Inciting Family Healthy Eating: Taxation and Nudging

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Abstract

This paper examines whether a tax on unhealthy food and a nudge are suitable to promote families healthy eating. We consider, in a theoretical model, an economy composed of two types of family that differ in their income and their nutritional knowledge, which reflects their degree of misperception of the future health effects of diet, and choose their consumption according to their perceived utility. We find that the decentralized solution of taxation on unhealthy good achieves the first-best optimum if and only if it is possible for the central planner to implement a targeted tax policy. Investigating the case of a mixed policy, we find that taxation of unhealthy food and nudge are probably complementary public policy instruments to promote family healthy eating. The mixed policy reduces both the perception and income gaps between the two family types.

JEL classification: D83, H21, I18.

Keywords: tax, healthy eating, nudge, perception, family environment, nutritional knowledge

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1 Introduction

Unhealthy eating patterns can negatively affect people's health. Diseases related to an unhealthy diet, such as diabetes, have reached epidemic proportions worldwide (Lovic et al., 2020). Empirical evidence suggests that unhealthy food consumption is associated with an increased risk of childhood obesity (Ludwig et al., 2001; Malik et al.,2006), which in turn is associated with increased risks of non-communicable diseases such as type 2 diabetes, hypertension, coronary heart disease, cardiovascular disease, and certain types of cancers. Obesity in childhood and adolescence has consequences for morbidity and mortality in adulthood (Reilly and Kelly, 2011) and significantly reduces life expectancy, particularly in young adults (Fontaine et al., 2003). Therefore, due to the strong link between diet and the rise of obesity and overweight in children, improving children's diets has become an important challenge for public decision-makers.

Food products consumed by children most often come from the family environment. The implementation of nutritional policies to improve children's diets within the family environment seems more delicate due to the lack of control that public decision-makers have over this environment. Nevertheless, there are public interventions, such as unhealthy goods taxation or nutritional labels that aim to improve diets within the home environment. These interventions mostly target parents, who are primarily responsible for food choices in the family.

The purpose of this paper is to theoretically analyze the effectiveness of public policies aiming at promoting healthy eating within the family environment. Specifically, we study the effectiveness of a tax policy on the consumption of an unhealthy good and a mixed policy based on the simultaneous use of tax on the consumption of an unhealthy good and nudge in a framework where parents differ in their income and their degree of misperception of the effects of diet on their children's future health.

There are many reasons why consumers might not act in their own best interest when making food choices. Allcott et al., (2019) identified two reasons in the sweetened beverage tax debate: imperfect information and the lack of self-control. Levels of parental nutritional knowledge may also have an influence on family consumption patterns. A mother's low level of nutritional knowledge is associated with a lower dietary adequacy of children's food intake (Al-Shookri et al., 2001; Vereecken and Maes, 2010). Consumption of unhealthy foods can also be explained by addiction effects (Davis et al., 2011). All these biases support the need for public policy interventions to reduce diet-related disease.

In this paper, we focus on the case where the intervention of the public decision-maker is justified by an insufficient level of individuals' nutritional knowledge. Indeed, we assume that individuals cannot establish an accurate link between food consumption patterns and the future effects of food on health. This assumption is consistent with empirical evidence that has shown the need to raise public awareness about the effects of food on health (Khawaja et al., 2019).

To improve children's diets within the family environment, taxation of unhealthy goods is the most common public policy remedy. For example, in 2013, the World Health Organization called for policies to address obesity and explicitly favors taxation of unhealthy food.[1] Taxes on unhealthy goods are being used in more and more countries (Cawley et al., 2019). For example, the French government introduced a tax on all drinks with added sugar or artificial sweetener in 2012. Economic theory predicts that if the price of an item increases the consumption of that item will typically fall which justifies the use of taxes on unhealthy goods. Therefore, increasing the price of unhealthy goods, with taxation, should reduce the consumption level of the taxed goods. However, the effectiveness of taxation policies in reducing household consumption of unhealthy food has been questioned. Assessing the effects of a fat tax on the nutrients purchased by French households across different income groups, Allais et al., (2010) found that a fat tax has small and ambiguous effects on nutrients purchased by French households. Furthermore, the French soda tax evaluation conducted by Capacci et al., (2019) reveals that the soda tax showed evidence of very little reduction in purchases. They attribute this small reduction in purchases to the fact that the tax rate was very small. Tax increases the prices of unhealthy goods and in the case of intergenerational choices, in addition to reducing the unhealthy good consumption of children, it also reduce the parent's unhealthy good consumption, which is not associated with an externality. Therefore, these effects of the tax on parent's unhealthy good consumption make it no longer the first-best. Kalamov et al., (2020) have shown that a tax on unhealthy food may underinternalize or overinternalize the marginal damage of intergenerational externalities.

[1] World Health Organization. (2013). Global action plan for the prevention and control of noncommunicable diseases 2013-2020.

Nudge is another tool used to improve the quality of families' diets. Nudging is a technique to encourage individuals or a whole human group to change certain behaviors or to make certain choices without putting them under constraint or obligation and which does not involve any sanction (Sunstein and Thaler, 2008). The problem that may justify the use of nudge is that people sometimes do not make the best decisions for themselves (e.g., an individual may decide to consume a food that has harmful effects on his future health), so they can be helped to make better choices. According to Sunstein and Thaler, (2008) a specific reason why people make bad choices is that they do not have complete self-control. Self-control issues are most likely to arise when decisions and their consequences are separated in time, which is the case for dietary choice. The use of nudge (such as nutrition labeling systems) to improve the nutritional quality of family diets has become quite common in several countries. Nutrition labels are simplified nutrition information usually provided on the front of food packaging aiming to help consumers with their food choices. The nutrition information provided must be selected on the basis of consistency with dietary recommendations. Crosetto et al., (2018) study in a laboratory framed field experiment, in Grenoble (France) the impact of five Front of Pack labels (Multiple Traffic Lights, Reference Intakes, Health Star Rating, Nutri-Score and SENS[2]) on the nutritional quality of shopping carts. They found that labels significantly improve the shopping carts' nutritional quality.

Our choice to focus only on the study of a taxation policy and a mixed policy is justified by two reasons. First, we want to study whether a simple tax policy on unhealthy goods can restore the first-order optimum and to what extent this is possible. Secondly, the use of nudge in the mixed policy aims to reduce the misperception gap between the two types of families and to serve as a support for the tax with the objective to improve the nutritional quality of families' diets. Therefore, we do not study a nudge policy without a tax policy, since the implicit assumption of using nudge as a separate policy would be that nudge not only reduces the misperception gaps between both family types, but also corrects all the misperceptions of each family type.

We also do not study the case where the tax revenue is used to subsidise the price of the healthy good because the literature on the taxation of unhealthy goods has highlighted the regressive nature of the tax (Allais

[2]SENS, Simplified Nutritional Labelling System is a French nutrient profiling system that means in French "Système d'Etiquetage Nutritionnel Simplifié".

et al., 2010). Indeed, people with low socioeconomic status consume more unhealthy food on average and therefore bear the burden of the tax on unhealthy food. Since we include in our model heterogeneity in family incomes, the family with a higher income could benefit more from a subsidy on the price of the unhealthy good, especially if it was already the main consumer before the subsidy was introduced.

We assume in the model that the healthy good is more expensive than the unhealthy good. Indeed, apart from the existence of misperceptions, if unhealthy goods are cheaper than healthy goods, a family with a lower income would turn to unhealthy products and therefore this could explain the problem of excessive consumption of unhealthy goods.

We consider an economy composed of two types of families that differ in their income and their nutritional knowledge. Each family consists of a parent and a child, and each individual lives two periods: childhood and adulthood. At each period, they can consume two types of goods: an unhealthy good and a healthy good. Consumption of the unhealthy good generates immediate satisfaction but has also adverse consequences on the child's future health, which are misperceived by the parent. In turn, the consumption of the healthy good generates immediate satisfaction and has beneficial effects on the child's future health, which are misperceived by the parent as well.

We first show that the decentralized solution of taxing the consumption of the unhealthy good and redistributing the tax proceeds in the form of transfers achieves the first-best optimum if and only if it is possible for the central planner to implement a targeted tax policy. We then find that a mixed policy of supporting the tax with a nudge achieves the first-best optimum while setting a uniform tax for all family types. Using a numerical example, we illustrate that the individual choice outcome is non-optimal.

Our paper is related to the growing literature on sin taxes.[3] Kalamov et al., (2020) examine whether taxes on unhealthy food are suitable for internalizing intergenerational externalities inflicted by parents when they decide on their children's diet in a framework where parents are imperfectly altruistic and thus consider only a part of the child's future utility and health costs. They find that the optimal steady-state tax rate on unhealthy food is indeed strictly positive but is only second-best because, in addition to reducing the

[3]A sin tax is an excise tax on specific goods and services due to their ability, or perception, to be harmful or costly to society. For example sin taxes include those on cigarettes, alcohol, and vaping.

food consumption of the child, it distorts the parent's food consumption, which is not associated with an externality. Cremer et al., (2016) analyze the political support of a tax on the unhealthy good, combined with a subsidy for the healthy good, and examine how the government can affect this political support by earmarking the tax revenue. They consider an economy wherein individuals differ in their incomes and their degree of misperception concerning the health effects of fat and the healthy good. Individuals vote over a fat tax according to their misperceived utility. A fraction of the tax proceeds is earmarked to reduce health insurance premiums and the remainder finances a subsidy for the healthy good. As a prelude to their main question, they show that the equilibrium level of the fat tax is typically not optimal, neither from a utilitarian nor from a Rawlsian perspective. We model our utility function closely to theirs but our approach differs in two main directions. First, we separate the satisfaction (utility) derived from the consumption of the healthy good from the health benefit associated with the consumption of the healthy good and assume that only the health benefit associated with the consumption of the healthy good is misperceived by parents. Second, we are not interested in a voting equilibrium tax and the tax revenue is redistributed as a transfer in our model. We contribute to this literature by showing that even if a uniform tax does not achieve the first-best optimum in a utilitarian perspective where individuals differ in their income and their degree of misperception, the first-best optimum can be achieved if the central planner has the possibility to set a targeted tax policy according to the degree of misperception.

Our study is also related to the literature on the use of tax and nudge to modify agents' behavior. Fahri et al., (2020) develop a theory of optimal taxation with behavioral agents. They use a general framework that encompasses a wide range of biases such as misperceptions and internalities and study how to incorporate nudge into the optimal taxation framework. Comparing effectiveness of tax and nudge in correcting internalities, they find that a nudge can be better or worse than a tax depending on the tax's revenue redistribution and the internality-corrective objectives of the government. We contribute to this literature by showing that it is better to combine nudge and tax in a mixed policy to correct agents' misperceptions.

Finally, our paper is related to the literature on food labels. Moran et al., (2018) used an online survey to study whether warning labels influence parents' beliefs on sweetened beverages' healthiness and their purchase intentions of sweetened beverages. They found that warning labels significantly reduced the odds of selecting sweetened beverages and may correct parents' misperceptions about sweetened beverages' healthiness. Dubois et al., (2021) examine whether four pre-selected front-of-pack nutrition labels ("Nutri-Score", "Nutri-Repère", "Nutri-Couleurs" and SENS) improve food purchases in real-life grocery shopping settings. They found that the effect sizes of front-of-pack nutrition labels were smaller on average than those found in comparable laboratory studies. They found also that the most effective nutrition label, Nutri-Score, increased the purchases of foods in the top third of their category nutrition-wise but had no impact on the purchases of foods with medium, low, or unlabeled nutrition quality. Hence, the important contribution of our paper is to theoretically show that the use of labels to improve the nutritional quality of individuals' food choices can be more effective if it is used as a complementary support to the taxation of unhealthy food items.

The remainder of the paper is organized as follows. Section 2 describes the model and provides the results of the individual choice. The social optimum is specified in Section 3. Section 4 provides a simple numerical example. We discuss the results of the model and conclude in section 5.

2 The Model

We consider an economy composed of two types of families that differ in their nutritional knowledge: the family of type 1 has better nutritional knowledge than the family of type 2. Families differ also in their income denoted by w^i. Each family consists of a parent and a child, and each individual lives two periods, childhood and adulthood. At each period, they can consume two types of good: an unhealthy good, that is, a high-fat or sugary food, denoted by c^u (e.g., potato chips or sodas) and a healthy good denoted by c^h (e.g., vegetables). We assume that the effects of food intake in childhood on health appear later in adulthood. Indeed, the consumption of unhealthy goods during childhood could have negative health effects (causing obesity or overweight) in adulthood. It is also quite possible that the effects of diet on health appear in childhood. For example, a child may become overweight or obese. Empirical studies have shown that most obese children and adolescents remain obese in adulthood (Hughes et al., 2011; Srinivasan et al., 1996; Must and Strauss, 1999; Simmonds et al., 2016). These studies suggest that the likelihood of persistence of obesity into adulthood is high for overweight and obese children and adolescents.

We suppose that consumption during childhood is the family consumption chosen by the parent, so that c^{hi} denotes family i's healthy consumption and c^{ui} denotes its unhealthy consumption, when parents and children live together.

2.1 Health risks

We assume that the effects of childhood consumption on health appear later in adulthood and may affect an individual's health. Specifically, the family consumption of the healthy good generates a future health benefit for the child, $b(c^{hi})$, that is misperceived by parents. More precisely, the future health benefit for the child associated to family consumption of the healthy good perceived by parent i is $\alpha^i b(c^{hi})$ with b an increasing and concave function (i.e., $b' > 0$ and $b'' < 0$) and α^i the part of the health benefit associated with the consumption of the healthy good perceived by the parent (i.e., $1-\alpha^i$ is the part of the health benefit associated with the consumption of the healthy good misperceived by the parent). Family consumption of the unhealthy good may cause overweight or obesity in the long-run, which usually comes with health problems. These negative effects of the unhealthy good consumption on child's future health are captured by the damage function, $d(c^{hi})$, with d an increasing and convex function (i.e., $d' > 0$ and $d'' > 0$).[4] The convexity of the damage function implies that the marginal damage of consuming the unhealthy good is increasing. Intuitively, this means that the higher the consumption of the unhealthy good, the larger the adverse health effects. In the short-run, parents may misperceive parts of these negative long-run effects of unhealthy good consumption on their child's future health. Their perceived damage function is given by $\beta^i d(c^{hi})$ and β^i the part of the health damage associated with the consumption of the unhealthy good perceived by the parent (i.e., $1 - \beta^i$ is the part of the health damage associated with the consumption of the unhealthy good misperceived by the parent). The effects of diet on children's future health perceived by the parent could be smaller than the real effects of diet on children's future health. For example, by studying the impact of food risk perception on fish consumption behavior in five European countries, Pieniak et al., (2008) find that consumers perceive a rather low risk of food poisoning from eating fish

[4]We denote by: $b' = \frac{\partial b(c^{hi})}{\partial c^{hi}}$, $b'' = \frac{\partial^2 b(c^{hi})}{\partial c^{hi2}}$, $d' = \frac{\partial d(c^{ui})}{\partial c^{ui}}$ and $d'' = \frac{\partial^2 d(c^{ui})}{\partial c^{ui2}}$.

across the countries.

We make the following assumption:

Assumption A1: $0 < \alpha^i \leq 1$ and $0 < \beta^i \leq 1$.

Indeed, the public health problem related to diet would be that individuals exhibit a high consumption level of unhealthy food and a low consumption level of healthy food. This seems to be more likely to occur if individuals perceive lower health benefits and costs related to diet than the effective health benefits and costs of diet. It is well documented in the nutrition literature that consumers have a stronger belief in the presence of beneficial than of harmful components in their diet (Verbeke et al., 2005). In assessing potential misperceptions among parents regarding the healthfulness of sugary drinks for their children, Munsell et al., (2016) found that almost all parents (96%) provide sweetened beverages to their children and believe that some sweetened beverages are healthy options for children, particularly flavoured waters, fruit juices and sports drinks. This supports the hypothesis that individuals perceive low risks associated with diet. Consequently, misperceptions in our model refer to the idea that people perceive lower health benefits and costs associated with diet than the real health benefits and costs associated with diet. We also suppose that $\alpha^1 > \alpha^2$ and $\beta^1 > \beta^2$, i.e., parent of type 2, with lower nutritional knowledge, have a higher misperception about the effects of diet on the future health of their children than parent of type 1. This hypothesis is in line with empirical studies suggesting that nutritional knowledge could affect individuals' perceived healthiness of food (Ares et al., 2008) and their evaluation of food healthiness (Crites and Aikman, 2005).

2.2 Preferences

The utility of a parent i depends on the family consumption of healthy good c^{hi}, unhealthy good c^{ui}, the child's future health benefit associated with healthy consumption, and the child's future health cost associated to unhealthy consumption. The intrinsic utility provided by the family consumption of the healthy good is captured by the function $u(c^{hi})$. The satisfaction parents obtain from the family consumption of the unhealthy good is reflected by the function $v(c^{ui})$. We suppose that the utility function is additively separable. Parent i's utility is written:

$$\hat{U}_i(c^{hi}, c^{ui}) = u(c^{hi}) + v(c^{ui}) + \alpha^i b(c^{hi}) - \beta^i d(c^{ui}) \tag{1}$$

with $u' > 0$, $u'' < 0$, $v' > 0$ and $v'' < 0$

Moreover, we suppose that the marginal satisfaction of the unhealthy good is greater than the marginal health cost associated with the unhealthy good (i.e., $v'(c^{ui}) > d'(c^{ui})$. This assumption makes sense because if the consumption of the unhealthy good costs more than it brings in, then no family would be interested in consuming it.

2.3 Individual choices

Parent i chooses the family consumption of healthy and unhealthy goods by maximizing utility (1) subject to their budget constraint:

$$\begin{aligned} \max_{c^{hi},c^{ui}} \quad & \hat{U}_i(c^{hi}, c^{ui}) = u(c^{hi}) + v(c^{ui}) + \alpha^i b(c^{hi}) - \beta^i d(c^{ui}) \\ s.t. \quad & w^i = p^u c^{ui} + p^h c^{hi} \end{aligned} \tag{2}$$

with p^u and p^h, the prices of the unhealthy good and the healthy good respectively. We suppose that $p^h > p^u$.

The first order conditions are written:[5]

$$u'(c^{hi}) + \alpha^i b'(c^{hi}) = \tfrac{p^h}{p^u}\left[v'(c^{ui}) - \beta^i d'(c^{ui})\right] \tag{3}$$

$$w^i - p^h c^{hi} - p^u c^{ui} = 0 \tag{4}$$

Equations (3) and (4) give the demand functions of the healthy good and the unhealthy good as functions of the perception parameters (α^i and β^i), prices (p^h and p^u), and income (w^i).

Each parent i chooses family consumption levels of healthy and unhealthy goods such that the sum of the marginal satisfaction of healthy consumption and his/her perceived marginal health benefit associated to healthy consumption is equal to the difference between the marginal satisfaction of unhealthy consumption and his/her perceived marginal health cost associated to unhealthy consumption weighted by the price ratio.

[5]The second order condition is satisfied (see Appendix 1).

Results of the comparative statics with respect to the perception parameters (α^i and β^i) and income (w^i) are summarized in table 1.[6]

Table 1: the effects of perception parameters and income on family consumption of healthy and unhealthy goods.

Parameters	Effects on c^{hi}	Effects on c^{ui}
α^i	+	-
β^i	+	-
w^i	+	+

The consumption levels of healthy and unhealthy goods are influenced by a perception effect and an income effect. Income and perception have a positive impact on the consumption of healthy good. In contrast, income and perception have opposite effects on the consumption of unhealthy good. Consequently, it easily comes the following results:

Proposition 1

- *If both family types have the same income level ($w^1 = w^2$), then the family with more nutritional knowledge (type 1) will consume more healthy good and less unhealthy good than the family with less nutritional knowledge (type 2).*
- *If the type 1 family has a higher income than the type 2 family ($w^1 > w^2$), then the type 1 family will consume more healthy good than the type 2 family but may consume more or less unhealthy good than the type 2 family.*
- *If the type 1 family has a lower income than the type 2 family ($w^1 < w^2$), then the type 1 family will consume less unhealthy good than the type 2 family but may consume more or less healthy good than the type 2 family.*

In the case that both family types have the same income level, only the perception effect influences the consumption of the healthy and unhealthy

[6]See Appendix 2 for proof of the comparative statics.

goods. The nutritional quality of the diet of the family that has better perceptions of the effects of food on health will be better than the nutritional quality of the diet of the family that suffers from more important misperceptions of the effects of food on health. If the incomes of the two families are different, one could have the family with better nutritional knowledge consuming more or less healthy good or unhealthy good than the family with little nutritional knowledge.

On the one hand, a lower misperception of the future health benefits associated with the healthy good increases the family's healthy good consumption and decrease its unhealthy good consumption. Similarly, a lower misperception of the future health damage associated with the unhealthy good increases the family's healthy good consumption and decreases its unhealthy good consumption. Consequently, the family with more nutritional knowledge and therefore the highest perceived health benefits and costs of the family consumption will be more willing to consume more healthy good and less unhealthy good than the family with little nutritional knowledge. On the other hand, an increase in income leads to an increase in the consumption of both the healthy and unhealthy goods.

3 Social optimum

We assume a utilitarian social central planner whose welfare function is expressed by the sum of individual utilities. But she has no misperceptions about the effects of diet on health and therefore makes decisions based on the parent's true utility.

3.1 First-best solution

The program of the utilitarian social central planner is written:

$$\max_{c^{hi},c^{ui}} \quad \sum_{i=1}^{2} \left[u(c^{hi}) + v(c^{ui}) + b(c^{hi}) - d(c^{ui})\right] \tag{5}$$

$$s.t. \quad W = p^u \sum_{i=1}^{2} c^{hi} + p^h \sum_{i=1}^{2} c^{hi}$$

with $W = w^1 + w^2$

The optimal conditions are given by, $\forall\ i = 1, 2$:[7]

$$u'(c^{hi}) + b'(c^{hi}) = \mu p^h \tag{6}$$

$$v'(c^{ui}) - d'(c^{ui}) = \mu p^u \tag{7}$$

$$W - p^u \sum_{i=1}^{2} c^{ui} - p^h \sum_{i=1}^{2} c^{hi} = 0 \tag{8}$$

At the optimum, all families consume the same amount of healthy and unhealthy goods, i.e., $c^{h1} = c^{h2} = c^{h\star}$ and $c^{u1} = c^{u2} = c^{u\star}$.

Combining equations (6) and (7) , we deduce that:

$$u'(c^{h\star}) + b'(c^{h\star}) = \frac{p^h}{p^u} \left[v'(c^{u\star}) - d'(c^{u\star})\right] \tag{9}$$

and the budget constraint

$$c^{u\star} = \frac{W}{2p^u} - \frac{p^h}{p^u} c^{h\star} \tag{10}$$

Comparing equations (3) and (9), we see that for any $\alpha^i < 1$ and/or $\beta^i < 1$, families' consumption levels of healthy and unhealthy goods are non-optimal.

The non-optimality of the individual choice solution stems from parents' misperception of the long-term consequences of their family consumption patterns on their children's future health, which justifies the need for public intervention to reduce health inequalities and against diet-related non-communicable diseases.

3.2 Taxation policy

Public intervention is required to restore the social optimum. In this section, we study the case of a differentiated tax on the consumption of the unhealthy good.

[7] μ denotes the Lagrange multiplier.

We suppose that the public authority decides to tax the consumption of unhealthy good. An argument often raised against the taxation of unhealthy goods (fat taxes or soda taxes) is the regressive nature of this policy (Allais et al., 2010; Leicester and Windmeijer, 2004). On average, people with low socioeconomic status consume more unhealthy food (Ogden et al., 2011; Best and Papies, 2019; Wang et al., 2010) and therefore bear the burden of a tax on unhealthy goods. Nevertheless, this regressive nature of the tax can be minimized if the revenues of the taxes on unhealthy food are used for the benefit of the poor (Jacobson and Brownell, 2000; Brownell et al., 2009).

Moreover, there is empirical evidence that suggests that taxation of unhealthy food items is an effective means for reducing consumption of these goods (Epstein et al., 2012; Block et al., 2010), and therefore reducing the prevalence of obesity (Lin et al., 2011; Hall et al., 2011). Allcott et al., (2019) suggest that taxation of an unhealthy good (soda) is probably a good idea.

Let us consider the decentralized problem with a differentiated tax τ^i on the consumption of the unhealthy good of the type i family. We assume that the tax revenue is redistributed to families as a transfer s^i. The government budget constraint writes:

$$p^u \sum_{i=1}^{2} \tau^i c^{ui} = \sum_{i=1}^{2} s^i \tag{11}$$

Parents choose the family consumption levels of healthy and unhealthy goods by maximizing their perceived utility (1) subject to their modified budget constraint.

For a type i family, the individual choice program then becomes:

$$\begin{aligned} \max_{c^{hi},c^{ui}} \quad & \hat{U}_i(c^{hi}, c^{ui}) = u(c^{hi}) + v(c^{ui}) + \alpha^i b(c^{hi}) - \beta^i d(c^{ui}) \\ s.t. \quad & w^i + s^i = p^u(1+\tau^i)c^{ui} + p^h c^{hi} \end{aligned} \tag{12}$$

The first order conditions are written:

$$u'(c^{hi}) + \alpha^i b'(c^{hi}) - \tfrac{p^h}{p^u(1+\tau^i)} \left[v'(c^{ui}) - \beta^i d'(c^{ui}) \right] = 0 \tag{13}$$

$$w^i + s^i - p^h c^{hi} - p^u(1+\tau^i)c^{ui} = 0 \tag{14}$$

Equations (13) and (14) give the demand functions of healthy good (c^{hi}) and unhealthy good (c^{ui}) as a function of the tax τ^i and transfers s^i, $c^{hi}(\tau^i, s^i)$ and $c^{ui}(\tau^i, s^i)$.

We show that the social optimum can be decentralized by discriminating taxes and transfers.

Proposition 2 *The social optimum can be decentralized by means of the following instruments:*

- *a tax,*

$$\tau^i = \frac{p^h}{p^u}\frac{v'(c^{u\star}) - \beta^i d'(c^{u\star})}{u'(c^{h\star}) + \alpha^i b'(c^{h\star})} - 1 \tag{15}$$

- *a transfer,*

$$s^i = (1+\tau^i)\frac{W}{2} - w^i - \tau^i p^h c^{h\star} \tag{16}$$

Proof. See Appendix 3 ■

The tax that each type of family will pay depends on its marginal rate of substitution of the unhealthy good for the healthy good. Each family's tax rate will be higher the larger the difference between the initial prices of the two goods.

$$\frac{\partial \tau^i}{\partial \alpha^i} = -\frac{p^h}{p^u} b'(c^{h\star}) \frac{v'(c^{u\star}) - \beta^i d'(c^{u\star})}{\left(u'(c^{h\star}) + \alpha^i b'(c^{h\star})\right)^2} < 0 \tag{17}$$

$$\frac{\partial \tau^i}{\partial \beta^i} = -\frac{p^h}{p^u}\frac{d'(c^{u\star})}{u'(c^{h\star}) + \alpha^i b'(c^{h\star})} < 0 \tag{18}$$

The central planner will tax families proportionally to their levels of misperception of the health effects of food. The greater the misperception an individual has about the effects of food on health, the higher the amount of tax he will pay. The tax paid by the family of type 2 will be higher than the tax paid by the family of type 1, regardless of income levels.

The difference between the transfer received by the family of type 1 (s^1) and the transfer received by the family of type 2 (s^2) is given by:[8]

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[8] $(\frac{W}{2} - p^h c^{h\star}) = p^u c^{u\star} > 0$. This is deduced from equation (10)

$$s^1 - s^2 = (\tau^1 - \tau^2)(\frac{W}{2} - p^h c^{h\star}) - (w^1 - w^2) \tag{19}$$

The first term of equation (19) is always negative, but the second term can be positive or negative depending on whether the family of type 1 is assumed to have a higher or lower income than the family of type 2. If we assume that the income of the family of type 1 is higher than the income of the family of type 2 ($w^1 > w^2$) or we assume that both types of families have the same income ($w^1 = w^2$), then the transfer received by the family of type 2 will be higher than the transfer received by the family of type 1. On the other hand, if we assume that the income of the family of type 2 is higher than the income of the family of type 1, the sign of equation (19) becomes ambiguous.

If possible, the implementation of a targeted tax policy could therefore solve the problem of non-optimality of family consumption of healthy and unhealthy goods. However, it is very difficult if not impossible in practice for a central planner to put a discriminating tax on food products. The viable solution to restore the social optimum with taxation is to set a uniform tax for both family types.

3.3 Mixed policy: taxation and nudge

Let us now consider the most realistic tax policy, in which the central planner sets a uniform tax for both family types and supports the tax with an non-economic instrument called a nudge in a mixed policy. The reason for using a nudge is that it is a tool that can help families to improve the nutritional quality of their diets with negligible implementation costs. The nudge we consider corresponds to information provided by the public authority concerning the healthiness of food items. The use of nudge therefore aims to reduce the degree of individuals' misperception of the effects of diet on health. The nudge used in our model can be interpreted as a nutrition labelling system (like "Nutri-Score"[9]) for example. Its goal is to make healthy food choices easier. We assume that the implementation of the nudge, η, does not generate additional costs for the public authority.

[9] "Nutri-score" is a five-level nutrition labelling system, ranking from A to E and from green to red, placed on the front of food packaging, based on the nutritional value of a food product.

Following Farhi and Gabaix (2020), we assume that the nudge influences consumption but has no effect on a parent's budget constraint. As in Farhi and Gabaix (2020), we also assume that the reaction of an individual to the implementation of the nudge depends on his nudgeability ρ^i. Nugeabitlity here refers to a parent's sensitivity to the change in their food choice environment after the implementation of the nudge. More precisely, parent's nudgeability refers to his or her ability to identify a good as healthy or unhealthy in response to the implementation of the nudge. We can therefore assume that parents who suffer from greater misperception are more sensitive to the implementation of nudge (i.e., $\rho^2 > \rho^1$). Intuitively, a parent who has a good perception of the health benefits and costs of food will have a good classification of goods based on their healthiness. Therefore, the introduction of the nudge will not significantly modify his or her consideration of the healthiness of goods. On the other hand, a parent who has erroneous perceptions of the effects of food on health will have a bad classification of goods according to their healthiness. For this parent, the implementation of the nudge may alter his or her consideration of the healthiness of goods.

In general, a nudge may also affect the agents' perceived utility. In our model, the nudge increases the health benefit, associated with the consumption of the healthy good, perceived by parents. Similarly, a nudge increases the health cost, associated to the consumption of the unhealthy good, perceived by parents.

Under the implementation of the nudge, parent i's utility is now given by:

$$\hat{U}_i(c^{hi}, c^{ui}) = u(c^{hi}) + v(c^{ui}) + (\alpha^i + \rho^i\eta)b(c^{hi}) - (\beta^i + \rho^i\eta)d(c^{ui}) \tag{20}$$

where $\rho^i \geq 0$ captures the nudgeability of the agent i ; $\rho^i = 0$ corresponds to a non-nudgeable agent.

Under the implementation of the mixed policy, parents choose family consumption of healthy and unhealthy goods by maximizing perceived utility (20) subject to their budget constraint.

$$\begin{aligned} \max_{c^{hi}, c^{ui}} \quad & \hat{U}_i(c^{hi}, c^{ui}) = u(c^{hi}) + v(c^{ui}) + (\alpha^i + \rho^i\eta)b(c^{hi}) - (\beta^i + \rho^i\eta)d(c^{ui}) \\ s.t. \quad & w^i + s^i = p^u(1+\tau)c^{ui} + p^h c^{hi} \end{aligned} \tag{21}$$

The first order conditions are written:

$$u'(c^{hi})+(\alpha^i+\rho^i\eta)b'(c^{hi})=\tfrac{p^h}{p^u(1+\tau)}\left[v'(c^{ui})-(\beta^i+\rho^i\eta)d'(c^{ui})\right] \quad (22)$$

$$w^i+s^i-p^hc^{hi}-p^u(1+\tau)c^{ui}=0 \quad (23)$$

We make the following assumption in order to obtain a nudge that is always positive and to be able to analyze the effects of perception parameters on the nudge:[10]

Assumption A2: Each family type perceives the health benefit and cost of food in the same way (i.e., $\alpha^1=\beta^1$ and $\alpha^2=\beta^2$)

Proposition 3 *Under assumption A2, social optimum can be decentralized by:*

- *a nudge such that,*

$$\eta^\star=\frac{(\alpha^1-\alpha^2)\left[d'(c^{u\star})\times u'(c^{h\star})+v'(c^{u\star})\times b'(c^{h\star})\right]}{(\rho^2-\rho^1)\left[v'(c^{u\star})\times b'(c^{h\star})+d'(c^{u\star})\times u'(c^{h\star})\right]} \quad (24)$$

- *a uniform tax,*

$$\tau^\star=\frac{u'(c^{h\star})+b'(c^{h\star})}{v'(c^{u\star})-d'(c^{u\star})}\times\frac{v'(c^{u\star})-(\alpha^i+\rho^i\eta^\star)d'(c^{u\star})}{u'(c^{h\star})+(\alpha^i+\rho^i\eta^\star)b'(c^{h\star})}-1 \quad (25)$$

- *transfers,*

$$s^i=p^hc^{h\star}+p^u(1+\tau^\star)c^{u\star}-w^i \quad (26)$$

Proof. See Appendix 4 ■

The nudge allows the central planner to address the differences in perceptions of the effects of food on health between the two family types and to

[10] The optimal nudge, uniform tax, and transfers if we release assumption A2 are given and discussed in Appendix 5.

set a uniform tax on the consumption of the unhealthy good. Under the implementation of the mixed policy, a portion of the income of the family with the highest income is redistributed to the family with the lowest income as a transfer. Thus, the mixed policy also allows the central planner to reduce the income gap between the two family types.

We can easily show that the greater the gap in perceptions of the health effects of food between the two family types, the more important the optimal nudge will be.

Intuitively, nudge is used by the central planner as a tool to address the difference in perceptions of the effects of food on health between the two family types so that a uniform tax can be set. Thus, if the perceived health effects of food of the family with better nutritional knowledge increases, then the difference in perceived health effects of food between the families becomes larger and so does the value of the nudge that allows to compensate the perception gap. On the other hand, if the perceived health effects of food for the family with less nutritional knowledge increases, then the difference in perceived health effects of food between the families decreases and so does the value of the nudge that makes it possible to overcome the difference in perceptions.

4 Numerical example

We run numerical simulations to consolidate the results of our theoretical model.[11] We make graphical representations to illustrate proposition 1, which compares consumption levels of the healthy and unhealthy goods for the two family types.

Let's take as a numerical example: $u(c^{hi}) = (c^{hi})^{\theta}$, $v(c^{ui}) = (c^{ui})^{\theta}$, $b(c^{hi}) = \frac{1}{2}(c^{hi})^{\theta}$ and $-d(c^{ui}) = \left(\overline{C} - c^{ui}\right)^{\theta}$, with $\overline{C}$ the maximum value that the consumption of unhealthy good can reach and $0 < \theta < 1$.

We compare the healthy and unhealthy goods consumption levels of the individual choice outcome to the first-best optimum and healthy and unhealthy goods consumption levels of the individual choice outcome between the two family types when the income of the type 1 family varies *ceteris paribus*. Table 2 gives the predefined values of all parameters.

[11] The numerical results are obtained with Mathematica 10.

Table 2: predefined values of parameters

Parameters	Predefined values
α^1	1/2
α^2	1/4
β^1	1/2
β^2	1/4
p^h	2
p^u	1
$\overline{C}$	100
θ	1/2
w^1	$\in [50; 250]$
w^2	100

Figure 1 represents the variation of the healthy good consumption levels of both family types and the first-best solution as a function of type 1 family's income. The vertical purple line represents the income value of the type 2 family ($w^2 = 100$). One can see that the quantity of the healthy good consumed by the type 2 family is lower than the quantity of the healthy good that should be consumed by each family at the first-best. Thus, there is an underconsumption of the healthy good by the type 2 family compared to the first-best. For the type 1 family, its consumption of the healthy good is lower than the quantity of the healthy good that should be consumed by each family at the first-best if its income is less than 140 (i.e., $w^1 < 140$) and higher if its income is more than 140 (i.e., $w^1 > 140$). When the incomes of both family types are equal (i.e., $w^1 = w^2 = 100$), the type 1 family consumes more fo the healthy good than the type 2 family, but the healthy good consumption levels of both family types are less than the quantity of the healthy good that should be consumed by each family at first-best. If the type 1 family has a higher income than the type 2 family, the healthy good consumption of the type 1 family is always higher than the healthy good consumption of the type 2 family. In contrast, if the type 1 family has a lower income than the type 2 family, the healthy good consumption of the type 1 family may be lower than the healthy good consumption of the type 2 family (if $w^1 < 80$ in our case).

Figure 2 shows the variation of the unhealthy good consumption levels of both family types and the first-best optimum as a function of the type 1 family's income. The vertical purple line represents the income value of the type 2 family ($w^2 = 100$). We observe that the quantity of the unhealthy good consumed by both family types is greater than the quantity of the unhealthy good that should be consumed by each family at the first-best. Therefore, there is an overconsumption of the unhealthy good by both family types compared to the first-best. If both family types have the same income or the type 1 family has a lower income than the type 2 family, the type 1 family consumes less unhealthy good than the type 2 family. Even if the type 1 family has a higher income than the type 2 family, it still consumes less unhealthy good than the type 2 family as long as the income gap is not too large. The type 1 family's consumption of the unhealthy good rises above the type 2 family's consumption of the unhealthy good if its income is about twice higher than the income of the type 2 family.

These two graphs confirm that if parents suffer from misperceptions about the future health effects of diet, families' consumption levels of healthy and unhealthy goods are non-optimal. These graphs also show that the income gap plays an important role on the levels of families' healthy and unhealthy goods consumption. Especially if the income gap between families is very large, one could have the family with better nutritional knowledge consuming more or less healthy good or unhealthy good than the family with little nutritional knowledge.

Figure 1: Families' healthy good consumption levels and the first-best's healthy good consumption as a function of type 1 family's income.

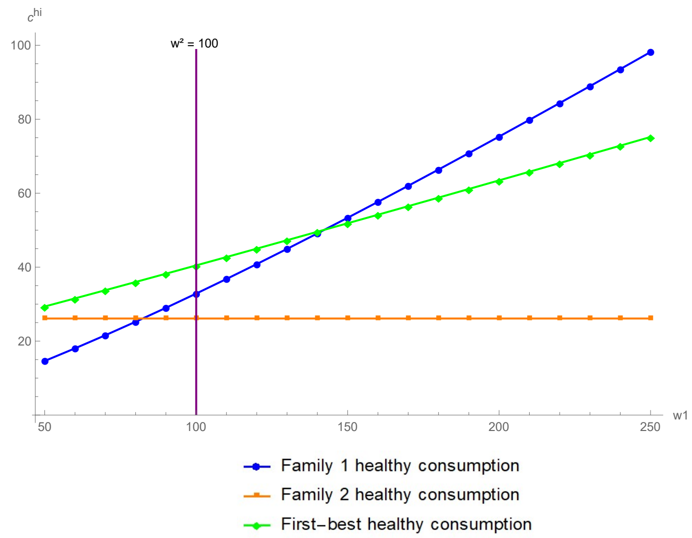
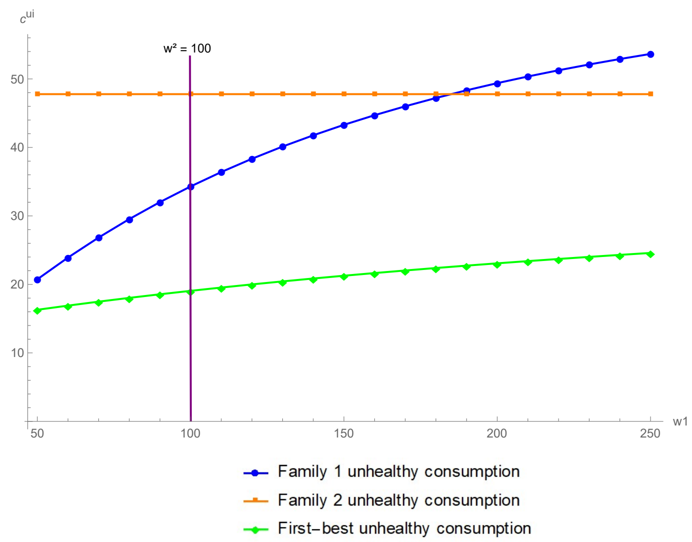


Figure 2: Families' unhealthy good consumption levels and the first-best's unhealthy good consumption as a function of type 1 family's income.



5 Discussion and concluding remarks

This paper studies the effectiveness of two public policies (tax and nudge) in an economy where parents differ in their income and their degree of misperception of the effects of diet on their children's future health.

Our model clearly highlights the need for public interventions to improve the nutritional quality of families' diets in a context where parents suffer from misperceptions about the long-term health effects of diet. We show that a simple tax policy on the consumption of the unhealthy good achieves the first-best optimum if and only if it is possible to implement a targeted tax policy. Then, we find that the use of nudge as a support to the tax on the consumption of the unhealthy good allows to reach the first-best optimum with a uniform tax for both types of families.

In our model, we consider family consumption and therefore we implicitly assume that the parent and the child consume the same types of goods. One might think that the model does not show the existence of children's consumption, and therefore think that we can consider it as the choice of a given individual living two periods. However, this configuration does not fit the model for two reasons. First, it would be necessary in this case to take into account the consumption of this individual in the second period, and therefore the existence of a source of income or a possible saving which would allow him/her to finance his/her consumption during the second period. In our model, the family consumption of the period includes the consumptions of both the parent and the child which are financed by the parent of the period. Thus there is no need to save for the second period because the family consumption of the second period will be financed by the income of the child of the first period who will become the parent in the second period. Second, if we consider that it is the choice of an individual living two periods, the result of the individual choice can be the result of a rational choice. The individual will make his/her decisions by making a trade-off between his/her instantaneous satisfaction derived from the consumption of the two types of goods and his future health depending on his consumption levels. In our model, there are intergenerational externalities due to the parents' lack of nutritional knowledge. If we assume that parents care about their children's health when they become adults, then they will need better knowledge about the link between their eating patterns and their children's future health. This may justify public intervention to clarify the link between health and diet, which would not necessarily be required if the model were considered to apply to the choice of an individual living two periods. One way to avoid this confusion about the existence of children in the model for future work would be to distinguish between parental and child consumption.

Another point of the model that should be discussed for an empirical application is the measurability of the perception and nudgeability parameters α^i, β^i, and ρ^i. The optimal nudge in our model is based on the assumption that the values of these parameters are known in advance. The values of the perception parameters (α^i and β^i) can be obtained from experimental studies that measure individuals' perceptions of the effects of eating certain food items on their future health or their perceptions of the safety of certain food items. In contrast, the determination of the values of the nudgeability parameters (ρ^i) seems more delicate because it requires first implementing the nudge and then measuring how individuals react to the implementation of the nudge. The way to find out if the implementation of a nudge will have the desired effect on the purchase decisions of food items would be to first conduct an experiment on the implementation of the nudge. This will allow the decision-maker to measure individuals' sensitivities to the nudge and to evaluate the capacity of the nudge to alter their food choices. The nudge can be considered as optimal if it allows decision-maker to get as close as possible to the intended goal. If we take the example of food labels, a label can be considered as optimal if it effectively reduces the consumption of unhealthy goods and increases the consumption of healthy goods. To be optimal, a nudge must be understandable by consumers and have real effects on their food purchase decisions.

The results of our model suggest that decision-makers should support their tax policies on the consumption of unhealthy items with nudges designed to reduce individuals' misperceptions. The implementation of food labels, for example, that allow to assess the healthiness of food items could better guide consumers' food choices. Nutrition education programs would also be desirable to improve the nutritional quality of families' diets. Finally, the results of our model suggest a potential complementarity between the use of taxation of unhealthy goods and a nudge. To confirm this potential complementarity between tax and nudge found in our model, experimental studies are required to find out if tax and nudge are complementary public policy instruments. These extensions are left for future research.

References

Al-Shookri A., Al-Shukaily L., Hassan F., Al-Sheraji S., and Al-Tobi A. (2011), "Effect of Mothers Nutritional Knowledge and Attitudes on Omani Childrens Dietary Intake", *Oman Medical Journal*, 26(4), p. 253-257.

Allais O., Bertail P., and Nichèle V. (2010), "The Effects of a Fat Tax on French Households' Purchases: A Nutritional Approach", *American Journal of Agricultural Economics*, 92(1), p. 228-245.

Allcott H., Lockwood B. B., and Taubinsky D. (2019), "Should We Tax Sugar-Sweetened Beverages? An Overview of Theory and Evidence", J*ournal of Economic Perspectives*, 33(3),p. 202-227.

Ares G., Giménez A., and Gámbaro A. (2008), "Influence of nutritional knowledge on perceived healthiness and willingness to try functional foods", *Appetite*, 51(3), p. 663-668.

Best M. and Papies E. K. (2019), "Lower socioeconomic status is associated with higher intended consumption from oversized portions of unhealthy food", *Appetite*, 140, p. 255-268.

Block J. P., Chandra A., McManus K. D., and Willett W. C. (2010), "Point-of-Purchase Price and Education Intervention to Reduce Consumption of Sugary Soft Drinks", *American Journal of Public Health*, 100(8), p. 1427-1433.

Brownell K. D., Farley T., Willett W. C., Popkin B. M., Chaloupka F. J., Thompson J. W., and Ludwig D. S. (2009), "The Public Health and Economic Benefits of Taxing Sugar-Sweetened Beverage", *The New England journal of medicine*, 361(16), p. 1599-1605.

Capacci S., Allais O., Bonnet C., and Mazzocchi M. (2019), "The impact of the French soda tax on prices and purchases. An ex post evaluation", *PLOS ONE*, 14(10), e0223196.

Cawley, J., Thow, A. M., Wen, K., and Frisvold, D. (2019). "The economics of taxes on sugar-sweetened beverages: a review of the effects on prices, sales, cross-border shopping, and consumption", *Annual review of nutrition*, 39, 317-338.

Cremer H., Goulão C., and Roeder K. (2016), "Earmarking and the political support of fat taxes", *Journal of Health Economics*, 50, p. 258-267.

Crites S. L., and Aikman S. N., (2005), "Impact of nutrition knowledge on food evaluations", *European Journal of Clinical Nutrition*, 59(10), p. 1191-1200.

Crosetto, P., Lacroix, A., Muller, L., and Ruffieux, B. (2018) "Nutritional and economic impact of 5 alternative front-of-pack nutritional labels: experimental evidence", hal-01805431

Davis C., Curtis C., Levitan R. D., Carter J. C., Kaplan A. S., and Kennedy J. L. (2011), "Evidence that food addiction is a valid phenotype of obesity", *Appetite*, 57(3) p .711-717.

Dubois P., Albuquerque P., Allais O., Bonnet C., Bertail P., Combris P., Lahlou S., Rigal N., Ruffieux B. and Chandon, P. (2021), "Effects of front-of-pack labels on the nutritional quality of supermarket food purchases: evidence from a large-scale randomized controlled trial", *Journal of the Academy of Marketing Science,* 49(1), p. 119-138.

Epstein L. H., Jankowiak N., Nederkoorn C., Raynor H. A., French S. A., and Finkelstein E. (2012), "Experimental research on the relation between food price changes and food-purchasing patterns: a targeted review", *The American Journal of Clinical Nutrition*, 95(4), p. 789-809.

Farhi E. and Gabaix X. (2020), "Optimal Taxation with Behavioral Agents", *American Economic Review*, 110(1), p. 298-336.

Fontaine K. R., Redden D. T., Wang C., Westfall A. O., and Allison D. B.(2003), "Years of Life Lost Due to Obesity", *JAMA*, 289(2) p. 187-193.

Hall K. D., Sacks G., Chandramohan D., Chow C. C., Wang Y. C., Gortmaker S. L., and Swinburn B. A. (2011), "Quantification of the effect of energy imbalance on bodyweight", *The Lancet*, 378(9793), p. 826-837.

Hughes A. R., Sherriff A., Lawlor D. A., Ness A. R., and Reilly J. J. (2011), "Incidence of obesity during childhood and adolescence in a large contemporary cohort", *Preventive Medicine*, 52(5), p. 300-304.

Jacobson M. F. and Brownell K. D. (2000), "Small taxes on soft drinks and snack foods to promote health", *American Journal of Public Health*, 90(6),

p. 854-857.

Kalamov Z. and Runkel M. (2020), "Taxes on unhealthy food and externalities in the parental choice of children's diet", *Health Economics*, 29(8), p. 938-944.

Khawaja A. H., Qassim S., Hassan N. A., and Arafa E. S. A. (2019), "Added sugar: Nutritional knowledge and consumption pattern of a principal driver of obesity and diabetes among undergraduates in UAE", *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, 13(4), p. 2579-2584.

Kourlaba G., Kondaki K., Grammatikaki E., Roma-Giannikou E., and Manios Y. (2009), "Diet quality of preschool children and maternal perceptions/ misperceptions: The GENESIS study", *Public Health*, 123(11), p. 738-742.

Leicester A. and Windmeijer F. (2004), *The 'fat tax': economic incentives to reduce obesity*, London, UK, Institute for Fiscal Studies.

Lin B.H., Smith T. A., Lee J.Y., and Hall K. D. (2011), "Measuring weight outcomes for obesity intervention strategies: The case of a sugar-sweetened beverage tax" *Economics & Human Biology*, 9(4), p. 329-341.

Lovic D., Piperidou A., Zografou I., Grassos H., Pittaras A., and Manolis A. (2020), "The Growing Epidemic of Diabetes Mellitus", *Current Vascular Pharmacology*, 18(2), p. 104-109.

Ludwig D. S., Peterson K. E., and Gortmaker S. L. (2001), "Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective, observational analysis", *The Lancet*, 357(9255), p. 505-508.

Malik V. S., Schulze M. B., and Hu F. B. (2006), "Intake of sugar-sweetened beverages and weight gain: a systematic review" *Am J Clin Nutr*, 84, p. 274–288.

Moran A. J. and Roberto C. A. (2018), "Health Warning Labels Correct Parents' Misperceptions About Sugary Drink Options", *American Journal of Preventive Medicine*, 55(2), e19-e27.

Munsell C. R., Harris J. L., Sarda V., and Schwartz M. B. (2016), "Parents beliefs about the healthfulness of sugary drink options: opportunities to address misperceptions", *Public Health Nutrition*, 19(1), p. 46-54.

Must A. and Strauss R. S. (1999), "Risks and consequences of childhood and adolescent obesity", *International Journal of Obesity*, 23(2), S2–S11.

Ogden C., Kit B., Carroll M., and Park S. (2011), "Consumption of sugar drinks in the United States, 2005-2008", *NCHS data brief*, 71, p. 1-8.

Pieniak Z., Verbeke W., Scholderer J., Brunsø K., and Ottar Olsen S. (2008), "Impact of consumers' health beliefs, health involvement and risk perception on fish consumption: A study in five European countries", B*ritish Food Journal*, 110(9), p. 898-915.

Reilly J. J. and Kelly J. (2011), "Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: systematic review", *International Journal of Obesity*, 35(7),p. 891-898.

Roberto C. A., Wong D., Musicus A., and Hammond D. (2016), "The Influence of Sugar-Sweetened Beverage Health Warning Labels on Parents Choices", *Pediatrics*, 137(2), e20153185.

Simmonds M., Llewellyn A., Owen C. G., and Woolacott N. (2016) "Predicting adult obesity from childhood obesity: a systematic re- view and meta-analysis", *Obesity Reviews*, 17(2), p. 95–107.

Srinivasan S. R., Bao W., Wattigney W. A., and Berenson G. S. (1996), "Adolescent overweight is associated with adult overweight and related multiple cardiovascular risk factors: The Bogalusa Heart Study", *Metabolism*, 45(2), p. 235–240.

Sunstein C. R. and Thaler R. H. (2008), *improving decisions about health, wealth, and happiness*, London: Penguin Books.

Verbeke W., Sioen I., Pieniak Z., Camp J. V., and Henauw S. D. (2005), "Consumer perception versus scientific evidence about health benefits and safety risks from fish consumption", *Public Health Nutrition*, 8(4), p. 422–429.

Vereecken C. and Maes L. (2010), "Young children's dietary habits and associations with the mothers nutritional knowledge and attitudes", *Appetite*, 54(1), p. 44–51.

Wang Y., Jahns L., Tussing-Humphreys L., Xie B., Rockett H., Liang H., and Johnson L. (2010), "Dietary Intake Patterns of Low-Income Urban African-

American Adolescents", *Journal of the American Dietetic Association*, 110(9), p. 1340-1345.

Appendix 1: proof of the second order conditions of the maximization program.

The bordered Hessian matrix of our maximization program (2) is given by:

$$\overline{\mathcal{H}} = \begin{pmatrix} 0 & -p^h & -p^u \\ -p^h & u'' + \alpha^i b'' & 0 \\ -p^u & 0 & v'' - \beta^i d'' \end{pmatrix}$$

With $u'' = \frac{\partial^2 u(c^{hi})}{\partial {c^{hi}}^2} < 0$; $b'' = \frac{\partial^2 b(c^{hi})}{\partial {c^{hi}}^2} < 0$; $v'' = \frac{\partial^2 v(c^{ui})}{\partial {c^{ui}}^2} < 0$ and $d'' = \frac{\partial^2 d(c^{ui})}{\partial {c^{ui}}^2} > 0$

The diagonal principal minor of order 2 (m_2) is :

$$m_2 = \begin{vmatrix} 0 & -p^h \\ -p^h & u'' + \alpha^i b'' \end{vmatrix} = -{p^h}^2 < 0$$

The diagonal principal minor of order 3 (m_3) is :

$$m_3 = \left|\overline{\mathcal{H}}\right| = -\left[p^{u2}(u'' + \alpha^i b'') + {p^h}^2(v'' - \beta^i d'')\right] > 0$$

The last 2 diagonal principal minors of the bordered Hessian matrix evaluated at the optimum are alternatively negative and positive. Moreover the objective function $\hat{U}_i$ is strictly concave. Our program therefore admits a global maximum.

Appendix 2: proof of the comparative statics in table 1.

The first order conditions of the Lagrangian of the maximization program of a parent i are given by:

$$\frac{\partial \mathcal{L}}{\partial c^{hi}} = 0 \Rightarrow \quad u'(c^{hi}) + \alpha^i b'(c^{hi}) - \lambda p^h = 0 \equiv \mathcal{L}_h \qquad (27)$$

$$\frac{\partial \mathcal{L}}{\partial c^{ui}} = 0 \Rightarrow \quad v'(c^{ui}) - \beta^i d'(c^{ui}) - \lambda p^u = 0 \equiv \mathcal{L}_u \qquad (28)$$

$$w^i - p^h c^{hi} - p^u c^{ui} = 0 \equiv F(c^{hi}, c^{ui}) \tag{29}$$

Differentiating the first order conditions with respect to α^i we obtain:

$$\mathcal{L}_{hh}\frac{dc^{hi}}{d\alpha^i} + \mathcal{L}_{hu}\frac{dc^{ui}}{d\alpha^i} + F_h\frac{d\lambda}{d\alpha^i} + \mathcal{L}_{h\alpha^i} = 0 \tag{30}$$

$$\mathcal{L}_{uh}\frac{dc^{hi}}{d\alpha^i} + \mathcal{L}_{uu}\frac{dc^{ui}}{d\alpha^i} + F_u\frac{d\lambda}{d\alpha^i} + \mathcal{L}_{u\alpha^i} = 0 \tag{31}$$

$$F_h\frac{dc^{hi}}{d\alpha^i} + F_u\frac{dc^{ui}}{d\alpha^i} + F_{\alpha^i} = 0 \tag{32}$$

With:

$\mathcal{L}_{hh} = \frac{\partial \mathcal{L}_h}{\partial c^{hi}} = u''(c^{hi}) + \alpha^i b''(c^{hi}) < 0$; $\mathcal{L}_{hu} = \mathcal{L}_{uh} = \frac{\partial \mathcal{L}_h}{\partial c^{ui}} = 0$;

$\mathcal{L}_{uu} = \frac{\partial \mathcal{L}_u}{\partial c^{ui}} = v''(c^{ui}) - \beta^i d''(c^{ui}) < 0$; $\mathcal{L}_{h\alpha^i} = \frac{\partial \mathcal{L}_h}{\partial \alpha^i} = b'(c^{hi}) > 0$;

$\mathcal{L}_{u\alpha^i} = \frac{\partial \mathcal{L}_u}{\partial \alpha^i} = 0$; $F_h = \frac{\partial F(c^{hi},c^{ui})}{\partial c^{hi}} = -p^h$; $F_u = \frac{\partial F(c^{hi},c^{ui})}{\partial c^{ui}} = -p^u$; $F_{\alpha^i} = \frac{\partial F(c^{hi},c^{ui})}{\partial \alpha^i} = 0$

We deduce that:

$$\frac{dc^{hi}}{d\alpha^i} = \frac{p^{u2} b'(c^{hi})}{\Delta} > 0 \tag{33}$$

and

$$\frac{dc^{ui}}{d\alpha^i} = -\frac{p^h p^u b'(c^{hi})}{\Delta} < 0 \tag{34}$$

with $\Delta = -(p^{h2}\mathcal{L}_{uu} + p^{u2}\mathcal{L}_{hh}) > 0$

Analogically, differentiating the first order conditions with respect to β^i we obtain:

$$\mathcal{L}_{hh}\frac{dc^{hi}}{d\beta^i}+\mathcal{L}_{hu}\frac{dc^{ui}}{d\beta^i}+F_h\frac{d\lambda}{d\beta^i}+\mathcal{L}_{h\beta^i}=0 \tag{35}$$

$$\mathcal{L}_{uh}\frac{dc^{hi}}{d\beta^i}+\mathcal{L}_{uu}\frac{dc^{ui}}{d\beta^i}+F_u\frac{d\lambda}{d\beta^i}+\mathcal{L}_{u\beta^i}=0 \tag{36}$$

$$F_h\frac{dc^{hi}}{d\beta^i}+F_u\frac{dc^{ui}}{d\beta^i}+F_{\beta^i}=0 \tag{37}$$

With:

$\mathcal{L}_{h\beta^i}=\frac{\partial\mathcal{L}_h}{\partial\beta^i}=0$; $\mathcal{L}_{u\beta^i}=\frac{\partial\mathcal{L}_u}{\partial\beta^i}=-d'_u<0$; $F_{\beta^i}=\frac{\partial F(c^{hi},c^{ui})}{\partial\beta^i}=0$

We deduce that:

$$\frac{dc^{hi}}{d\beta^i}=\frac{p^h p^u d'(c^{ui})}{\Delta}>0 \tag{38}$$

and

$$\frac{dc^{ui}}{d\beta^i}=-\frac{{p^h}^2 d'(c^{ui})}{\Delta}<0 \tag{39}$$

Analogically, differentiating the first order conditions with respect to income w^i we obtain:

$$\mathcal{L}_{hh}\frac{dc^{hi}}{dw^i}+\mathcal{L}_{hu}\frac{dc^{ui}}{dw^i}+F_h\frac{d\lambda}{dw^i}+\mathcal{L}_{hw^i}=0 \tag{40}$$

$$\mathcal{L}_{uh}\frac{dc^{hi}}{dw^i}+\mathcal{L}_{uu}\frac{dc^{ui}}{dw^i}+F_u\frac{d\lambda}{dw^i}+\mathcal{L}_{uw^i}=0 \tag{41}$$

$$F_h \frac{dc^{hi}}{dw^i} + F_u \frac{dc^{ui}}{dw^i} + F_{w^i} = 0 \tag{42}$$

With:

$\mathcal{L}_{hw^i} = \frac{\partial \mathcal{L}_h}{\partial w^i} = 0$; $\mathcal{L}_{uw^i} = \frac{\partial \mathcal{L}_u}{\partial w^i} = 0$; $F_{w^i} = \frac{\partial F(c^{hi}, c^{ui})}{\partial w^i} = 1$

We deduce that:

$$\frac{dc^{hi}}{dw^i} = -\frac{p^h \mathcal{L}_{uu}}{\Delta} > 0 \tag{43}$$

And

$$\frac{dc^{ui}}{dw^i} = -\frac{p^u \mathcal{L}_{hh}}{\Delta} > 0 \tag{44}$$

Appendix 3 : proof of proposition 2.

The central planner sets the tax rate so that equation (13) is equal to zero for $c^{hi} = c^{h\star}$ and $c^{ui} = c^{u\star}$, $\forall i = 1, 2$.

$$u'(c^{h\star}) + \alpha^i b'(c^{h\star}) - \tfrac{p^h}{p^u(1+\tau^i)} \left[v'(c^{u\star}) - \beta^i d'(c^{h\star}) \right] = 0 \tag{45}$$

We deduce that:

$$\tau^i = \frac{p^h}{p^u} \frac{v'(c^{u\star}) - \beta^i d'(c^{u\star})}{u'(c^{h\star}) + \alpha^i b'(c^{h\star})} - 1 \tag{46}$$

From the parent i's budget constraint and equations (10) and (14), we deduce that:

$$s^i = (1 + \tau^i)\frac{W}{2} - w^i - \tau^i p^h c^{h\star} \tag{47}$$

Appendix 4: proof of proposition 3.

The central planner's objective is to implement a nudge and a uniform tax that achieve the levels of healthy and unhealthy goods consumption of the first-best with the mixed policy. Thus, we can rewrite equation (22) as follows:

$$u'(c^{h\star}) + (\alpha^i + \rho^i\eta)b'(c^{h\star}) = \tfrac{p^h}{p^u(1+\tau)}\left[v'(c^{u\star}) - (\beta^i + \rho^i\eta)d'(c^{u\star})\right] \tag{48}$$

$$\Rightarrow \frac{p^u}{p^h} = \frac{v'(c^{u\star}) - (\beta^i + \rho^i\eta)d'(c^{u\star})}{(1+\tau)\left[u'(c^{h\star}) + (\alpha^i + \rho^i\eta)b'(c^{h\star})\right]} \tag{49}$$

From equation (9) we also have:

$$\frac{p^u}{p^h} = \frac{v'(c^{u\star}) - d'(c^{u\star})}{u'(c^{h\star}) + b'(c^{h\star})} \tag{50}$$

From equations (49) and (50), we deduce that:

$$\frac{v'(c^{u\star}) - (\beta^i + \rho^i\eta)d'(c^{u\star})}{(1+\tau)\left[u'(c^{h\star}) + (\alpha^i + \rho^i\eta)b'(c^{h\star})\right]} = \frac{v'(c^{u\star}) - d'(c^{u\star})}{u'(c^{h\star}) + b'(c^{h\star})} \tag{51}$$

$$\Rightarrow (1+\tau) = \frac{u'(c^{h\star}) + b'(c^{h\star})}{v'(c^{u\star}) - d'(c^{u\star})} \times \frac{v'(c^{u\star}) - (\beta^i + \rho^i\eta)d'(c^{u\star})}{u'(c^{h\star}) + (\alpha^i + \rho^i\eta)b'(c^{h\star})} \tag{52}$$

If we rewrite equation (52) for each family type we get:
For the type 1 family ($i = 1$):

$$(1+\tau) = \frac{u'(c^{h\star}) + b'(c^{h\star})}{v'(c^{u\star}) - d'(c^{u\star})} \times \frac{v'(c^{u\star}) - (\beta^1 + \rho^1\eta)d'(c^{u\star})}{u'(c^{h\star}) + (\alpha^1 + \rho^1\eta)b'(c^{h\star})} \tag{53}$$

For the type 2 family ($i = 2$):

$$(1+\tau) = \frac{u'(c^{h\star}) + b'(c^{h\star})}{v'(c^{u\star}) - d'(c^{u\star})} \times \frac{v'(c^{u\star}) - (\beta^2 + \rho^2\eta)d'(c^{u\star})}{u'(c^{h\star}) + (\alpha^2 + \rho^2\eta)b'(c^{h\star})} \tag{54}$$

From equations (53) and (54), we obtain:

$$\begin{aligned}\left[v'(c^{u\star}) - (\beta^1 + \rho^1\eta)d'(c^{u\star})\right]\left[u'(c^{h\star}) + (\alpha^2 + \rho^2\eta)b'(c^{h\star})\right] = \\ \left[v'(c^{u\star}) - (\beta^2 + \rho^2\eta)d'(c^{u\star})\right]\left[u'(c^{h\star}) + (\alpha^1 + \rho^1\eta)b'(c^{h\star})\right]\end{aligned} \tag{55}$$

Let's denote by A and B:

$$A = (\beta^1\alpha^2 - \alpha^1\beta^2)d'(c^{u\star}) \times b'(c^{h\star}) + (\beta^1 - \beta^2)d'(c^{u\star}) \times u'(c^{h\star}) + (\alpha^1 - \alpha^2)v'(c^{u\star}) \times b'(c^{h\star})$$

and

$$B = (\rho^2 - \rho^1)\left[v'(c^{u\star}) \times b'(c^{h\star}) + d'(c^{u\star}) \times u'(c^{h\star})\right] + \left[\rho^2(\alpha^1 - \beta^1) - \rho^1(\alpha^2 - \beta^2)\right]d'(c^{u\star}) \times b'(c^{h\star})$$

Then, we deduce that:

$$\eta^\star = \frac{A}{B} \tag{56}$$

Under assumption A2 ($\alpha^1 = \beta^1$ and $\alpha^2 = \beta^2$), then:

$$\eta^\star = \frac{(\beta^1 - \beta^2)d'(c^{u\star}) \times u'(c^{h\star}) + (\alpha^1 - \alpha^2)v'(c^{u\star}) \times b'(c^{h\star})}{(\rho^2 - \rho^1)\left[v'(c^{u\star}) \times b'(c^{h\star}) + d'(c^{u\star}) \times u'(c^{h\star})\right]} \tag{57}$$

$$\tau^\star = \frac{u'(c^{h^\star}) + b'(c^{h^\star})}{v'(c^{u\star}) - d'(c^{u^\star})} \times \frac{v'(c^{u\star}) - (\beta^i + \rho^i\eta^\star)d'(c^{u^\star})}{u'(c^{h^\star}) + (\alpha^i + \rho^i\eta^\star)b'(c^{h^\star})} - 1 \tag{58}$$

and from equation (23),

$$s^i = p^h c^{h\star} + p^u(1 + \tau^\star)c^{u\star} - w^i \tag{59}$$

Appendix 5: the optimal nudge, uniform tax, and transfers if we release assumption A2.

If we release assumption A2, the optimal nudge, uniform tax, and transfers are given by:

$$\eta^\star = \frac{A}{B} \lesseqgtr 0 \tag{60}$$

$$\tau^\star = \frac{u'(c^{h\star}) + b'(c^{h\star})}{v'(c^{u\star}) - d'(c^{u\star})} \times \frac{v'(c^{u\star}) - (\beta^i + \rho^i \eta^\star) d'(c^{u\star})}{u'(c^{h\star}) + (\alpha^i + \rho^i \eta^\star) b'(c^{h\star})} - 1 \tag{61}$$

and from equation (23),

$$s^i = p^h c^{h\star} + p^u (1 + \tau^\star) c^{u\star} - w^i \tag{62}$$

with:

$$A = (\beta^1\alpha^2 - \alpha^1\beta^2) d'(c^{u\star}) \times b'(c^{h\star}) + (\beta^1 - \beta^2) d'(c^{u\star}) \times u'(c^{h\star}) + (\alpha^1 - \alpha^2) v'(c^{u\star}) \times b'(c^{h\star}) \gtrless 0$$

and

$$B = (\rho^2 - \rho^1)\left[v'(c^{u\star}) \times b'(c^{h\star}) + d'(c^{u\star}) \times u'(c^{h\star})\right] + \left[\rho^2(\alpha^1 - \beta^1) - \rho^1(\alpha^2 - \beta^2)\right] d'(c^{u\star}) \times b'(c^{h\star}) \gtrless 0$$

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$$\frac{\partial \eta^\star}{\partial \alpha^1} = \frac{(-\beta^2 d'b' + v'b')B - \rho^2 d'b'A}{B^2} \gtreqless 0 \tag{63}$$

$$\frac{\partial \eta^\star}{\partial \beta^1} = \frac{(\alpha^2 d'b' + d'u')B + \rho^2 d'b'A}{B^2} \gtreqless 0 \tag{64}$$

$$\frac{\partial \eta^\star}{\partial \alpha^2} = \frac{(\beta^1 d'b' - v'b')B + \rho^1 d'b'A}{B^2} \gtreqless 0 \tag{65}$$

$$\frac{\partial \eta^\star}{\partial \beta^2} = \frac{(-\alpha^1 d'b' - d'u')B - \rho^1 d'b'A}{B^2} \gtreqless 0 \tag{66}$$

The sign of the optimal nudge as well as the effects of perception parameters on the nudge are ambiguous when we release assumption A2. Therefore, both the sign of the optimal nudge and the effects of perception parameters on the nudge cannot be accurately analyzed without our additional assumption A2 on the perception parameters.