RESEARCH IN ECONOMICS AND RURAL SOCIOLOGY

Nutritional policies, food-chain regulation and food consumption

If, for a long time, the prime objective of food policies was to guarantee food safety, nowadays the objectives are more qualitative, at least in the developed countries. The importance of eating "better" has increased progressively in a context where life expectancy is increasing and where shortage has given way to an abundance of low-priced products. According to nutritional standards, food has even become a potential risk factor, with bad eating habits favouring the occurrence of specific illnesses like obesity, diabetes, cancer and heart disease. In the United States, obesity ranks second among the main causes of death (300,000 deaths per year), after tobacco (around 400,000 deaths per year). And the World Health Organization considers that a high energy diet poor in fruit and vegetables is a factor in obesity risk, a risk that may increase because of the relative fall in prices of food products. We attempt to find out whether the present structure of food prices goes against the nutritional recommendations.

The food price structure and the socio-economic characteristics of households play a leading role in the distribution of food consumptions, with the price structure going against nutritional quality. In parallel, the private actors' strategies in the fruit and vegetable sector have not favoured the global consumption of these products whereas the reform of the Sugar Policy could stimulate industrial demand for added sugar. In the face of these observations which are against the nutritional recommendations and the PNNS (French National programme for Nutrition and Health), the public authorities may consider acting on prices to stimulate the consumption of fruit and vegetables by means of subsidies and/or reduce the consumption of fatty animal products by means of taxes. The simulated effects of such policies do not look homogenous within the population, a factor which in some cases could increase the disparities between population categories.

All the results presented here come from a project within the French PNRA (the Food Research Programme) of the French National Research Agency, bringing together economists and nutritionists. Its aim was to contribute to the elaboration of an integrated Public Health Policy by taking an interest in the various levers as regards nutritional policy and public health at the disposal of the public authorities. To do so, we first try to understand better the mechanisms of food-related decision making, while questioning the relationships between nutritional quality and food cost. Next, we studied the articulations between public policies, in particular agricultural ones, and producers' strategies in certain food chains and their effect on consumption. Last, we tried to assess the changes in consumption that would be induced by actions on the prices of products, on the nutritional qualities of products and on information at the consumers' disposal.

Very restricted food choices for consumers and their consequences

Food choices are strongly linked to the socio-economic characteristics of households

What are the relationships between the socio-economic characteristics of individuals or households and food choices? By using the SU.VI.MAX panel (adult panel from 45 to 62, see frame 1), we show that the respect for the PNNS recommendations about 5 fruit and vegetables per day (see frame 2) is less frequent among people under 50 years without higher education. The variety of fruit and vegetables consumed also increases with the education level and the socio-professional category (SPC), in particular among men. The share of fruit in the cost of the daily food intake is not defined in the same way for men and women: it tends to increase with the education level and SPC for men, while it tends to decrease for women according to the SPC. By mobilising data from the EENS survey, which this time includes children, we show that low consumption of fruit and vegetables is more frequent among children whose parents practice an independent profession, or have a secondary school education rather than a higher education level as well as those whose household is in a situation of food insecurity (this being defined as "limited or uncertain availability of adequate and safe food or a limited or uncertain capacity to acquire food in a socially acceptable way").

A score in line with the PNNS recommendations was developed (from 13 components) to assess the deviation between food composition and nutritional recommendations. The probability of having a high score, that is, having a diet close to the recommendations, increases with the age whatever the sex. On the other hand, no statistical link was shown between this score and the education level.

The foods with high nutritional quality are usually the most expensive ones

It is now well-established that for equivalent energy contents, food of good nutritional quality is usually more expensive than that of low nutritional quality, because of its low energy density and its rich content in essential nutrients. We checked that people with the highest scores in terms of content in a number of nutrients (fixed at 23 here) by comparison with the recommendations at the same time have more expensive and lower energy food (per day or for 10 MJ) than those who have low scores.


Frame 1: Data sources

As a preamble, we must emphasise the importance of having access to various data sources, collected over long enough periods. Therefore, it is essential to put significant means into these operations without which it is impossible to develop high quality analyses on these matters.

Work on consumer behaviour relies on panel data. Three main sources were used: 1) data on 4,282 adults (from 45 to 62) coming from the SU.VI.MAX panel (Survey called "SUpplementation in VItamines and anti-oxidant Minerals" which aimed on the one hand to find out the efficacy of supplements of vitamins and anti-oxidant minerals on the prevention of heart disease and cancer, and on the other hand to build up a database of French food consumption) complemented by data on children, coming from the ENNS survey (French National Nutrition Health Survey), 2) data on subjects coming from the INCA1 (National and Individual Survey on food consumption, 1998) and 3) data coming from TNS-SOFRES household panel which provides all the food purchases of about 8,000 households over several years (2001-2002). This last panel is used for various econometrical modelling works on food consumption and helps assess data on consumer behaviour in the face of price fluctuations. It also includes data on the characteristics of households, including information on the agents' weight and size within households. Last, experimental economic methods were also used to analyse the behaviour of less favoured populations, in a more specific way.

For the most part, the research on food chains is based on surveys carried out within the project, and another part on the price data collected by the Markets News Service of the Ministry of Agriculture and Forestry.

In order to propose a ranking of food groups according to their nutritional quality/price ratio, we divide foods into 7 categories and 26 subcategories and for each of them we calculate a good nutritional quality index, the SAIN (Nutrient Adequacy Score for Individual foods) based on nutritional quality, and an index formed of components to be limited on a nutritional level, the LIM (Limited nutrients), based on the contents in sugar, salt and saturated fatty acids (SFA). Then we estimate the cost of energy inputs (in €100 kcal) and the nutritional quality (SAIN/LIM ratio) of each of the groups and subgroups. The egg/meat/fish and fruit/vegetable categories appear to be the most expensive energy sources (graph 1) but also those with the best nutritional quality. Conversely, the groups of "added fats" and the "sweet fat-salted fat products" are cheap energy sources but with low nutritional quality. "Dairy products" are in an intermediate position while "starchy foods" are both cheap from the energy point of view and of good nutritional quality. If, at a finer level of analysis (subgroup), the relationship is less clear, we may, however, distinguish several subgroups of very good nutritional quality/price ratio like pulses, wholemeal cereal products, potatoes, milk, offal and eggs. Vegetable fats, dried fruit and oilseeds are also well ranked but are to be consumed in moderation because of their high energy density. These results suggest that it would be appropriate to make fruit, vegetables, fish and wholemeal cereals more financially accessible.

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Graph 1:"Price/nutritional quality /ranking" between main food categories

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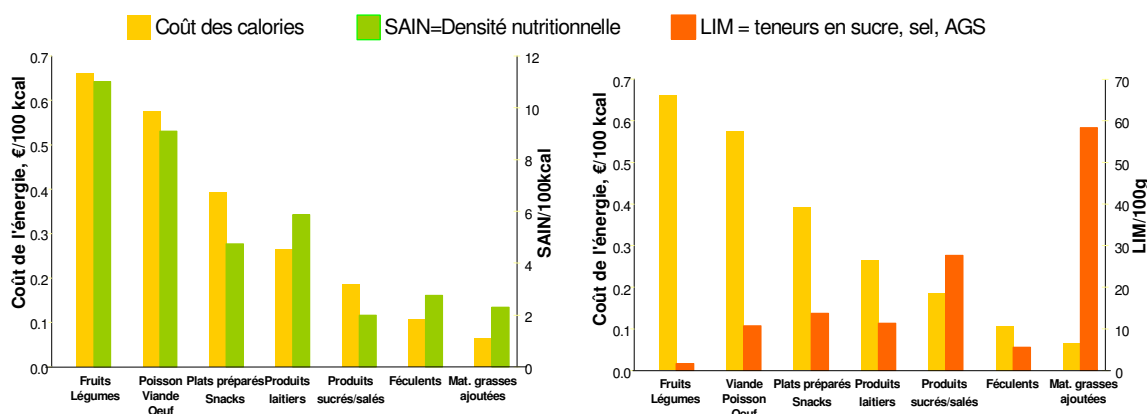
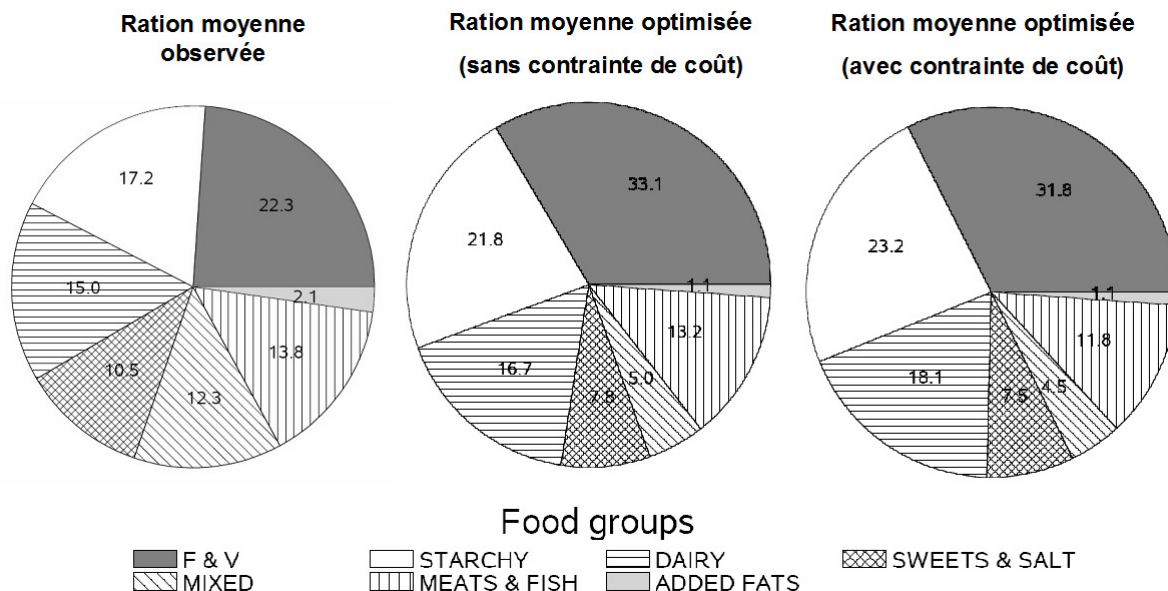## The respect for nutritional constraints has a cost which depends on consumption habits

A model of the behaviour of a consumer choosing a food intake, taking into account his habits, price structure and nutritional constraints shows that it is possible to define an optimal food from the nutritional point of view at a very low cost but that it implies moving far away from the food habits observed in the French population. By modelling iso-caloric intakes (1,800 and 2,200 Kcal) integrating increasing constraints as regards nutrition and habits, we obtain a minimum price to respect the recommended nutritional intakes (RNI) which, per day, varies from 1.25 € to 3.04 € for women and from 1.30 € to 3.37 € for men. The lower limits of these brackets correspond to the minimum respect of the habits (all foods can be consumed) while the upper limits are obtained by keeping the closest to these habits (the consumed foods are constrained to be close to those consumed in the average intake observed). The increase in nutritional constraints results in an increase in food diversity and the contribution of fruit and

vegetables as well as in a reduction in energy density. Last, the nutritional profile (SAIN/LIM ratio) actually permits foods of good nutritional quality/price to be identified since this ratio increases for the foods selected in the optimised ratios when the level of nutritional requirements is raised. Our results show that the nutritional profile (SAIN/LIM) ratio effectively helps identify the right nutritional quality/price ratio since this ratio increases for the selected foods in the optimized intakes when the nutritional requirement level is increased.

The previous results obtained from average intakes poorly reflect the variety of situations. The same type of analysis carried out from individual intakes shows that agents having an "expensive" food list are more likely to have a "winning" list insofar as they can satisfy their Average Nutritional Need (ANN) by simple adjustments of the amounts of food they already consume. In other words, for these agents, the change in food habits could be relatively limited. If we now move away from habits by allowing the agent model to integrate all possible foods, people with a small budget must modify their food choices in a more substantial way than others in order to respect recommendations.

Generally, to respect the ANN, an optimized intake, restricted or not by cost, sees its share of vegetables (starchy and fruit and vegetables) and dairy products (yoghurts, milk) increase, while its share of sweet fats, salted fats and, above all, ready-cooked dishes must be sharply reduced (graph 2). The cost constraint also reduces the share of meat products and the relative share of fruit and vegetables in the plant products.

Graph 2: Food composition per food category according to the optimization degree of the intake

The Body Mass Index (BMI) is highly dependent on food consumption

The heterogeneousness of the BMIs of a household's agents is higher for obese households than for "slim" households,[1] which justifies an analysis at individual level. This is carried out via the disaggregation of food purchase data into individual consumption (see frame 1). We show that consumption of energy, proteins, lipids and carbohydrates increases with the individuals' corpulence, whatever the sex. On average, lipids bring 40% of the global energy content (higher than the 35% recommended), while proteins and carbohydrates respectively represent 16% and 40%, (the rest coming from other nutrients). Estimates suggest that "overweight" or "obese" people consume more lipids than "slim" ones, in the same way that they consume more of all the categories of products. Furthermore, while children have a higher consumption of carbohydrates than adults do, the less favoured socio-economic categories tend to consume less fruit and vegetables, meats and fish but more sweet or fat products.[2]

The relationship between individual food consumption and BMI is highly significant. A 100 kcal increase per day in food consumption during a year would imply a weight increase of 1.7 to 2.4 kg for children, 2.6 to 3.5 kg for women and 3 to 3.6 kg for men (considering they all have medium sizes).

Producers' strategies with ambiguous effects on the respect for nutritional recommendations

Two chains, very significant from the point of view of nutritional stakes but also posing different problems as regards the possible mode of intervention were worthy of particular attention: the fruit and vegetables (F&V) chain and the sugar chain. The F&V chain was favoured because of the positive role of its products in combating public health problems while the excessive consumption of sweet products was recently highlighted by the AFFSA (French Agency for Health and Food Safety) as a major risk factor un obesity, diabetes and heart disease.

The F&V market segmentation has not led to an increase in consumption

It is generally acknowledged that the average individual consumption of F&V in France is around 350 g/j, which, compared with a consumption objective of 400 g/j, assesses the average deficit to be filled at 50

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[1] An obese or slim household is defined by a medium BMI for all the persons in a household respectively higher or lower than 30.

[2] For the survey requirements, we put together, within the same category of products, the following products: sugar, chocolates and sweets, jams, honey and butters, ice creams, soft drinks, fries, salted and sweet biscuits, pastries, cooked pork meats. We shall test further the impact of taxation on the products of this category.

g/j per day and per person. A priori, such a growth in the consumption of F&V may be sought through several levers of action.

For a few years, the F&V market has seen an increasing segmentation of the supply. How is this segmentation done and does it lead to an increase in consumption? The main criteria of segmentation in the apple market, for instance, the most consumed fruit in France, are: varieties, grade and packaging (bags, loose and punnets). The market data studied (see frame 1) show that the price dispersion is moderately explained by varieties, a little more by the channel of distribution, and that the packaging mode and grades play a major role. Moreover, the differences in average prices between distribution channels are due more to differences in segmentation (relative amount of segments loose, bag, punnet) than to product prices within each of these segments.

Frame 3: Estimation of the relationships between food consumption and body mass index

The observation of individual food consumption is highly imperfect. We only have individual observations of global consumption, on a declarative basis and over short recorded periods (a week). This is the case of the SU.VI.MAX or INCA panels. More precise data on purchases, however, are available over longer recorded periods (several years) but this is on household purchases and not on individual consumption. By crossing the TNS-SOFRES data (over 2 years) with the nutritional data on consumed products (energies, proteins, lipids, carbohydrate), we disaggregated household purchases into individual consumptions. To do so, we suppose that individual food consumption depends not only on age and sex but also on Body Mass Index (BMI), this being calculated from the information on the agents' weight and size within each household. Then it is possible to assess the relationship between obesity and consumption at individual level by avoiding the aggregation bias of households and by also taking into account the average physical activity or the average metabolic need. The use of a long period (2 years) helps more easily establish a significant statistical relationship between consumption and obesity, contrary to the usual nutritional studies based on observations of weekly food intake.

Over the last few years, we have noted that average prices have increased and that consumption itself has stagnated. Market segmentation does not seem to have been a significant growth lever of consumption. Therefore, segmentation would be a consumer discrimination tool allowing firms to capture the increase in value by making an increase in the average price possible without reducing the quantities sold.

In the long run, promotional actions do not lead to a significant increase in consumption

On this basis, we took an interest in the price of the first segment, which plays a key role in the attraction of populations with low incomes and the levels of which result from price fixing strategies which may alternate "fixed" prices and promotional actions. The study on price fluctuations linked to promotional actions and their effects on consumption shows that the richest socioprofessional categories benefit more from special offers than other socioprofessional categories. Therefore, we may suppose that their higher preferences for fresh F&V compared to that of the other categories lead them to seize more promotional opportunities than other households. For these rich categories, purchasing during special offers falls into two simultaneous rationales: a storing process (less frequent purchases but higher volumes per purchasing act) and a stimulation of consumption (the global volumes purchased over the year are higher in households buying more frequently during special offers). Conversely, the probability of purchasing during special offers is lower in the intermediate and less rich SPC (socio-professional categories) and purchases during special offers are based more on a storing logic with little effect on the quantities purchased over the year. Therefore, special offers do not much increase the global consumption of F&V and this small increase concerns more the rich SPC than the intermediate or poor SPC.

The exercise of market power by the retail industry on the tomato market is moderate and has not resulted in any significant drop in consumption

Many analysts regularly highlight a dysfunction in the F&V market due to the confrontation between a splintered productive sector and a concentrated retail industry. Therefore, the retail industry is blamed for taking advantage of its market power by practising excessively low upstream prices on the one hand and excessively high consumption prices on the other.

A modelling of the price formation on the tomato market, the most consumed vegetable in France, helps assess the market power exercised by the retail industry, both upstream and downstream. The model, composed of a system of demand equations, supply equations and price equations which include terms assessing the market power of the retail industry, is based on the final consumption data and prices at dispatching and retail stages for the two main varieties of tomatoes ("round" tomato and "grappe" tomato), from 2001 to 2006. We show that if the markets were run in a competitive way, in 2006 the retail price of the "grappe" tomato would be 2% lower than the observed price and the producer's price would be 10% higher. As the exercise of market power has declined over time, deviations were much higher in 2001 (10% and 55% respectively for the "grappe" tomato). But the increase in consumption which would result from competitive running of the market would be low, around 1% in 2006.

Therefore, on the tomato market, the exercise of market power by the retail industry is moderate. It chiefly resulted in a transfer of value to the retailers' benefit and to the producers' detriment without generating any significant drop in consumption, at least in the most recent years.

Graph 3: Evolution of prices observed and estimated under the hypothesis of competitive markets. "grappe" tomatoes, year 2006,
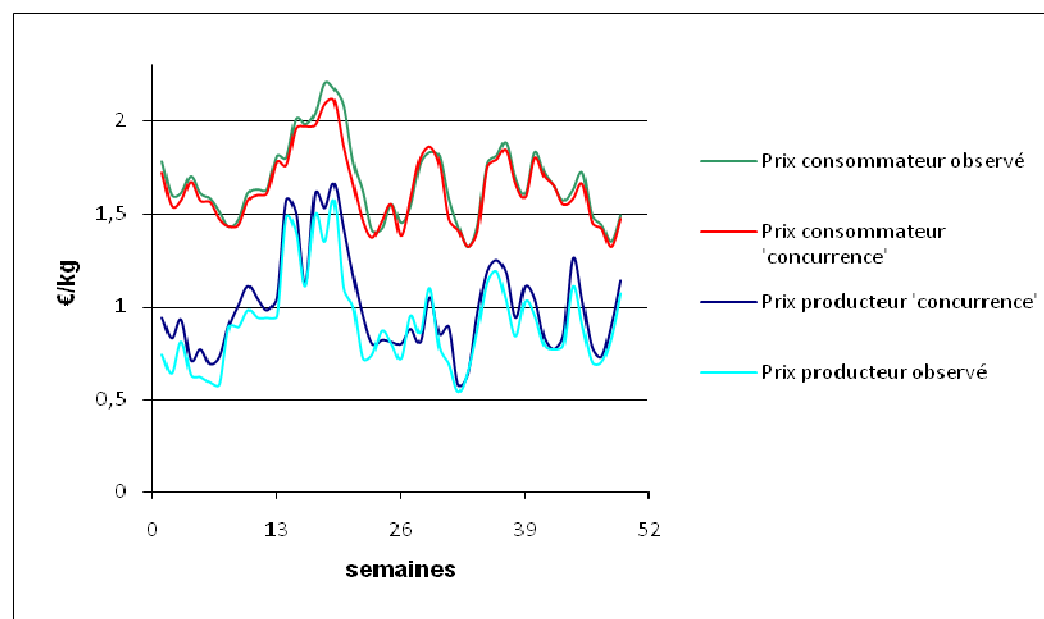
Retail observed price/retail "competitive" price/shipping competitive price/shipping observed price

The sugar policy reform should result in a reduction in the overall demand for sweeteners by the agrifood industries but in an increase in the quantity of added simple sugar

The intakes of sugar mainly come from industrial products where sugar is intentionally added: sweets, biscuits and pastries, milky deserts and sweetened drinks. The 2005 reform of the Sugar Agricultural Policy will result in a significant drop in the sugar price between 2006 and 2010 in the EU. The impact of this reform on the formulation of the Agrifood Industries'(AFI) products and therefore, on the AFI demand for sugar and glucose syrups (a sweetener made from cereals) was analysed in 5 sectors selected on the basis of their high consumption in sweet materials: fruit-processing industries; fresh dairy products, cool soft-drinks, ice-creams and sorbet industries, biscuit factories. To meet the national demand, these sectors consume more than 650,000 tons of caloric sweeteners.

For these 5 sectors, 42 recipes corresponding to various products were modelled. For each recipe, the model allows the simulation of the optimal choice of sweetener according to its price and the constraints relating to the choice of sweeteners (requirements concerning dry extract, sweetness, requirements specific to some of the products). Assuming a constant price for the glucose syrup, the anticipated 36% drop in the sugar price following the reform (from 700 €/t to 404 €/t) would result in a 25% increase in sugar demand, from 495,000 t to almost 620,000 t. The fruit processing industry and industries producing ice-creams and sorbets largely contribute to that rise, the use of glucose syrup being widespread, contrary to the refreshments industry and dairy industry. In return, the demand for glucose for all these industries collapses from 170,000 t to about 20,000 t. The global demand from all these industries for caloric sweeteners drops by about 4% (going from 665,000 t to 640,000 t) because of the higher sweetening power of sugar compared with glucose, the substitution ratio between sugar and glucose varying according to the exact role of sugar in the recipe. On the other hand, the quantity of simple added sugars increases by about 23,000 t since glucose syrups are mixtures of simple carbohydrates and compound carbohydrates. These estimates suppose that the final consumption of goods is unchanged. If the drop in sugar prices affected the price of the final goods, it could result in a slight increase in final demand which would represent an increase in sugar consumption of about 5,000 t, that is to say less than 1% of present consumption.

Therefore, the reform of the Sugar Policy should have relatively limited impacts on the consumption of sweeteners. It leads to a drop in the consumption of caloric sweeteners but in an increase in the consumption of simple added sugars which goes against the PNNS recommendations.

The differentiated impacts of possible bonus/malus policies

Would a public policy of the bonus/malus type change food behaviour towards safer food? Several works based on various approaches explore this path of public intervention which today is the subject of intense debates (see frame 4).

Bonus/malus policies would help reduce the spread of obesity

The first approach extends the analysis of the links between BMI and food consumption (see frame 3). From the reconstruction of individual consumptions, it is possible to study consumer reactivity to price fluctuations. To do so, it is necessary to assess the price-elasticities of food groups (fish, meats, fruit and vegetables, starchy food, dairy, fatty sweet and salted foods, fats and an ultimate category putting all the other foods together), while taking into account individual heterogeneousness. The "fatty sweet and salted products" thus have a relatively high price elasticity, which means that consumers quite strongly adapt their consumption to changes in prices. This group of products is composed of products that are relatively dense in calories and represents a not insignificant part of the global quantity of calories consumed (from 18 to 25% according to the socio-economic categories). Its cost per calorie (15 cents for 100 kcal) is low by comparison with categories like meat (40 cents for 100 kcal), fish (68 cents), fruit and vegetables (34 cents) or diary (20 cents).

With such elasticities, an increase in 10% in the price of "fatty sweet and salted products" would reduce children's obesity by a quarter and children's overweightness by more than 28%. For adults, this measure would have no effect on men's obesity but a major effect on women with almost a 14% drop in obesity. On the other hand, the impact of a 10% drop on the price (subsidy) of fruit and vegetables would be high on men and children's obesity, the impact on obese women being slightly lower. A complete policy of the bonus/malus type (a 10% drop in fruit and vegetables prices and a 10% increase for the group of "fatty-sweet-and-salted products") would amplify these results, with almost a 33.5% reduction in children's obesity. There would also be high effects on women (-11.6% for overweightness and - 20.6% for obesity) but lesser in men (-8.8% for overweightness and -11.3% for obesity). On the one hand, these results are the consequence of a close relationship between food and BMI and, on the other hand, of a significant response by household consumption to the change in the relative prices of products.

…but they would affect the various consumer groups differently

Economically and socially very heterogeneous, consumers have various food consumptions and do not react to changes in prices in a similar way. This variability in behaviour is a major dimension to take into account in order to anticipate the impact of policies on prices. The use of an original methodology, called "mixed model" from the 2004 TNS Panel data, helped identify 7 groups of food behaviour and assess types of food demand, in an endogenous way, without any *a priori* knowledge of the characteristics of the various groups.[3]

The sensitivity of a food budget to household income first appears to be very low in all groups. It is particularly interesting to examine three types of demands in detail, and therefore of consumers. On the one hand, the group with the higher rate of overweight or obese people (2/3 of the group among whom almost 21% are obese) ("**OB**" group) and, on the other hand, the two groups mainly comprising households with very low incomes. The first of the two groups with very low incomes typically includes large families having the highest proportion of children under 13 years old. More than a third of them live in rural areas ("**M-R**" group). Their consumption mode indicates lower consumption of fruit and vegetables than average and high consumption of soft drinks. Their items of consumption which are most sensitive to prices are fresh vegetables, meat and fresh dairy produce. The second group of poor households is urban and, on average, composed of households with three members or less ("**M-U**" group). We note here a high consumption in ready-to-eat foods and soft drinks. The most sensitive items to prices are fish and cereal products. These "**M-R**" and "**M-U**" groups are opposed in terms of the price elasticity of fresh vegetables (high in "**M-R**" and low in "**M-U**"). As to the "**OB**" group, it partly concerns the households living in rural areas (1/3 of the total), made up of middle-aged people (average over 56 years old) and having an income per capita from medium to high. Their food consumption mode is clearly high in fat and sugar.

The analysis of the sensitivity of demand for fruit and vegetables shows that the demand for fresh vegetables of the "**M-R**" and "**OB**" groups is very elastic to prices. A public intervention targeting consumption of fruit and vegetables and depending on a consumption subsidy for fresh vegetables would be of greater profit to poor "**M-R**" households and to those of "**OB**" groups (where there is a high proportion of obese people). On the other hand, subsidising fresh fruit would be more favourable to the richest households whose demand is the most elastic, without having any noticeable impact on the "OB" agents who have a virtually inelastic demand for fresh fruit.

If an intervention targeting the demand for products rich in sugar (sugar, sweets soft drinks, wines and other alcoholic beverages), in particular that from the households of the "**OB**" group, appeared justified, it would be necessary to concentrate this intervention on sweets because the elasticities of other products are relatively low. Furthermore, the demand for meat of the "**M-R**" and "**OB**" groups appears quite elastic to prices like the demands for cheese and animal fat for overweight people (-1 for the "**OB**" group). A taxation of these groups of fatty products (meat, cheese, animal fat) would end up modifying

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[3] As the existing studies impose *a priori* groups (according to income, demographic composition and so on…), the originality of this approach lies in its lack of *a priori*.

the food behaviour of "**OB**" group people in the good sense, but in return would negatively affect the poor households' consumption of meat-based products.

Frame 4: Should we intervene to rebalance food consumption?

If we think that people are informed and fully aware of the risks taken, a public intervention on food consumption does not seem appropriate. However if at least one part of the agents ignores the long term effects of their choices or are short-sighted about their daily choices, we may put forward arguments in favour of a paternalist approach to the problem where the public decision-maker tries to correct individual behaviour in the name of a well-being criterion that is different from what agents maximize on the short term. In other words, the social assessment of the food goods concerned does not only depend on individual preferences. If in Economics the paternalist approach has long existed, some of the reasons why public and individual judgements differ were more recently shown. The recent progresses in Behavioural Economics help show situations in which, *a priori*, agents adopt paradoxical behaviours such as sensitivity to the decision-making context or temporal incoherence, moving apart from the rationality attributed to the *homo oeconomicus*.

In this context, a paternalist public decision-maker may intervene in a non coercive way, for instance by modifying the order of presentation of foods in a school canteen in order to favour the consumption of healthy foods. Coercive interventions like taxes or rules are, *a priori,* more difficult to justify. Economists have looked at situations in which the agents differ according to their degree of "irrationality" and recommend the adoption of a cautious paternalism which balances the benefits for "irrational" agents against the disadvantages for rational agents. In fact, if we can show that an intervention is necessary, we cannot easily demonstrate its optimal extent. However the use of tax/subsidies is suggested to correct the faults committed by "irrational" agents insofar as, at a given moment, they regret their past decisions (we speak of temporal incoherence because temporal preferences are biased towards the present).

Beyond the evident diversity of responses to bonus/malus policies, such work tests the impact of these policies on the various categories of population.


Real though relatively unequal effects of the bonus/malus policies, in experimental circumstances

As we know, the prevalence of obesity and overweightness is higher in disadvantaged populations. This is why specific work based on the methods of experimental economics was carried out with women belonging to less favoured social categories (1st decile of income). For comparison, a supplementary group (or reference group) of women belonging to better favoured categories (beyond the 3rd decile in the distribution of incomes) also took part to the experiments. On the basis of the consumption reported, we first observe higher global consumption of foods in women with high incomes, and higher consumption of nutritionally "harmful" products in women with low incomes, in absolute value and in percentage of the diet.

The products proposed in the experiment are ranked in 4 groups, fruit and vegetables, other safe products (including in particular some dairy products, meat, fish and beverages), neutral products and "harmful" products from a nutritional point of view (in particular sweet, fatty and sweet, fatty and salted products). The test of a first policy of a 30% price reduction in fruit and vegetables shows an increase in fruit and vegetable consumption in both groups, this being higher in the reference group. Moreover, the consumption of the other safe products drops in the group of disadvantaged women, while it rises in the reference group. This suggests that women with low incomes have a tendency to make a substitution between fruit and vegetables and other safe products and that this phenomenon does not concern women with high incomes.

The implementation of a bonus/malus policy of greater scope (-30% for the price of fruit and vegetables and other safe products and + 30% for the price of harmful products) would lead to a modification of food consumption globally in the expected sense, with the exception of the other safe products, the consumption of which would drop in women with low incomes and would increase in others. From a quantitative point of view, the price elasticities of fruit and vegetables are roughly of the same order (-1) in both groups though the price elasticity of fruit is higher than that of vegetables (-1.42 against - 0.57). In a similar way, the price elasticities of the "harmful" products do not vary much between both groups and are close to -1. Therefore, we should emphasise the very high individual heterogeneousness of behaviour in women with low incomes: 40% of them reduce their consumption of fruit and vegetables when this product's price drops, which is only the case for 10% women of the group of reference (see graph 4). If both tested policies improve the purchasing power of each of the two groups, the impact, however, is higher for women with high incomes, because of their initial consumption mode and of their better adaptation to the new pricing context. Last, the nutritional quality of the diet is improved by both policies: the policy of a price reduction in fruit and vegetables has the particular effect of increasing the density of nutrients while the bonus/malus policy induces a more balanced diet. From this point of view, these policies would be efficient but they would reinforce the inequalities since the observed improvement is not so high in the disadvantaged groups.

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**Graph 4: Distribution function of individual
price elasticities of fruit and vegetables
(for both groups, women with low incomes
and reference group)**

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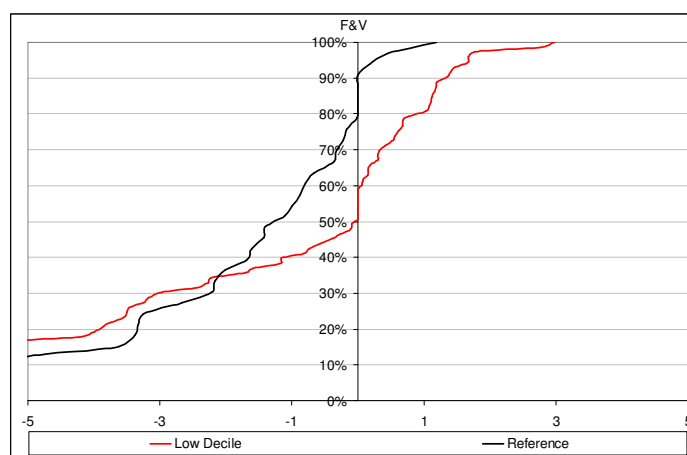
Non targeted policies seem more efficient than targeted policies

Last, we tried to quantify the economic and health impacts of several scenarios of public policies more specifically aiming to increase the consumption of fruit and vegetables. The policy scenarios are described in a more complete way than in the previous studies: cut in prices by reducing VAT, consumption subsidy by aid to the lowest incomes, policy of generic information. The analysis was carried out on the basis of a market equilibrium model, the various economic parameters (elasticities of demand, supply, incomes and information) and health (incidence and mortality) being gauged on the basis of the available literature. In this way we show that even in the context of optimistic assumptions, the increases in the average levels of consumption remain modest, whatever the policy chosen. However, the costs per year of life saved within these policies are relatively low, which may justify their implementation. However, non-targeted policies (of the price-cut type) appear to be more efficient than targeted policies (purchase coupons given under income conditions), because at equivalent budgetary cost, the number of avoided deaths would be higher. Non-targeted policies sometimes increase the disparities between the population with low incomes and the other categories; in some cases, they may

even deteriorate the nutritional situation of the poor. Conversely, targeted policies improve the situation of the less favoured but may, under some conditions, deteriorate that of others. Last, non-targeted policies based on economic tools (of the VAT reduction type) are potentially less unequal than those based on information, but the cost per life saved is higher.

The increases in average levels of consumption, in response to the implementation of public policies of TVA reduction, aid to disadvantaged populations, or information, would ultimately remain modest. Moreover, non-targeted policies are more efficient than targeted policies even if they are likely to increase the disparities between categories of population.

A few conclusions of this research programme

The PNNS has set ambitious objectives of changes in food consumption in the French population. In particular, it aims to increase the consumption of fruit and vegetables significantly and reduce the intakes of lipids and simple sugars. We showed that in the Fruit and Vegetables sector, the strategies of private actors did not increase global consumption of these products. In the same way, the recent reform of the European Sugar Policy is not heading towards a reduction in food intakes of simple sugars.
Similarly, we showed the importance of the food price structure and the socio-economic characteristics of households in their food consumption as well as the link between food cost and its nutritional quality. It also appears that the respect for nutritional constraints by the French population would increase the consumption of vegetable products (starchy and fruit and vegetables) and dairy products while the share of ready-to-eat and fatty sweet and fatty salted products should be reduced.

Beyond policies of information or education, the use of bonus/malus policies to induce these changes could prove to be necessary. A joint policy subsidising fruit and vegetables and taxing fatty/sweet products could help increase consumption of fruit and vegetables and reduce consumption of fatty animal products. But the heterogeneousness of consumer response to such changes could increase the disparities between categories of population. Nevertheless, such policies could reduce the prevalence of obesity and contribute to reaching the objectives fixed by the PNNS.

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UMR en Nutrition Humaine, Inserm/Inra/Universités Aix Marseille 13385 Marseille	Nicole Darmon - Matthieu Maillot *Nicole.Darmon@univmed.fr*	*Nutritional quality of foods and choice of food intakes*
UMR GREMAQ – INRA – Toulouse School of Economics – 31000 Toulouse	Céline Bonnet, Philippe Bontems, Helmuth Cremer, Philippe De Donder, Pierre Dubois, Olivier de Mouzon, Valérie Orozco, Vincent Réquillart, Michel Simioni, Marine Spiteri, *Philippe.bontems@toulouse.inra.fr, vincent.requillart@toulouse.inra.fr*	*Producers' and chains strategies, foundations of public intervention, consumers' demand and public intervention, cost-efficacy analysis*
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