potential impact of 'Choices' adoption on health-related risk factors. They calculated the effect of consuming a diet that complies with the criteria of a front-of-package label on a specific cardiovascular risk factor, such as cholesterol levels, for the total Dutch adult population. Leroy et al. (2015) performed similar analyses on the French market. To ensure, as much as possible, that the tested scenarios are within a domain of food characteristics acceptable to the consumers and feasible for the producers, they restricted the reformulation assumptions to ranges of nutritional values already existing in each food group in the French market. The simulation results provide the magnitude of health benefits that would be obtained if all participants in the food industry complied with a nutritional quality standard.

In line with this strand of research, the first goal of subtask 1 is to review the available literature in the field of nutrition and public health to evaluate the potential impact of food reformulation on health outcomes.

The second goal of subtask 1 is to review studies dealing with the evaluation of food reformulation efforts really implemented by the food industry in different countries. Indeed, recent investigations have addressed the impact of food reformulation strategies not potentially but really implemented by the food industry in different countries, either based on private initiatives or through partnerships set up with public authorities.

The third goal is to quantify and compare the relative contributions of changes implemented on the supply side (food reformulation effect) and changes on the demand side (variation of purchases in the different food groups) on the quality of the average consumer's diet.

(ii) **Subtask 2:** Which policy instruments can be used to favor quality improvements, and how could firms react to these instruments?

The initiatives mentioned above are mainly based on voluntary commitments, sometimes made in the framework of bilateral agreements between regulatory agencies and firms. In the United Kingdom, the partnership between the food industry and the government for salt reduction was based on negotiated reformulation targets signed by 75 organizations in 2010 (Wyness et al., 2011). In France, in the framework of the National Program for Health and Nutrition implemented by the government, 39 firms or groups of firms signed such commitments between 2008 and 2016.

The theoretical literature on voluntary approaches suggests that their impacts depend on several factors (e.g., Segerson and Miceli, 1998; Segerson, 2013). Although voluntary approaches could offer potential cost savings for regulators and firms, their impacts may be small in the absence of credible threats. The success of voluntary approaches also depends on the availability of the monitoring tools necessary to quantify and control their implementation. In the field of nutrition, some articles suggested that these voluntary initiatives could be insufficient to really address the public health challenge and recommended the adoption of more stringent policies. The goal of subtask 2 is to analyze the possible impact of these coercive policies and then contribute to their assessment.

A first policy relies on the implementation of minimum quality standards (MQS). The theoretical literature on MQS provides mixed insights. In a simple setting, in which differentiation between products relies on a single characteristic, quality standards seem to be quite efficient (Crampes and Hollander, 1995; Ronnen, 1991). For example, the ban upon trans-fatty acids (TFA) in New York state and in Denmark, where a mandatory maximum content of TFA was implemented in 2004, seems to have had positive impacts (Unnevehr and Jagmanaite, 2008). In a more complex setting, however, in which products are differentiated by multiple characteristics, setting MQS might be counterproductive, even if the market underprovides quality (Deltas *et al.*, 2013). Other tools such as food taxes can also be designed to influence the quality provided by firms. For instance, the regulator might define a quality threshold by which products that have a quality higher than the threshold are not taxed, whereas products that have a quality lower than the threshold are taxed. Such a policy seems to be efficient, provided that the quality threshold is not too stringent so that a firm prefers to reformulate its product to avoid the tax, leading to positive results for health and welfare (Duvaleix-Treguer *et al.*, 2012).

The goal of subtask 2 is to better understand firms' strategic reactions to nutritional policies targeting food quality improvements and to derive a set of optimal policies. We propose a model of product differentiation, taking into account both the taste and health characteristics of products, and use it to assess the health and welfare impacts of taxation and MQS-based policies. An important challenge comes from the need to integrate these two characteristics, both of which affect consumers' utility.

In the model of product differentiation that we develop, we consider two mono-product firms competing on price and product characteristics. The products are differentiated along a one-dimensional product characteristic axis (e.g., more or less salty), but the position of a product on this axis may affect consumers' utility in two ways: through its health impact (the lower the content of salt, the greater the health benefits), on the one hand, and its taste (due to the content of salt), on the other hand. Thus, we take into account the linkages between the nutritional quality of food products and their taste characteristics. This complex relationship between the taste and health characteristics of a product is a key point in the analysis of firms' strategies. Using this framework, we compare the impacts of three policies – imposing an MQS; setting an excise tax based on the nutrient contents of the two products; and setting an excise tax based on the nutrient content of the 'bad' product – on consumer demand, prices, product characteristics, a health indicator, and welfare.

# PART 1

Food reformulation: where do we stand? Whant can we expect from voluntary commitments?

(L.G. Soler and M. Spiteri, with the contribution of O. Hamza)

To address public health issues related to poor dietary habits, governments and public health agencies have been implementing policies intended to promote preventive behaviors using information campaigns and food product labeling. Reviews of these policies show that they have had some positive impact that, however, remains small, at least in the medium term (Brambila-Macias et al., 2011). In addition, these policies are suspected to increase health inequalities, with less-educated individuals responding less to information policy (Etile, 2014).

Given the modest impacts of information-based policies, public health agencies are now considering other policies to modify the market environment and facilitate healthier food choices, even by non-health-sensitive consumers. A broad range of instruments has been considered, from price policies to nutrition-related standards (Brambila-Macias et al., 2011). Among them, policies focused on food quality are intended to facilitate healthy choices by consumers, even those who are not fully informed about the links between food consumption and health. Decreasing the salt and fat content in foods and increasing the whole grain content are good examples of food composition changes being made to address health-related issues. Are policies focused on the supply side more promising than those focused on consumers? The goal of this article is to help answer this question on the basis of a literature review and the treatment of data collected in France.

More precisely, we aim at estimating the public health benefits that can be expected from realistic scenarios of changes in food quality. Indeed, food reformulation raises some difficulties related to the absence of price differentiation and market incentives and to the commercial risks induced by product taste modifications. Given these limitations, if food companies would implement realistic food reformulation initiatives, what could be their impacts on consumers' intakes, chronic disease incidence and mortality, even in the absence of changes in consumers' behaviors?

Considering the available literature, it is worthwhile to note that most papers deal with the effects of 'potential' changes in food quality and are based on reformulation scenarios and simulations rather than 'real' changes implemented by the food industry. In the first section, we focus on these studies, which give interesting insights about the magnitude of public health benefits potentially induced by the improvement of food quality.

The reason that most articles deal with *potential* reformulation scenarios is linked to the lack of precise data on quality changes and reformulation initiatives implemented by the food industry. Indeed, as noticed by van Raaij *et al.* (2008) "such considerations can only be made if up-to-date information is available from food consumption surveys, if up-to-date market information is available on recently launched reformulated foods, and if the compositions of newly reformulated foods are known and included in up-to-date food composition tables". Recently, however, such datasets have been developed in some countries (see, for instance, Ménard *et a*l., 2011), enabling researchers to

evaluate not only 'potential' scenarios of food reformulation but also real changes implemented by the food industry.

In line with these recent approaches, the second section focuses on reformulation initiatives currently implemented by the food industry. On the basis of the available literature and the analysis of French data, we determine to what extent the food industry has already engaged in food reformulation initiatives and quantify their real impact on consumers' intakes. An important issue will be to compare the changes induced by food industry efforts *versus* changes induced by the modification of consumers' behaviors.

## 1. **Food reformulation: what is the potential public health impact?**

Recent investigations have focused on the impacts of the adoption of nutritional quality standards by the food industry on consumers' diets. Most of them estimate the impact of changes in the nutritional quality of foods by simulating food reformulation scenarios. Depending on the publication, these scenarios may consider one or several nutrients and one or several food groups. The impact may be estimated through the variation of the total amounts of nutrients delivered into the market or the variation in consumers' intakes. In some cases, the impact on health is estimated using epidemiologic models, which allow translating changes in nutrient intakes into incidences of cardiovascular diseases, disability-adjusted life years (DALYs) or quality-adjusted life years (QALYs), and life expectancies. Few studies have assessed the cost-benefit balance of food reformulation.

Two types of studies have been conducted in the last decade to assess food reformulation scenarios. The first is related to the reduction of the salt content in foods, and the second simulates the adoption of more general quality standards by the food industry.

### 1.1. Reducing the salt content in foods

Reducing the salt intake is considered an important public health strategy in many countries. Several articles have dealt with the potential impact of salt content reduction in foods, some of which compare this strategy with policies based on prices (taxes) or information (labeling, information campaigns).

Hendriksen *et al.* (2014) evaluated the health benefits of salt reduction strategies related to processed foods for the Dutch population. First, they calculated that, if all consumers would comply with the recommended maximum intake of 6 g/day, the burden of disease might be reduced by 56,400 DALYs, and the life expectancy might increase by 0.15 year for a 40-year-old individual. In comparison to this baseline scenario, they considered two other scenarios based on the substitution of high-salt foods with low-salt foods by consumers and the reduction in the sodium content of

processed foods. The results show that the substitution of foods with comparable low-salt alternatives would lead to slightly higher salt intake reductions and thus to greater health gains. The estimates for sodium reduction in processed foods would be slightly lower. Using data from the United States, United Kingdom and Netherlands, Dötsch-Klerk *et al.* (2015) assessed the potential impact on population salt intake of a cross-industry food product reformulation towards two criteria: an interim intake goal of 6 g/day and a longer-term goal of 5 g/day. Modeling using the 6 and 5 g/day criteria resulted in estimated reductions in population salt intake of 25 and 30% for the three countries, respectively, the latter representing an absolute decrease in the median salt intake of 1.8–2.2 g/day. Bruins *et al.* (2015) estimated the potential health impact of product reformulation in the Netherlands by considering packaged soups containing, on average, 25% less sodium. They showed implementing one-year salt reductions in soups might potentially reduce the related burden of disease by approximately 800 DALYs. Bertram *et al.* (2012) estimated the number of fatal cardiovascular disease (CVD) events and non-fatal strokes that would be prevented in South Africa each year following a reduction in the sodium contents of bread, soup mix, seasoning and margarine. They calculated that the proposed reductions would decrease the average salt intake by 0.85 g/person/day, which would result in 7,400 fewer CVD deaths and 4,300 fewer non-fatal strokes per year compared with the current situation.

Collins *et al.* (2014) evaluated the cost-effectiveness of public health policies aiming to reduce the dietary salt intake of the English population based on information campaigns, labeling, and voluntary and mandatory changes in food. They showed that all policies would result in a life-year gain over the baseline. Over 10 years, the information policies gained approximately 1,960 life-years, voluntary reformulation 14,560 life-years, and mandatory reformulation 19,320 life-years. Each policy appeared to achieve cost savings, with mandatory reformulation offering the largest cost savings. Smith-Spangler *et al.* (2010) assessed the cost-effectiveness of two population strategies to reduce the sodium intake in the US: government collaboration with food manufacturers to voluntarily cut sodium in processed foods and a sodium tax. Collaboration with industry would decrease the mean population sodium intake by 9.5%, increasing the QALYs by 2.1 million and saving $32.1 billion in medical costs. A tax on sodium that decreases the population sodium intake by 6% would increase the QALYs by 1.3 million and save $22.4 billion over the same period. Gillespie *et al.* (2015) considered public health actions to reduce dietary salt intake in relation to inequity issues. The authors considered English adults and forecasted the effects of mandatory and voluntary product reformulation, nutrition labeling and social marketing (e.g., health promotion, education). They modeled the effects on coronary heart disease (CHD) mortality up to 2025 and simultaneously assessed the socio-economic differentials of the effect. Mandatory reformulation might prevent or postpone 4,500 CHD deaths in total, with the effect greater in the most deprived group. Voluntary reformulation was predicted to be less effective and inequality-reducing, preventing or postponing 1,500 CHD deaths in total, with the effect greater in the most deprived group (but less than in the mandatory reformulation). Social marketing and product

labeling might each prevent or postpone 500 CHD deaths, but only minimally affect the inequality.

1.2. Adoption of quality standards by the food industry

In the framework of the Choices Programme launched in The Netherlands in 2006, products can qualify for a health stamp by meeting a set of nutritional criteria. Roodenburg *et al.* (2013), compared the actual intakes in the Dutch population to a scenario where all foods that did not comply were replaced by similar foods that did comply with the Choices criteria. They showed that the median energy intake would be reduced by 16% by replacing normally consumed foods with Choices-compliant foods. The intakes of nutrients with a maximal intake limit were also reduced (ranging from -23% for sodium to -62% for trans-fats). Stratified analyses in this homogeneous study population showed only small differences across gender, age, body mass index and education. Roodenburg *et al.* (2011) developed the Daily Menu Method to simulate the changes in the calculated nutrient intakes that would be the result of consumers changing their diets in favor of food products complying with the Choices standard in The Netherlands, Greece, Spain, the USA, Israel, China and South Africa. For each of the key nutrients, these average intakes were translated into three Typical Daily Menus per country, and the average intakes based on these three menus were compared with the average intakes from three Choices Daily Menus. To compose the Choices Menus, foods from the Typical Menus that did not comply with the Choices criteria were replaced with foods that did comply and are available on the market. The calculated intakes of energy, saturated fat, trans-fats, added sugar and sodium were reduced, and the fiber intakes were increased.

This was the case for all countries for which this calculation was carried out, also the size of the effects differed between countries.

Masset *et al.* (2016) modeled the effect of two potential pizza reformulation strategies on the nutrient intakes of US youth based on the standards established by the Nestlé Nutritional Profiling System (NNPS). In a reformulation scenario, the nutrient content of pizzas was adjusted to the NNPS standards if they were not met. In a substitution scenario, pizzas that did not meet the standards were replaced by the closest pizza, based on nutrient content, which met all of the NNPS standards. Pizzas consistent with all the NNPS standards (29% of all pizzas) were significantly lower in energy, saturated fat and sodium than pizzas that were not. Among pizza consumers, the modeled intakes in the reformulation and substitution scenarios were lower in energy (-14 and -45 kcal, respectively), saturated fat (-1.2 and -2.7 g), and sodium (-143 and -153 mg) compared to the baseline values.

Combris *et al.* (2011) assessed the potential contribution of improving the nutritional quality of processed foods on individuals' nutritional intake in France. Three food groups were considered: breakfast cereals (355 items collected in 2008), biscuits and

pastries (1,805 items collected in 2008), and bread-based products (620 items collected in 2009). The formulations of the food items with the lowest nutritional quality were modified to three different levels to improve the overall level of quality in a given category. On this basis, the distribution of individuals' nutrient intakes from the three food groups among the French population was assessed. The scenarios generated important improvements (increases in the amount of fiber or decreases in the amounts of sugar, fat or sodium delivered to the market). Improvement of the products with the lowest nutritional quality would also lead to significant variation in individuals' nutrient consumption for the average adult and child consumers of the three groups (ranging from 4.2 to 18.8%, depending on the scenario, the food group and the nutrient considered).

Leroy *et al.* (2015) assessed the potential impact of food reformulation on health outcomes in France by using an epidemiological model that links changes in food and nutrient intakes to changes in adverse health outcomes. To determine the target values, they used the nutrient profiles determined for the 'Choices' program as a benchmark and considered two reformulation scenarios. The 'high reformulation scenario' assumed that all products comply with the Choices standard, provided that the changes in the nutrient content required to reach this standard do not exceed 25%, while in the 'low reformulation scenario', the gap must not exceed 20%. The high reformulation scenario would lead to average variations in consumers' intakes that depend on the nutrients: − 12.7% for sodium, +5.6% for fiber, − 14.8% for saturated fat (SFA) and − 14.4% for added sugars. The magnitudes of the impacts on diseases and mortality depend on the food category, the magnitude of the reformulation scenario for each food category–nutrient pair and the relative risks related to each nutrient. Among the nutrients, the highest-impact reformulation target was SFA, which has the greatest effect on Deaths Avoided (DA) (1,897), followed by sugar and sodium, which had similar impacts (746 and 608 DA, respectively). The reformulation of fiber had the lowest impact (223 DA). The DA number was much higher for low-income categories than for high-income categories: 34%, 28%, 21% and 18% for modest, lower-average, upper-average and well-off people, respectively. The low reformulation scenario had significantly smaller impacts, leading to average variations in consumers' intakes of − 9.3% for sodium, +4.5% for fiber, − 11.7% for SFA and − 4.6% for added sugars. The overall impact was 2,408 DA, which is a 3.7% reduction in mortality due to the chronic diseases considered in the model.

## 2. **Food reformulation: impact of current initiatives on consumers' intakes**

### 2.1. Initiatives implemented by the food industry

One response of the food industry to the health and nutrition challenge has been to launch new products based on nutrition claims and innovative foods, such as functional foods, targeting health-conscious consumers. Market incentives exist for such product differentiation strategies and depend on the number of health-conscious consumers

and their willingness to pay a price premium for healthier and innovative foods. In France, for instance, approximately 20 percent of food products have a nutritional claim (Oqali, 2015).

A second strategy is intended to improve the nutritional quality of the current supply (the remaining 80 percent). The point here is to improve the food quality to ameliorate the nutritional quality of consumers' diets, even of those who are not sensitive or fully informed about the links between food consumption and health. In this case, the goal is not to implement product differentiation strategies and charge higher prices, but rather to promote the brand reputation and deliver corporate social responsibility.

From this perspective, some global companies have defined private nutritional standards that are used to implement food reformulation strategies and/or support labeling initiatives. The goal is generally to reduce the salt, sugar or fat content in food products.

For instance, since 2003, Unilever has reviewed its entire foods portfolio for their levels of trans-fat, saturated fat, sodium, sugar and calories ("Balanced diets and healthy lifestyles", FoodDrinkEurope, 2015). This has been done as part of the Nutrition Enhancement Program of the company, which aims to evaluate and improve the nutritional quality of the Unilever foods portfolio. This has led to thousands of tons of these nutrients being eliminated from its portfolio. Thus, in 2014, the sugar content was reduced by 12% in sweetened tea beverages (with a final target of 25% by 2020), and 60% of the products portfolio was reduced in salt (with a final target of 75% by 2020). Partially hydrogenated oil has been removed from 100% of the products since 2012[1]. Nestlé developed in 2004 the Nestlé Nutritional Profiling System (NNPS) to guide the reformulation of its products ("Balanced diets and healthy lifestyles", FoodDrinkEurope, 2015). Nestlé's entire product portfolio has been assessed against the Nestlé Nutritional Foundation sodium criteria (as defined in the NNPS), and the overall sodium reduction achievement was 4.7%. For example, the sodium content was cut by 14.5% to 22.5% in the Maggi soup line in Austria. The company is now looking into potential solutions for those products that do not currently meet the required standards. Nestlé undertook similar reformulation efforts for sugar, saturated fat and trans-fat. Mars initiated in 2007 a product renovation program with the goal of continuing to improve the nutritional balance of key products in the snack food portfolio ("Balanced diets and healthy lifestyles", FoodDrinkEurope, 2015). Thus, since 2002, Mars has removed 97% of the added trans-fat. The company also removed 3,000 tons of saturated fat from the European diet per year and replaced this with unsaturated fat (sunflower oil). For example, in 2009, nougat bars (Mars, Snickers and Milky Way) saw their saturated fat content reduced by 15 to 20% versus the previous recipes. At the end of 2012, a slight reduction of the fat content in the chocolate covering Snickers, Twix, Bounty and Balisto bars led to a total fat reduction of 1.7 billion fewer consumed calories across Europe.

[1] Unilever nutrition commitments, available at https://www.unilever.com/Images/summary-of-2014-uslp-nutrition-activities_tcm244-437390_en.pdf

Since 2007 and until now, Mars Food removed 441 tons of salt from its products sold in the EU.

Collective efforts have also been carried out by communities of food manufacturers, often in the framework of public-private partnerships. For instance, in the United Kingdom, the members of the Association of Cereal Food Manufacturers (ACFM, which includes the UK's leading manufacturers such as Cereal Partners, Jordans, and Kellogg's) started to reduce the salt in their branded products 18 years ago to respond to the UK Food Standards Agency's call for voluntary salt reduction targets ("Balanced diets and healthy lifestyles", FoodDrinkEurope, 2015). Another interesting case study comes from the Netherlands, where the business community is working together with the government to gradually reduce the levels of salt, saturated fat and calories (sugar, fat) in foods ("Improvement of product composition" [2], Federatie Nederlandse Levensmiddelen Industrie and Centraal Bureau Levensmiddelenhandel, 2016). In France, the National Health and Nutrition Programme (PNNS) launched in 2006 prioritized food reformulation initiatives in partnerships with the food industry. Since 2007, 39 'charters of voluntary commitments of nutritional progress' have been signed by food companies ("Les signataires des chartes d'engagements de progrès nutritionnels". social-sante.gouv.fr. Ministère des affaires sociales et de la santé, 19 Dec. 2016. Web. 3 Jan. 2017).

Also at the European level, a multistakeholder approach to increasing the healthiness of food products was promoted. At the conference on Food Product Improvement organized under the Dutch Presidency of the European Union in February 2016, member states and important stakeholders committed to a "roadmap for action"[3] that focuses on lowering the levels of salt, saturated fat and sugar in produced foods. The supporters of the document acknowledged the urgency to move step by step towards healthier food products and agreed that the problem crosses national borders, demanding transnational concerted action. The suggested plan of action is to implement multi-stakeholder cooperation, underpinned by sound research, data and independent monitoring and by exchanging best practices and facilitating industrial development and the implementation of knowledge. These agreements and actions should contribute to healthier choices being more easily available in the EU by 31 December 2020.

## 2.2. Impact of current initiatives on food composition and consumers' intakes

### Trans-fatty acids (TFAs)

The most notable development in product reformulation has been the significant

[2] "Improvement of product composition", available at http://www.fnli.nl/wp-content/uploads/2015/01/20160222_FNLI-Infographic-on-Improvement-of-Product-Composition.pdf
[3] "Roadmap for action on food product improvement", available at https://www.rijksoverheid.nl/documenten/formulieren/2016/02/22/roadmap-for-action-on-food-product-improvement

reduction in TFAs. The health concerns surrounding TFAs have led health agencies to implement different types of actions such as mandatory food labeling in the United States, ingredient bans in Denmark and New York City, and voluntary self-regulation in some countries (L'Abbeet al., 2009). Many recent studies have reported significant changes in the use of TFAs and demonstrated that the food industry has made real progress in reducing the TFA content in a variety of products (Downs et al.,2013). Although some additional progress is needed, studies have confirmed that the industry has reformulated a large part of packaged foods and found substitutes in such a way that TFAs are disappearing from many products (Unnevehr and Jagmanaite, 2008).

In Denmark, Stender *et al.* (2006) reported that legislation has, within a few years, virtually eliminated the intake of industrially produced trans-fats. Nevertheless, similarly good results have been observed in Spain where food reformulation remains voluntary: recent figures from the Observatory for Nutrition and the Study of Obesity of AECOSAN show that the presence of TFA in Spanish manufactured foods does not represent a public health problem since their quantities are very low. Almost all groups analyzed have a trans-fat percentage lower than 2% of total fat. Those that exceeded 2% are almost all dairy products, which, along with meat, naturally contain more trans-fat (Pérez-Farinos *et al.*, 2016).

As a private initiative, margarine manufacturers (IMACE) have committed to improve the quality of their business-to-business (B2B) and retail products ("Balanced diets and healthy lifestyles", FoodDrinkEurope, 2015). This led to setting a trans-fat criterion in the IMACE Code of Conduct (currently, the trans-fat content has to be below 2% on a fat basis). IMACE reported that, in B2B margarines, the average trans-fat level on a fat basis decreased from 7.1% in 2004 to 1.3% in 2014.

**Salt**

Significant efforts intended to reduce the salt contents of foods are also underway. A remarkable case is the United Kingdom, which has been developing a strategy to progressively reduce the population salt intake (He et al., 2013). In 2005, the UK Food Standards Agency (FSA) established target levels of salt for each food category. The aim was to reduce the salt added to foods by small amounts and repeat the reduction at 1- to 2-year intervals. Several reports have shown that the salt contents of foods were significantly decreased as a result of the FSA's actions (Shankar *et al.*, 2013). The final outcomes, however, remain above the initial target (Webster et al., 2010); the average salt intake has only fallen from 9.5 to 8.6 g in the United Kingdom, still above the 6 g/day target. In Australia, where voluntary sodium reduction targets have been set for three food categories, the sodium levels for 1849 packaged foods on the shelves of Australian supermarkets between 2010 and 2013 were examined by Trevena *et al.* (2014). The mean sodium level of bread products fell from 454 to 415 mg/100 g (9% lower), and the proportion reaching the target rose from 42% to 67%. The mean sodium content of breakfast cereals also fell substantially, from 316 to 237 mg/100 g

(25% lower) over the study period. The decline in the mean sodium content of bacon/ham/cured meats from 1,215 to 1,114 mg/100 g (8% lower) was smaller but associated with a rise in the proportion meeting the target from 28% to 47%. In Belgium, the Federal Public Health Service set voluntary reduction benchmarks for 13 food categories. According to a September 2013 announcement, the plan resulted in salt reductions in meat products (16 to 36 percent), bread (22 percent), dehydrated soups (17 percent), and cheese (7.5 to 20 percent) (Center for Science in the Public Interest, 2016). In the Netherlands, except for bread whose level of sodium has been regulated for a long time, food reformulation relies on voluntary agreements. According to the last reformulation monitoring performed in 2014[4], the sodium levels in bread (loafs), potato chips, spreadable cheese, and processed legumes were significantly lower than those in the reference year 2011. In France, reductions in the salt contents of foods have been observed in many food categories since 2003. However, the decrease in salt content ranged only between 4 percent and 10 percent, whereas a 20 percent reduction in salt consumption had been proposed as a target for the food industry (Anses, 2012).

**All nutrients**

In relation to other important nutrients, such as total fat, added sugars and fiber, only a few studies have been conducted worldwide, as brand-level nutrient databases are not available in many countries (Ng and Popkin, 2012). In the USA, the Healthy Weight Commitment Foundation (HWCF), which includes 16 members of the nation's leading consumer packaged goods food and beverage manufacturers, voluntarily pledged to collectively remove 1 trillion calories from their products by 2012 and 1.5 trillion calories by 2015 (baseline 2007) to improve the food supply for American children and their families. Ng *et al.* (2014) found that between 2007 and 2012, the 16 HWCF food and beverage manufacturers met and exceeded their 2012 pledge, selling 6.4 trillion fewer calories in the marketplace in total, which translates to a reduction of 78 kcal/capita/day.

In Ireland, the food and beverage industries have made concerted efforts to reduce the levels of energy, total fat, saturated fat, sugar and sodium in their products. By using Irish consumption data, the impacts of the product reformulations of 14 Irish companies on the daily nutrition intake of Irish consumer groups at two points in time – loosely, 2005 and 2012 - were projected (FDII/Creme Global, 2016). The largest decrease in percentage terms was for sodium, with a decrease of 36.6% (energy 11.5%, total fat 9.8%, saturated fat 12%, sugar 13.8%), and the greatest reduction in absolute terms was for sugar, with a decrease of 3,486 tons (total fat 1,202 tons, saturated fat 621 tons, and sodium 288 tons). 36,060 million fewer kilocalories of energy had been sold between 2005 and 2012. The authors also estimated the daily nutrient intakes of

[4] Main results available at http://www.rivm.nl/en/Topics/F/Food_Reformulation/Monitoring

Irish sub-populations, at the baseline and post-reformulation. For instance, beverages excluding milk recorded reductions in energy (by 2-3%) and sugar (by 3-4%) for all subpopulations. Sodium was significantly reduced across the greatest number of food categories, decreasing by up to 10% for teenagers (for all food categories combined). Spreading fats significantly decreased intakes for all five nutrients for all subpopulations. The adult intakes of energy, total fat, saturated fat and sodium were reduced by 4%. Soups, sauces and miscellaneous foods also achieved significant reductions in all nutrients for all subpopulations studied, apart from the reduction of sodium intake for preschoolers, which was not significant. A 34% reduction in the saturated fat intake for teenagers and a 34% reduction in total fat for children were recorded. Rice, pasta, savories and breakfast cereals recorded the greatest reductions in sodium for all four sub-populations, with rice, pasta, and savories recording a 47% decrease in mean intakes for adults.

In another report from FDII/Creme global (2016) focusing on beverage products, the authors compared two time points on the Irish market (baseline 2005-2010 and follow-up 2012) and investigated how the shift in market sales for regular and low/no-cal beverages and the reformulation of beverages have had an impact on Irish consumers. Data were forwarded by 4 FDII members, which include some of the largest beverage manufacturers on the Irish market. Two methods were used, considering only shifts in market sales (method 1) or both shifts in market sales and the reformulation of beverages (method 2). Differences in mean intakes between the baseline and follow-up period for all populations were significant (this was true for both method 1 and method 2). Teenagers experienced the greatest levels of energy reductions among all the populations, with a 49 kcal/day reduction for high consumers (P97.5 intakes) using Method 2, followed by 36 kcal/day in children, 22 kcal/day in preschoolers and 14 kcal/day in adults. The reductions in energy mean intakes ranged from 8% (Method 1 for preschoolers and children) to 22% (Method 2 for preschoolers) for consumers of FDII beverages only. The reductions in sugar mean intake ranged from 8% (Method 1 for children) to 23% (Method 2 for preschoolers) for consumers of FDII beverages only. The reductions in sugar mean intake from the total diet ranged from 0.48% (Method 1 for preschoolers) to 2.32% (Method 2 for children) for all consumers.

In France, in the framework of the 'charters of voluntary commitments of nutritional progress', Enderli *et al.* (2014) estimated the market shares of reformulated products and the potential impact on the nutritional intakes of the French population. All food sectors and nutrients were impacted by the charters, with the reformulated products representing a median market share of 4.4% in volume. The most impacted food markets were processed meat, with 54.6% of the market in volume improved on lipids and 72.4% improved on sodium; gourmet seasoning preparations, with 74.2% of the market in volume improved on lipids and 75.8% on sodium; and breakfast cereals, with 30.7% of the market in volume improved on sugar. The total volumes of nutrients sold on the market from improved products varied by 0.2% to 542.5% in absolute value, depending on the categories of foods and nutrients considered, with a median impact

of 10.2%. In particular, high levels were observed for saturated fat (-60.7% of SFA delivered onto the market by improved French fries and improved frozen side dishes), trans-fat (-69.3% of TFA delivered onto the market by improved pie pastries), and vitamin D and omega 3 (+100% delivered onto the market by the improved products). Overall, the total impact of the charters on the average nutritional quality of foods remained modest, but they nevertheless allowed significant improvements in the nutritional intakes of the French population. Significant variations of the total daily intake were observed for the 8 studied nutrients: respectively for men and women, -11.4 and -10.6 kcal/day for energy intake, -0.09 and -0.06 g/day for salt, -0.4 and -0.4 g/day for sugar; and -0.4 and -0.3 g/day for lipids.

In another study (Oqali, 2016), the impact of changes in food composition, observed in the last years in France for a large part of the overall supply of processed foodstuffs, on consumers' intakes was assessed. Six groups of the population were considered, depending on the age and the gender. Modest but significant differences in the daily mean intakes were observed within all the nutrients studied but only for some of the populations considered:

- A decrease in the mean daily intake of sugar was observed for children and teenagers: from -0.2 g / day for girls aged 3 to 10 (-0.4%) to -0.4 g / day for boys aged 3 to 10 years (-0.6%);
- A decrease in the mean daily intake of saturated fats was observed for all the groups of the population except for boys aged 3 to 10: from -0.01 g / day for boys aged 11 to 17 (-0.1%) to -0.2 g / day for adult men (-1.8%);
- A decrease in the mean daily intake of sodium was observed: from -0.003 g / day for girls aged 3 to 10 (-0.5%), girls aged 11 to 17 (-0.6%) and adult women (-0.7%) to -0.01 g / day for boys aged 11 to 17 (-0.9%);
- A decrease in the mean daily intake of proteins was observed for all the groups of the population (approximately -0.1 g/day) except for adult women;
- An increase in the mean daily intake of fat was observed for all groups of the population: from +0.3 g / day for adult women (+ 2.1%) and adult men (+ 1.5%) to +0.6 g / day for boys aged 11 to 17 (+2.7%) and boys aged 3 to 10 (+ 2.7%);
- No significant changes were observed for the daily mean energy intakes, as calculated from the carbohydrate, fat and protein contents.

### 3. **Comparing the impact of food reformulation *versus* consumers' choices**

In 2005, the UK government launched an information campaign aimed at raising awareness of the consequences of high salt consumption and encouraged the food industry to voluntarily reformulate food products to reduce their salt content. Subsequent to these two policies, substantial reductions in salt intake were observed. Using longitudinal data on the contents of the grocery baskets of a nationally representative sample of households, Griffith *et al.* (2014) showed that the average salt content (of grocery purchases) fell by 5.1%, from 0.370 g in 2005 to 0.351 g in 2011.

This variation was divided into three components: the food reformulation of existing products by manufacturers, the net effect of the launching/removal of products, and consumer switching between products. The study showed that the decline in consumers' salt intakes was entirely due to the food reformulation effect. The reformulation of processed food and grains (bread and breakfast cereals) together contributed over three-quarters of the decline. The net effect of new product introduction and the removal of products was positive but was smaller in magnitude (approximately one-tenth the size) than that of reformulation. This was mainly driven by the introduction of new products that had a slightly higher salt content than existing ones. The cumulative effect of consumer switching was to increase the average salt intensity of the shopping basket over the period 2005 to 2011. In other words, the consumer switching between products worked in the opposite direction and led to a slight increase in the salt intensity of groceries purchased.

This study conducted in the U.K. clearly showed the complexity of the food reformulation issue, as food companies may act differently depending on the type of products. In addition, consumers' moves from some food groups to others may weaken (or amplify) the expected outcomes of food reformulation initiatives. To obtain a better understanding of the food industry and consumers' behaviors, we extended the analysis of Griffith et al. to the French case for a larger set of nutrients. More precisely, we used data collected in France to quantify the respective contributions of the three effects related to the reformulation of existing food products, the renewal of the food supply through the launching of new products and the removal of old products; and product substitutions made by consumers among already existing products on the market.

### 3.1. A focus on four food sectors

Four food groups were considered in this study: breakfast cereals, biscuits and cakes, potato chips and soft drinks. The availability of the data for dates $t_0$ and $t_1$ and the variety within these food groups in terms of recipes, levels of business concentration and nutrients of interest (subsequently named "key nutrients") guided this choice.

**Nutritional and purchase data**

The nutritional compositions of food products have been obtained from the French Observatory of Food Quality (Oqali[5]), which collects data on the characteristics of processed foodstuffs sold on the French market, including their nutritional

[5] Oqali is the "Nutrition section that deals with issues related to food product supply and characteristics" within the French Food Observatory. Its implementation has been entrusted to a research institute, INRA (French National Institute for Agricultural Research) and to a food safety agency, ANSES (French Agency for Food, Environmental and Occupational Health & Safety). The Oqali project aims at monitoring changes in the processed food supply available on the French market by measuring the nutritional quality evolution over time (i.e., nutritional composition and labelling information). At the end of 2016, The Oqali database contained data on approximately 48 500 food items from 29 different food sectors, corresponding to almost 80% of the French consumption of manufactured products.

compositions. The Oqali database is brand-specific and is specifically designed to monitor, over time, changes in products' packaging.

Table 1 below lists the key nutrients that have been selected in this study for each food group. These nutrients have been chosen because they are linked to important public health issues and have often been included in reformulation initiatives implemented by the food industry.

**Table 1: Key nutrients per food groups**

| Food groups | Nutrients |
|---|---|
| breakfast cereals | sugar, fats, saturated fats, fiber, sodium |
| biscuits and cakes | sugar, fats, saturated fats, fiber |
| potato chips | fats, saturated fats, sodium |
| soft drinks | sugar |

Within each food group, the sampled food products were partitioned into three subgroups:

- Group X: products removed from the market (or not collected at $t_1$): these products were collected at $t_0$ without being linked to any product collected at $t_1$;
- Group C: paired products collected at both $t_0$ and $t_1$, with or without changes in product packaging or nutritional composition;
- Group N: new products (not collected at $t_0$): these products were collected at $t_1$ without being linked to any product collected at $t_0$.

Food composition data have been matched with purchase data from Kantar Worldpanel to compute the market share of each product at dates $t_0$ and $t_1$. The Kantar Worldpanel database provides details on the quantities bought and the corresponding food expenditures by a representative panel of 20,000 households in France. The sample of data analyzed in the study consists of food products found in both the Oqali and Kantar Worldpanel datasets. Table 2 displays the market shares of the sampled food products.

**Table 2: Number of products and covered market share of the samples, per food group and date of data collection**

| | Date $t_0$ | | | Date $t_1$ | | |
|---|---|---|---|---|---|---|
| | **Year** | **Number of products** | **Covered market share (%)** | **Year** | **Number of products** | **Covered market share (%)** |
| **Breakfast cereals** | 2008 | 254 | 75.1 | 2011 | 362 | 74.6 |
| **Biscuits and cakes** | 2008 | 1436 | 70.4 | 2011 | 1824 | 65.4 |
| **Potato chips** | 2009 | 135 | 60.4 | 2011 | 217 | 81.0 |
| **Soft drinks** | 2010 | 619 | 78.1 | 2013 | 1208 | 86.3 |

The observation period covered 3 years. It is interesting to note that the observation period coincides with the dates of the implementation of voluntary agreements by food companies with the French government (Sebillotte, 2013).

Among the practical constraints encountered by Oqali, the dates of data collection are not exactly the same for the four food groups. Additionally, although it does not raise serious difficulties, but it is worth noting that the method of collecting data is not strictly identical in the case of potato chips. Indeed, in this case, the data sources differed between 2009 and 2011. Data at $t_0$ were provided by an industrial partner of Oqali, one of the main chip manufacturers. Only the products with the highest sales volumes were selected, implying, for example, that no low-priced private label products were collected. The data at $t_1$ came from the Oqali database: the objective was to achieve the most comprehensive collection to the greatest degree possible, regardless of the market shares of the products. That is why the covered market share is higher at $t_1$ (81%) than at $t_0$ (60%) for this food group.

Overall, the samples are representative of the market at both $t_0$ and $t_1$. Nevertheless, by comparing the compositions of the samples with the real market, we note that

- National brand breakfast cereals and biscuits and cakes were slightly overrepresented at $t_0$, whereas private label products were slightly underrepresented.

- National brand and private label potato chips in the mid-price range were over-represented at $t_0$, unlike the low-priced private label and hard-discount products, due to the method of collecting described above.

- National brand soft drinks were over-represented at $t_0$, unlike hard-discount

products.

Figure 1 and Figure 2 display the partitioning of the samples into the three subgroups in numbers of products and market shares (by volume), respectively. In Figure 2, the market shares were calculated by applying method 1 described in the "data processing" section.

It is important to note that the samples do not provide exhaustive coverage of the products on the market. Thus, there is a bias in the assignment of the products within the subgroups: some products actually belonging to group C (stable products) could have been classified within group N (new products) or group X (products withdrawn) because they were not collected for one of the two years of follow-up. This is particularly true for potato chips, due to the changes in data collection and some difficulties in making a link between the two references collected at $t_0$ and $t_1$ on the basis of the recorded characteristics.

In any case, the samples provide a good representation of the market. In the number of products, the $t_1$ sample consists of 48 to 59% of the new products (group N) and 41 to 52% of the stable products (group C), depending on the food group. 25 to 35% of the products collected at $t_0$ were withdrawn (group X). In volume, the stable products have larger market shares, varying from 64 to 79% of the food supply, depending on the food group.

**Figure 1: Partitioning of the samples into subgroups (in numbers of products)**

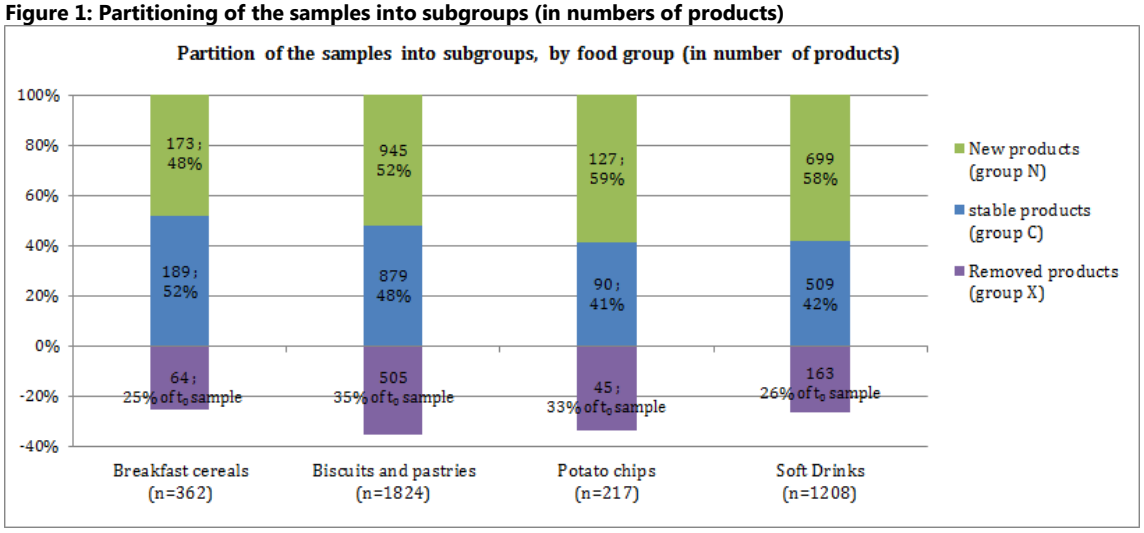
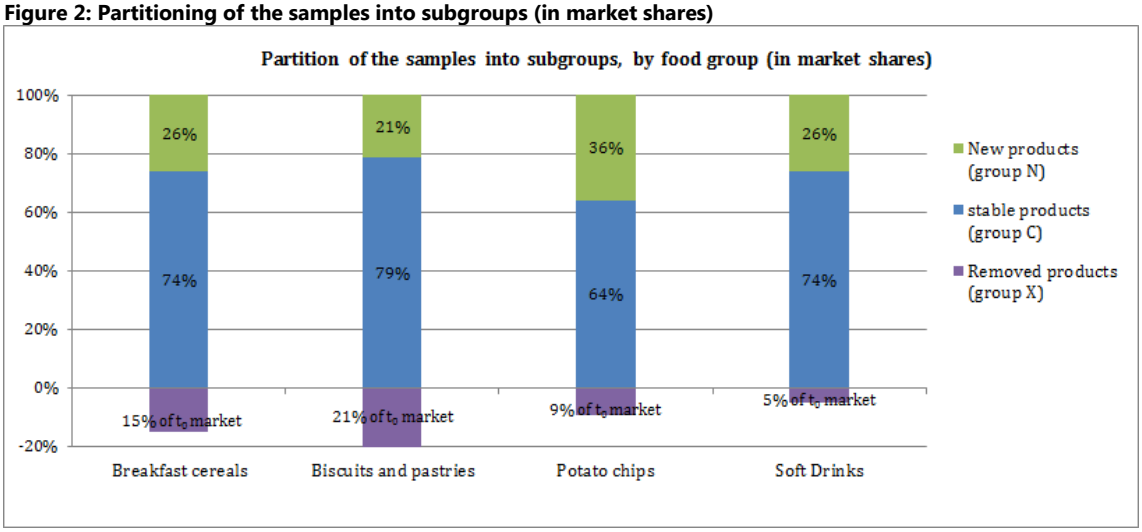


**Figure 2: Partitioning of the samples into subgroups (in market shares)**




It should be noted that the nutritional data collected by Oqali can be calculated by the manufacturers using different methods (e.g., calculations based on the recipe or analysis of the nutritional composition). Thus, some changes in the nutritional composition observed in stable products may be related to the evolution of the method of estimating the nutritional values or to the tolerances of the analytical measurements. These evolutions, even weak, are interpreted as a product reformulation in this study.

### 3.2. Method for decomposing the respective contributions of food industry and consumer behavior changes

We aim to measure the evolution of the nutritional quality of food consumption *via* the changes in the sales-weighted average content in key nutrients between dates $t_0$ and $t_1$ in a specific food group. To disentangle the effects of changes on the supply side from those on the consumer side, we use the method recently proposed by Griffith *et al.* (2014).

Let us denote by $S_t$ the sales-weighted mean content of a specific key nutrient, for one food group, at time t. This is given at $t_0$ and $t_1$ by

$$S_{t_0} = \sum_i w_{it_0} s_{it_0}$$

$$S_{t_1} = \sum_i w_{it_1} s_{it_1}$$

where i indexes individual food products,

$w_{it_0}$ is the market share of the food product i at $t_0$

$s_{it_0}$ denotes the content in a given nutrient of the food product i at $t_0$

(A similar notation applies for $t_1$)

The change in the sales-weighted mean content of a specific key nutrient is defined as follows:

$$\Delta S_t = S_{t_1} - S_{t_0}$$

The decomposition into supply and demand effects is given by:

$$\Delta S_t = \sum_{i \in C} w_{it_0} \Delta s_{it} \quad (1)$$
$$+ \sum_{i \in N} w_{it_1}(s_{it_1} - S_{t_o}) - \sum_{i \in X} w_{it_0}(s_{it_0} - S_{t_0}) \quad (2)$$
$$+ \sum_{i \in C} (s_{it_0} - S_{t_0}) \Delta w_{it} + \sum_{i \in C} \Delta s_{it} \Delta w_{it} \quad (3)$$

In this expression, the first term (1) accounts for the effect of food reformulation, carried out on products collected at both $t_0$ and $t_1$, considering their market share at $t_0$. Thus, the contribution of a reformulated product to this term will be greater if its market share at $t_0$ is high.

The second term (2) captures the impact of product renewal, more precisely, the entry of products to the market or their withdrawal between $t_0$ and $t_1$. It takes into account the nutrient content of the new products or the removed ones (compared with the overall sales-weighted mean nutrient content at $t_0$) and their market shares. Thus, for example, a new product with a high sugar content will increase the sales-weighted mean sugar content of the food group. This effect will be more important if its market share is high.

The last term (3) reflects switching by consumers inside group C (products collected at both $t_0$ and $t_1$):

- The sub-term $\sum_{i \in C}(s_{it_0} - S_{t_0})\Delta w_{it}$ represents the contribution of a change in the market share of a product between $t_0$ and $t_1$. For example, if consumers shift toward products that have a high sugar content (compared with the sales-weighted mean nutrient content of the food group at $t_0$), this will raise the overall sales-weighted mean sugar content.

- The sub-term $\sum_{i \in C} \Delta s_{it} \Delta w_{it}$ captures the covariance of changes in the nutrient content and the quantity shares of group C products; for example, if consumers

shift towards products that are reformulated to have less sugar, this term will be negative.

**Data processing**

The algorithm presented above is valid if the total market shares covered at $t_0$ and $t_1$ are equal to 100% and the nutritional composition of the sampled products is known. This is not exactly the case, as the Oqali samples do not cover 100% of the sales volume. The data must be then processed to satisfy this condition. Two methods of data processing, based on different assumptions, were carried out.

Method 1

A first computation was made by assuming that the non-collected references had, on average, the same characteristics as the whole sample and followed the same evolution between $t_0$ and $t_1$.

To make the sum of the market shares equal to 100%, for each food group and time of follow-up, the market share of each reference is transformed by

$w_{it}^* = w_{it} / C_t$

where $w_{it}^*$ stands for the corrected market share of the reference i at time t
$w_{it}$ is the market share of the reference i at time t
$C_t$ is the market coverage of the sample studied at time t

It is important to note that the processed market shares do not reflect the reality of the market. However, this data processing allows applying the algorithm in the required conditions.
This method of data processing distorts the data less if the market coverage of the samples studied is high and of the same order of magnitude at $t_0$ and $t_1$ and if the samples are representative of the market at each time of follow-up.

Method 2

A second computation was made by assuming that the products that were not identified in the Oqali data set but were present in the Kantar Worldpanel data set had, on average, the same nutritional composition as the whole sample and were stable over the period of observation.

In other words, the missing data were replaced by one 'aggregated product' whose market share is 100% - $C_t$ ($C_t$ is the market coverage of the sample studied at time $t_0$) and whose nutritional composition is the sales-weighted average composition of the

whole sample at $t_0$. This 'aggregated product' is assigned to group C, and it is assumed that its nutritional composition remains stable over the period from $t_0$ to $t_1$.

With such a method, it is important that the Oqali samples be representative of the market at $t_0$ and $t_1$ (for instance, an over-representation of 'low-fat' products at $t_0$ would lead to an underestimation of the weighted average of fat content in the whole sample that would affect the inferred data at $t_0$ and $t_1$).

Compared to method 1, method 2 tends to overestimate the volumes of the group C products and underestimate the magnitude of the reformulation initiatives. Thus, we expect that the two methods will lead to similar results, but the magnitude could be lower with method 2.

**Inference of nutritional composition data for products with missing information**

To run the algorithm, it is also necessary to avoid missing data of nutritional compositions. For products with missing information, we proceeded as follows:

- For group C products (collected at $t_0$ and $t_1$ but with missing nutritional data at both dates), we adopted each time a 'pessimistic' hypothesis by assuming that the products had not been reformulated. The sales-weighted mean nutrient content of the food category at $t_0$ was assigned for those products at both $t_0$ and $t_1$.

- For group C products with missing data only at one date ($t_0$ or $t_1$), we adopted the same value as the one available.

- For group X or N products with missing nutritional data, the sales-weighted mean nutrient content of the food category at $t_0$ was assigned.

### 3.3 Results

Tables 3 to 6 present the results of the decomposition method for the 4 food grous and key nutrients.

**Breakfast cereals**

In the breakfast cereals sector, the variation of the sales-weighted average nutrient contents between the 2 dates is, from a public health point of view, positive for sodium (related mean content decreases by 8.3% to 11.1% depending on the method) and negative for sugar, total fats and saturated fats (related mean contents increase by 0.5 to 0.7%, 7.5 to 10.1%, and 10.2 to 13.6%, respectively) and fiber (related mean content

decreases by 1.1 to 1.4%).

Interestingly, the contribution of food reformulation to the variation of the weighted-average nutrient contents is, for all nutrients, in the right direction: weak for total fat and SFA (it leads to decreases in the sales-weighted average product contents of SFA and total fat by 0.4 to 0.6% and 0.6 to 0.8%, respectively), moderate for fiber (it increases by 2.2 to 2.9% the sales-weighted mean fiber content) and sugar (it decreases by 2.3 to 3.0% the sales-weighted mean sugar content), and strong for sodium (it decreases by 7.3 to 9.7% the sales-weighted mean sodium content).

The results are more ambiguous for the launching (withdrawal) of new (old) products. Indeed, except for total fats (where it generated a 0.8 to 1.0% decrease in the sales-weighted average product content), the contributions of all other nutrients are in the wrong direction: increase in sales-weighted average contents in sodium, SFA and sugar and decrease for fiber.

Regarding consumers' behavior, it turns out that they switched from some food groups to others in such a way that they strongly reduced the sales-weighted mean sodium content but increased the sugar, total fat and SFA mean contents. This is particularly clear for total fats and SFA, as it is mainly the consumers' moves that explain the negative variation of the weighted-average contents of these nutrients.

**Biscuits and cakes**

In the biscuits and cakes sector, the variation of the sales-weighted average nutrient contents between the 2 dates is, from a public health point of view, positive for total fats and SFA (related mean contents decrease by 0.3 to 0.5% and 2.4 to 3.7%, depending on the method, respectively) and negative for sugar (related mean content increases by 1.1 to 1.7%) and fiber (related mean content decreases by 0.9 to 1.3%). Overall, the variations are small, except for that of SFA.

The contribution of product reformulation to the variation of the weighted average nutrient content is, for all nutrients, in the right direction, except for sugar (it is quite null for this nutrient). The magnitude is modest and slightly greater for SFA. Once again, the results related to the launching (withdrawal) of new (old) products are ambiguous. Indeed, except for total fats (it leads to a decrease in the sales-weighted mean content by 0.2%), the contributions for all other nutrients are in the wrong direction: increases in the sales-weighted mean contents of SFA and sugar and a decrease for fiber.

Regarding the consumer's behavior, it turns out that some consumers switched from some food groups to others in such a way that they strongly reduced the weighted mean SFA content but increased the sugar and total fat mean contents.

**Potato chips**

In the potato chips sector, we can observe very strong variations in the sales-weighted average nutrient contents in two cases: for sodium (the related mean content decreases by 10.2 to 12.6%), and SFA (the related mean content decreases by 47.4 to 58.5%). In both cases, this is mainly due to the reformulation effect and, to a lesser degree (approximately half the size), to the innovation/withdrawal effect. Conversely, consumers' switching weakened these changes as they slightly increased the sales-weighted mean contents of SFA (by 1.8 to 16%) and sodium (by 2.7% with method 1). This is mainly explained by the positive covariances in those nutrients' contents and the quantity shares of group C products: consumers turned away from products that were reformulated for less SFA and sodium. However, according to the innovation/withdrawal effect, it is worth noting that the consumers switched towards new products with less sodium and SFA.

**Soft drinks**

Finally, in the soft drinks sector, it appears that the sales-weighted average sugar content slightly decreased between $t_0$ and $t_1$. This was clearly the result of the reformulation effect that generated a 1.7 to 2.2% decrease, and the innovation/withdrawal effect that generated a 2.2 to 2.4% decrease in the mean sugar content. Conversely, consumers' switching offsets these effects, leading to a 3.8 to 4.4% increase in the average intake.

**Table 3: Results for breakfast cereals**

| Breakfast cereals | Weigthed average at t0 | Weigthed average at t1 | | Reformulation | | New products/product withdrawals | | Consumers swithing | | Variation of the weighted average t1/t0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 |
| Sugar (g/100g) | 27.7 | 27.9 | 27.8 | -3.0% | -2.3% | 1.4% | 1.0% | 2.4% | 1.8% | 0.7% | 0.5% |
| Total fats (g/100g) | 7.4 | 8.1 | 7.9 | -0.8% | -0.6% | -1.0% | -0.8% | 11.9% | 9.0% | 10.1% | 7.5% |
| SFA (g/100g) | 3.0 | 3.4 | 3.3 | -0.6% | -0.4% | 1.4% | 1.0% | 12.8% | 9.6% | 13.6% | 10.2% |
| Fiber (g/100g) | 5.1 | 5.1 | 5.1 | 2.9% | 2.2% | -5.1% | -3.8% | 0.8% | 0.6% | -1.4% | -1.1% |
| Sodium (g/100g) | 0.3 | 0.3 | 0.3 | -9.7% | -7.3% | 3.5% | 2.6% | -4.9% | -3.6% | -11.1% | -8.3% |

**Table 4: Results for biscuits and cakes**

| Cookies and biscuits | Weigthed average at t0 | Weigthed average at t1 | | Reformulation | | New products/product withdrawals | | Consumers swithing | | Variation of the weighted average t1/t0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 |
| Sugar (g/100g) | 32.3 | 32.8 | 32.6 | 0.1% | 0.1% | 0.8% | 0.5% | 0.7% | 0.5% | 1.7% | 1.1% |
| Total fats (g/100g) | 18.9 | 18.8 | 18.9 | -1.2% | -0.8% | -0.2% | -0.2% | 0.9% | 0.7% | -0.5% | -0.3% |
| SFA (g/100g) | 9.4 | 9.1 | 9.2 | -2.7% | -1.9% | 1.0% | 0.7% | -2.0% | -1.2% | -3.7% | -2.4% |
| Fiber (g/100g) | 2.8 | 2.8 | 2.8 | 0.8% | 0.6% | -2.2% | -1.4% | 0.0% | 0.0% | -1.3% | -0.9% |

**Table 5: Results for potato chips**

| Chips | Weigthed average at t0 | Weigthed average at t1 | | Reformulation | | New products/product withdrawals | | Consumers swithing | | Variation of the weighted average t1/t0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 |
| Total fats (g/100g) | 34.7 | 34.5 | 34.6 | 0.2% | 0.1% | -0.3% | -0.4% | -0.3% | -0.1% | -0.4% | -0.4% |
| SFA (g/100g) | 8.4 | 3.5 | 4.4 | -52.1% | -31.4% | -22.4% | -17.7% | 16.0% | 1.8% | -58.5% | -47.4% |
| Sodium (g/100g) | 0.7 | 0.6 | 0.6 | -11.1% | -6.7% | -4.2% | -3.4% | 2.7% | -0.1% | -12.6% | -10.2% |

**Table 6: Results for soft-drinks**

| Soft drinks | Weigthed average at t0 | Weigthed average at t1 | | Reformulation | | New products/product withdrawals | | Consumers swithing | | Variation of the weighted average t1/t0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 | Method 1 | Method 2 |
| Sugar (g/100mL) | 6.5 | 6.5 | 6.5 | -2.2% | -1.7% | -2.4% | -2.2% | 4.4% | 3.8% | -0.1% | -0.1% |

### 3.4. Discussion

Overall, the results show that, in the four food groups considered, product reformulation initiatives implemented by the food industry have improved existing products (available on the market at $t_0$ and $t_1$) for most targeted sector-nutrient pairs (except for the sugar contents of biscuits and cakes and the total fat contents of chips) and, in this sense, have contributed to the achievement of public health goals.

It is likely that some of these changes are linked to individual or collective agreements implemented by the food industry and the French government since 2008. In the breakfast cereals sector, for instance, several agreements were signed between 2008 and 2011 in which two food processors (Nestlé and Kellogg's) and several retailers (Casino, Scamark) were involved. In these formal agreements, they committed to improving the nutritional quality of food products, in particular regarding the salt, fiber, sugar and fat contents.

Another example is given by the potato chips sector. The saturated fat levels of potato chips sharply declined between 2009 and 2011, mainly thanks to reformulations (which led to a -2.6 to -4.4 g/100 g decrease in the sales-weighted average content of saturated fat in this sector). This decrease was the result of a collective action by the industry to replace the palm oil used for frying chips with sunflower oil, which contains less saturated fat.

In some cases, the magnitudes of the observed changes seem to be modest, but it is important to have in mind that the period of observation is only 3 years long. It is also important to have in mind that these changes have been implemented without any claim or signal provided to the consumers on the packaging (except for in the nutritional fact panels). In general, they have been 'silently' carried out to respond to public authorities' expectations, or to prove corporate social responsibility, rather than to 'attract' consumers (REF).

If we consider now the second effect related to the launching of new products and the removal of existing products, the results are more ambiguous, as this effect did not necessarily participate in this dynamic of the nutritional quality improvement of the food supply. In the soft drinks and potato chips sectors, the launching of new products contributed to reducing the sales-weighted mean content of 'negative' nutrients. This effect contributed to decrease the sales-weighted mean sugar content in the soft drink sector by 2%, and the sales-weighted mean SFA content in the potato chips sector by 18 to 22%. However, in the breakfast cereals and biscuits and cakes sectors, it turns out that the renewal of the food supply contributed negatively to achieving public health goals. Indeed, new products with high market shares belonged to categories with poorer nutritional quality compared to the sector average (and *vice versa* for product withdrawal). The consequence is that, over the observation period, this effect contributed, for instance, to increase by approximately 3% the sales-weighted mean

sodium content in the breakfast cereals and to decrease by approximately 2% the sales-weighted mean fiber content in biscuits and cakes.

How can this statement be explained? One assumption is related to the role of some nutrients in product taste and the associated marketing strategies and commercial risks. If we assume that consumers do not demand, generally, products with less salt or less fat and prioritize taste over health, then it is understandable that

- Food reformulation initiatives are primarily made to improve the nutritional quality of products already adopted by consumers, provided that the changes in the nutrient contents do not affect the product taste (and then they remain small) and are silently implemented to not cause product rejection by consumers.

- Commercial and communication strategies associated with the launching of new products aim to attract new consumers by promoting taste and pleasure rather than health. Then, integrating more stringent nutritional constraints into the design of new products may be considered 'too risky' in some food sectors.

Considering the third effect induced by consumers' switching from some food groups to other, during the observation period, it did not generally lead to an improvement in the nutritional quality of the diets. In several cases, consumers' switching offsets the reformulation effect. For instance, in the breakfast cereals sector, it is mainly the consumers' moves that explain the negative variation of the weighted average contents of total fats and SAF.

Our analysis does not provide any insights to explain consumers' changes. Did they move because they perceived some taste impact of the product reformulation, or did they move for other exogenous reasons (food prices, economic crisis, advertising, etc.)? We cannot answer this question here, but our results converge with those of Griffith et al. that suggest that policies targeting changes in the food supply may have greater impacts than those promoting changes in consumer behavior.

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# PART 2

## Quality standards versus nutritional taxes: health and welfare impacts with strategic firms[6]

(Vincent Réquillart, Louis-Georges Soler and Yu Zang)

**Abstract**

The goal of this paper is to better understand firms' strategic reactions to nutritional policies targeting food quality improvements and to derive a set of optimal policies. We propose a model of product differentiation, taking into account both the taste and health characteristics of products, and use it to assess the health and welfare impacts of alternative policies. We study how a duopoly of mono-product firms reacts to three alternative policies: a Minimum Quality Standard (MQS) policy, linear taxation of the two goods on the market, and finally taxation of the low-quality good. Among the three policy options analyzed, the MQS policy and the taxation of the low-quality product are the most preferred by a social planner. The definition of an optimal policy depends on the consumers' willingness to accept taste modifications, and the type of social planner. If taste is moderately important, the MQS policy is chosen by a populist and by a paternalist social planner. If taste is a major component of choice, a populist social planner chooses to tax the low-quality product whereas a paternalist social planner still prefers the MQS-based policy. Finally, for a paternalist social planner, an MQS-based policy always allows for higher levels of welfare than an information policy alone.

[6] Réquillart V, Soler L-G, Zang Y. Quality standards versus nutritional taxes: Health and welfare impacts with strategic firms. *Journal of Health Economics* 2016;50:268-285. (See: http://www.sciencedirect.com/science/article/pii/S0167629616302028)

# GENERAL CONCLUSION

This research aimed at better understanding firms' strategies in food innovation and reformulation and their responses to nutritional policies. It was based on two complementary approaches: first, an empirical analysis based on a literature review and the treatment of French data, and second, a theoretical investigation based on economic model of product differentiation.

The results of the empirical part (subtask 1) suggest that:

- The modification of the nutritional quality of foods may induce significant health benefits even in the absence of positive changes in consumers' diet patterns. Indeed product reformulation has the potential to contribute substantially to the improvement of consumers' intakes by reducing the salt, fat or sugar contents in foods. The induced health benefits may be significant and as important as those obtained by other types of policies. Product reformulation appears to be cost-effective and able to contribute more strongly to reduce health inequalities than policies focused on consumers' information.

- The food industry is already engaged in food reformulation initiatives in many countries. The results are sometimes significant, but overall the changes remain modest and smaller than the potential expected changes. While there are significant improvements in the nutritional quality of some products, the overall impact on consumers' intakes is still modest, as most products have yet to be reformulated.

- Compared to the reformulation of already existing products, the launching of new products and the removal of existing products have more ambiguous results. Some examples indicate that this effect does not necessarily participate in the dynamic of the nutritional quality improvement of the food supply. If we assume that consumers do not demand, generally, products with less salt or less fat and prioritize taste over health, then it is understandable that commercial and communication strategies associated with the launching of new products aim to attract new consumers by promoting taste and pleasure rather than health. Integrating more stringent nutritional constraints into the design of new products may be considered 'too risky' in some food sectors.

Overall investigations suggest that the difficulties faced by the companies to implement food reformulation must not be underestimated. Limitations to food reformulation relate mainly to consumer acceptance, safety aspects, technological challenges and food legislation. However, encouraging the reformulation of foods, especially for products with the lowest nutritional quality in each category of processed foods, is a worthy target for health policy makers.

Voluntary agreements may have positive effects on food quality. However, as this process is not yet generalized and adopted by the whole food sector, at the moment, the effects on consumers' intakes remain limited. This statement leads to raise the question of the generalization of food reformulation efforts, and the possible effects of more stringent policies.

In subtask 2, we proposed an economic model to better understand firms' reactions to nutritional policies and their effects on welfare and public health indicators. We considered three policies based on two different taxation schemes and the implementation of quality standards.

The results show that firms respond differently to the three instruments, leading to different impacts on market and public health outcomes. We find that only the MQS policy and the linear excise tax on the low-quality product are effective in a general sense. The choice, however, between the two depends on the priorities of the regulator and on consumers' resistance to move away from their initial taste preferences. Finally, we show that policies intended to change the food market environment allow for greater health benefits and welfare than policies based solely on information campaigns.

Although food reformulation alone would not be sufficient to dramatically reduce the prevalence of chronic diseases related to food consumption, it can play an important role in that direction.