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Welfare and sustainability effects of dietary recommendations

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ABSTRACT

The paper develops a framework combining a model of rational behaviour under dietary constraints, an epidemiological model of diet-related mortality, and a life-cycle-analysis model of environmental impact, which permits the ex-ante assessment of dietary recommendations in multiple sustainability dimensions (i.e., taste cost, welfare effect, deaths avoided, reductions in greenhouse gas emissions and acidification). It is applied to compare in a French context the relative effects and efficiency of six popular sustainable diet recommendations. The results confirm the synergies between the health and environmental dimensions: healthy-eating recommendations usually have a positive effect on the environment, although some exceptions exist. Most of the sustainable diet recommendations appear highly cost-effective, but those most commonly promoted on health grounds (e.g., targeting consumption of salt, fruits and vegetables and saturated fat) rank highest in terms of overall efficiency. Moreover, the valuation of benefits indicates that in most cases health benefits are significantly larger than environmental benefits. Overall, the analysis reveals some under-investment in the promotion of sustainable diet recommendations in France. The general lack of enthusiasm in policy circles for informational measures promoting behavioural change may reflect unrealistic expectations about the speed and magnitude of dietary change rather than an objective assessment of the efficiency of those measures.

1. Introduction

Food consumption patterns observed in developed countries raise two main types of concerns. First, it is widely recognized that the food sector contributes significantly to climate change through high greenhouse gas emissions (GHGEs): from 15 to 30% of total GHGEs are induced by food production, distribution and consumption (Esnouf et al., 2013). For this reason, changes in consumers' diets are often considered an important driver of climate change mitigation (Hoolohan et al., 2013; Carlsson-Kanyama and González, 2009; Tukker et al., 2011) and many reports suggest promoting new consumption patterns based on the reduction of meat and dairy consumption and the substitution of meat products by plant-based products within the diets of high-income country consumers (Stehfest et al., 2009; Berners-Lee et al., 2012; Friel et al., 2009).

Second, unhealthy diets, in association with physical inactivity, are risks factors strongly related to various chronic diseases, including obesity, strokes, diabetes, and some types of cancers (World Health Organization, 2003). This statement has led many public health agencies to set up prevention policies based on healthy-eating messages and information campaigns. Most frequent messages promoted by health agencies encourage individuals to adopt healthier diets and consume more fruit and vegetables (F&V) (Cappacci and Mazzocchi, 2011) and less salt (Shankar et al., 2013). Starchy foods products are other food groups whose consumption is often promoted by public health experts (Mancino et al., 2008), whereas some of them have recommended a decrease in consumption of soft drinks (Jou and Techakehakij, 2012).

As noted by Madiarmid et al. (2012), health and environmental issues need to be tackled together to ensure consistent dietary advice for consumers. Despite the fact that the convergence between health and environmental challenges is not systemically guaranteed (McDiarmid et al., 2012; Vieux et al., 2012; Masset et al., 2014), it is now widely accepted that the reduction of meat consumption and the shift toward plant-based diets would have a favorable effect on both environment and health (Pimentel and Pimentel, 2003; Soret et al., 2014; Berners-Lee et al., 2012; McEvoy et al., 2012; Aston et al., 2012; Scarboroug et al., 2012b).

Indeed, on the one hand, red meat is suspected to have a causal influence on colorectal cancer and other forms of cancers and may be associated with cardiovascular diseases because of its high cholesterol and saturated fat acids (SFA) contents (McMichael et al., 2007). On

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the other hand, plant-based products have much lower impacts on GHGEs than animal-based products (Masset et al., 2014).

Whether for health or environmental benefits, consumers are then more and more urged to make food choices while complying with a whole range of dietary recommendations which target health and environmental benefits. Education and information campaigns and food labeling are implemented in order to induce these dietary changes. However, a lot of research shows that the adoption of new diets by consumers are difficult for many, with campaigns raising, for instance, awareness of nutritional issues without having a large impact on behaviours (Pérez-Cueto et al., 2013).

If several reasons can be proposed to explain the difficulties in changing behaviours, one is related to the "taste cost" of change, that is, the utility loss induced by a dietary change that brings a new balance between long-term health or environmental goals and short-term pleasure and hedonistic rewards (Réquillart et Soler, 2014). In other words, the difficulties in complying with new food-based guidelines are likely due to the lack of compatibility of consumers' preferences with the diets that they would have to adopt in order to comply with these guidelines.

An important issue is then to determine sustainable diets complying with health and environmental recommendations and compatible, as much as possible, with consumer preferences. In other words, the challenge is to identify dietary recommendations with the potential to improve health and environment but generating the smallest "taste costs" for the consumers.

A first group of methods to address this issue builds on linear programming (LP) models which are used to estimate least-cost diets complying with a list of dietary requirements (Henson, 1991; Conforti and D'Amicis, 2000). Such LP models have been recently used by nutritionists to determine optimal diets complying with nutritional or environmental recommendations (Darmon et al., 2006; Maillot et al., 2010; Macdiarmid et al., 2012; Darmon et al., 2002, 2003; Srinivasan et al., 2006; Shankar et al., 2008; Arnoult et al., 2010). These methods suffer from important shortcomings because the objective functions and the substitution possibilities among goods are always arbitrarily restricted, and not based on real consumers' preferences. Therefore they cannot really take into account the consumers' taste costs and then be used to infer how nutritional and environmental dietary norms might influence real-world consumers.

A second type of approach with a stronger theoretical basis uses empirically-estimated demand systems (see Thow et al. 2010, Etilé, 2011, and Eyles et al., 2012 for recent reviews). These studies typically estimate price elasticities from demand curves, which are conceptually derived from constrained utility maximization, given prices and a budget constraint. This kind of research has been based on complete food demand systems (Smed et al., 2007, Allais et al. 2010; Briggs et al., 2013; Caillavet et al., 2014), which allows consideration of a large set of interdependent demand relationships. Such methods can support the simulation of impacts of price policies, taxes or subsidies, on food consumption and nutrient intakes. However, compliance with food-based or nutrient-based recommendations can only be assessed ex-post rather than introduced as constraints in order to determine the price modifications needed to comply with these constraints.

To overcome these limits, Irz et al. (2015) have developed a new analytical framework which builds on the microeconomic theory of the consumer under rationing, with the goal of identifying diets compatible with both dietary recommendations and consumer preferences. This framework is built to estimate the substitutions, and overall changes in diet, that would take place if consumers complied with these recommendations. Such a framework is used to assess the difficulty of achieving a given norm by identifying the magnitude and nature of the required substitutions in consumption. It also provides the basis for measuring the "taste cost" of complying with a particular nutritional dietary norm, which can then be used in conventional cost–benefit analysis. Compared to the demand system analyses used to assess the effect of price variations on consumption and nutrient intakes (and then finally, on compliance with nutritional or environmental recommendations), this method considers the dual problem which consists of determining the price system and the compensation value (i.e. the taste cost) such that a dietary recommendation can be adopted without loss of utility.

In the present paper, we use this theoretical framework to empirically estimate the health, environmental and welfare impacts of the adoption of various dietary guidelines by consumers. More precisely, we consider a set of nutrient-based (salt, SFA) and food-based (F&V, meat) dietary recommendations, determine the substitutions within the consumers' diet induced by their adoption, and estimate the loss of welfare (taste costs) induced by these changes. To deal with the health issue, we match the economic model with an epidemiological one, and assess the health impacts of diet changes in terms of chronic diseases prevalence and mortality. Similarly, to deal with the environmental issue, we estimate the effects of the diet changes on environmental indicators. By confronting the consumers' taste costs and the health and environmental outputs, we finally carry out a cost–benefit analysis of dietary recommendations.

In Section 2, we briefly present the theoretical model. In Section 3, we present the data and the empirical methods used to simulate the impact of various dietary recommendations on diets, welfare, environment and health. In Section 4, we present the empirical results for a set of food-based and nutrient-based recommendations. In Section 5, we assess the robustness of our results. Section 6 concludes the paper.

2. The Behavioural Model

The main building block of the analysis is a model of dietary adjustment under nutritional and/or environmental constraints (henceforth simply referred to as "dietary constraints"), which was first proposed to investigate the economics of nutritional recommendations by Irz et al. (2015). Making the assumption that the environmental impact of food consumption is linear in the quantities consumed, as is implicit in Life Cycle Analysis (Ekvall et al., 2007), extension of the model to the environment sphere is methodologically straightforward. The approach is based on the assumptions of utility maximization and economic rationality of consumers. Thus, observed consumption choices are those which, given prices and income, maximize utility, and any exogenous changes, for instance in prices, induce adjustments in optimal consumption choices. The strong assumption of rationality also implies that consumers have full knowledge of product characteristics and prices when making decisions. This paradigm, even if based on strong simplifying assumptions, has proved its usefulness and accuracy in the analysis of consumer choices. However, we acknowledge that alternative and legitimate views, for instance that consumption behaviours are primarily reasoned or automatic, have also been proposed to explain food choices, and that, at this stage, none of those three views can claim superiority in the ability to explain human behaviour (Grunert et al., 2012; Köster, 2007).

Formally, we adopt the conventional framework of neoclassical consumer theory by assuming that an individual chooses the consumption of H goods in quantities $x = (x_1, \dots x_H)$ to maximize a strictly increasing, strictly quasi-concave, twice differentiable utility function $U(x_1, \dots x_H)$, subject to a linear budget constraint $p \cdot x \leq M$, where p is a price vector and M denotes income. However, departing from the standard model, we now assume that the consumer operates under N additional linear constraints. Those constraints could, for instance, correspond to a maximum permissible CO_2 equivalent from the diet, a maximum consumption of meat, or, in the nutrition domain, maximum levels of consumption of "unhealthy" foods or nutrients (e.g. salt, saturated fat). Denoting by a_i^n the constant nutritional or environmental coefficient (henceforth referred to as technical