Inciting Family Healthy Eating: Taxation or Nudging?

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Abstract

This paper examines the effectiveness of public policies aimed at promoting healthy eating within the home environment to prevent diet-related health diseases that could be the consequences of childhood obesity or overweight. We theoretically study the effectiveness of standard policies such as taxation of unhealthy good and the use of nudge in a framework where parents have misperceptions about the effects of food consumption on their children's future health. We find that due to parents' misperception of the long-term consequences of their consumption patterns on their children's future health, the individual choice solution is nonoptimal. We show that a simple policy of taxing the consumption of unhealthy good is only second-best. We also find that nudge does not guarantee the possibility of reaching the first-best optimum. Moreover, we find that the mixed policy allows the tax to be set at its lowest level to achieve at least the socially optimal levels of healthy and unhealthy family consumption.

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Introduction

Food consumption patterns can negatively affect people's health when they engage in unhealthy eating behaviors. Diseases related to unhealthy diet, such as diabetes, that could be the consequences of obesity and overweight have reached epidemic proportions worldwide (James [2004]; Low et al. [2009]; Lovic et al. [2020]). According to the World Health Organization [2009][1], unhealthy diet is related to high blood pressure, high blood glucose, overweight and obesity, which are very high risks of mortality worldwide. There is also evidence suggesting 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 noncommunicable diseases such as type 2 diabetes (Wang et al. [2005]), hypertension (Nurdiantami et al. [2018]), coronary heart disease (Mora Samia et al. [2005]), cardiovascular disease (Shields et al. [2012]; Umer et al. [2017]), and certain types of cancers (Calle et al. [2003]; Calle and Thun [2004]; Vucenik and Stains [2012]). 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 issue for public decision-makers.

Food products consumed by children most often come either from the school environment (the school canteen) or from the family environment. The implementation of nutritional policies aimed at improving 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 Nutri-Score, that aim to improve diets within the home environment. These interventions mostly target parents who are primarily responsible for food choices in the family.

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 sugar-sweetened beverage tax debate: imperfect information and the lack of self-control. Levels of parental nutritional knowledge may also

[1] World Health Organization (Ed.), 2009. Global health risks: mortality and burden of disease attributable to selected major risks. World Health Organization, Geneva, Switzerland.

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 behavioral biases support the need for public policy interventions to reduce diet-related disease.

Although we observe an increasing effort to prevent health problems related to unbalanced diets in children and a growing literature in the study of children's eating habits, little is known about the type of public intervention that is most suitable for promoting healthy eating within the home environment.

The purpose of this paper relates to the study of the effectiveness of public policies aimed at promoting healthy eating within the home environment. Specifically, we theoretically study the effectiveness of standard policies such as taxation of unhealthy food and of a policy based on the use of nudge in a framework where parents have misperceptions about the effects of food on their children's future health.

In this paper, we focus on the case where the intervention of the public decision-maker is justified by an insufficient level of nutritional knowledge of individuals. Otherwise, we assume that individuals do not have enough nutritional knowledge to establish an accurate link between food consumption patterns and their effects 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 home environment, taxing unhealthy foods 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. However, the effectiveness of these taxation policies in slowing the rise of obesity has been questioned.

According to a study published by "Santé Publique France", in France in 2015, 21% of children aged 6 to 17 were overweight or obese. Even though the government had already implemented the soda tax in 2012 to improve the diet of French people. 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 very small reduction in purchases to the fact that the amount of the tax was very small. However, this amount cannot exceed a certain threshold. Indeed, the tax increases the price of unhealthy good and, in addition to reducing the unhealthy good consumption of the child, it also distorts the parent's unhealthy good consumption, which is not associated with an externality. Therefore, these opposite effects of the tax make it no longer the first-best. Kalamov and Runkel [2020] have shown that a tax on unhealthy food may underinternalize or overinternalize the marginal damage to intergenerational externalities.

Another tool also used to improve the quality of families' diets is the nudge. Nudging, or "libertarian paternalism" is a technique to encourage individuals or a whole human group to change certain behaviors or to make certain choices without being under constraint or obligation and which does not involve any sanction. Sunstein and Thaler [2008] coined the term in their book "*Nudge: Improving Decisions about Health, Wealth, and Happiness*". The problem that may justify the use of nudging is that people sometimes make decisions that are bad for them, 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 choices and their consequences are separated in time, which is the case in our model.

Parents could have misperceptions about the effects of food on their children's future health. Specifically, the effects of diet on children's future health perceived by parents could be smaller than the effective effects of diet on children's future health. For example, in studying the impact of food risk perception on fish consumption behavior in five European countries, Pieniak et al. [2008] find that consumers in general perceive a rather low risk of food poisoning from eating fish across the countries.

We obtain tree main results. First, we show that the decentralized solution of taxing the consumption of unhealthy good and redistributing the tax proceeds in the form of transfers is only a second-best optimum. Second, we find that the nudge allows for an improvement in the nutritional quality of families' diets but does not guarantee the possibility of reaching the first-best optimum. Third, we find that the mixed policy allows the tax to be set at its lowest level to achieve at least the socially optimal levels of healthy and unhealthy family consumption. In doing so, we contribute to the literature on policies aimed at improving children's diets by identifying a type of policy that could be considered as the most suitable to promote healthy eating within the home environment.

The remainder of the paper is organized as follows. Section 1 describes the model and provides the results of the individual choice. The social optimum is specified in Section 2. Section 3 is devoted to the implementation of the social optimum with non-economic instruments. Section 4 concludes.

1 The Model

We consider an economy composed of two types of family that differ in their nutritional knowledge: family of type 1 have a better nutritional knowledge than family of type 2. Both types of family have the same income denoted by w. The 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, high fat or sugar good, 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 consumption of unhealthy good in childhood has negative health effects (cause obesity or overweight) that appear in adulthood. One question would be whether the effects of consumption could appear during childhood instead. However, this possibility is not a limitation of our hypothesis since empirical studies have shown that most obese children remain obese in adulthood as well (Hughes et al. [2011]; Srinivasan et al. [1996]; Must and Strauss [1999]). Simmonds et al. [2016] found that the association between childhood obesity and adult obesity was strong. According to them, obese children and adolescents were about five times more likely to be obese in adulthood than those who were not obese and, about 55% of obese children become obese in adolescence and about 80% of obese adolescents remain obese in adulthood. These results 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 parents and then, c^{hi} denotes family healthy consumption and c^{ui} denotes family unhealthy consumption, when parents and children live together[2].

We model our utility function closely to that proposed by Cremer et al. [2016]. However, we use the probability of being in good health during adulthood instead of their health harm function. We also consider both the health benefits of healthy consumption and the health harms of unhealthy consumption on the probability of being in good health during adulthood.

[2] All decisions are taken at the same period t, so we can ignore the time index in the paper

1.1 Health risks

We assume that the effects of childhood consumption on health appear later in adulthood and may affect an individual's health. Specifically, we suppose that the children's probability of being in good health, when they are old are endogenous and depend on the childhood consumption. Indeed, in the long run, higher consumption of unhealthy good (fat good) may cause overweight or obesity which usually comes with health problems. These negative effects of unhealthy consumption are captured by the probability function of being in good health during adulthood, $\psi = \psi(c^{ui}, c^{hi})$ with $\psi'_u < 0$, $\psi'_h > 0$ and $\psi''_{uh} = 0$ [3]. In the short run, parents may ignore part of these negative long-run effects of unhealthy consumption. Their perceived probability function of being in good health during adulthood is $\psi^i = \psi^i(c^{ui}, c^{hi})$. We assume that parents are altruistic and derive utility from their child's future health but have misperceptions about the effects of diet on their child's future health. Indeed, it is now well documented in the food literature that consumers overestimate the quality of their diet (Variyam et al. [2001]), and have a stronger belief in the presence of beneficial than harmful components in their diet (Verbeke et al. [2005]). Parents also make mistakes when making food choices for their children about what they consider healthy foods. For example, parents consider fruit drinks, sports drinks, and sweetened teas as healthier and less likely to cause disease than soda (Moran and Roberto [2018]), and choose for their children large amounts of sugar-sweetened beverages when there is no label on these products (Roberto et al. [2016]). 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 drinks and sports drinks. Kourlaba et al. [2009] also found that 83% of mothers making food choices for their children overestimated the quality of their children's diets.

1.2 Preferences

The utility of a parent i depends on the family consumption of healthy good c^{hi}, unhealthy good c^{ui} and their child's future health defined here as the

[3] We denote by: $\psi'_u = \frac{\partial \psi}{\partial c^u}$, $\psi'_h = \frac{\partial \psi}{\partial c^h}$ and $\psi''_{uh} = \frac{\partial^2 \psi}{\partial c^u \partial c^h} = \frac{\partial^2 \psi}{\partial c^h \partial c^u}$

child's probability of being in good health during adulthood. The satisfaction parents obtain from the family consumption of healthy and unhealthy good is reflected by $u(c^{hi}, c^{ui})$. We suppose that utility of consumption, u, is an increasing and concave function, $u'_h > 0$, $u'_u > 0$, $u''_{hh} < 0$, $u''_{uu} < 0$, and additively separable, $u''_{hu} = 0$[4].

Consumption of healthy and unhealthy goods determines the perceived and effective probability of being in good health during adulthood, ψ^i and ψ respectively. These probabilities are increasing and concave with respect to the family consumption of healthy good, c^{hi}, and, decreasing and convex with respect to the family consumption of unhealthy good, c^{ui}.

Parent i perceived utility is given by:

$$\hat{U}(c^{hi}, c^{ui}) = u(c^{hi}, c^{ui}) + \psi^i(c^{hi}, c^{ui}) \tag{1}$$

where ψ^i is the child's probability of being in good health during adulthood perceived by the parent i. We suppose that the perceived child's probability of being in good health during adulthood, ψ^i, can differ from the true child's probability of being in good health during adulthood, ψ.

We assume that parents have misperceptions about the effects of diet on the child's probability of being in good health during adulthood.

Assumption A1: $\mid \psi'_u \mid > \mid {\psi^1}'_u \mid > \mid {\psi^2}'_u \mid$ and $\psi'_h > {\psi^1}'_h > {\psi^2}'_h$ [5].

This assumption means that marginal health benefits associated to healthy consumption and marginal health costs associated to unhealthy consumption perceived by parents are lower than the effective marginal health effects of diet. And within the population, parent with more nutritional knowledge perceive more marginal health benefits associated to healthy consumption and more marginal health harms associated to unhealthy consumption than parent with less nutritional knowledge. 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]).

[4] We denote by: $u'_h = \frac{\partial u}{\partial c^{hi}}$, $u'_u = \frac{\partial u}{\partial c^{ui}}$, $u''_{hh} = \frac{\partial^2 u}{\partial {c^{hi}}^2}$, $u''_{uu} = \frac{\partial^2 u}{\partial {c^{ui}}^2}$, and $u''_{hu} = \frac{\partial^2 u}{\partial c^{hi} \partial c^{ui}} = \frac{\partial^2 u}{\partial c^{ui} \partial c^{hi}}$

[5] We denote by: ${\psi^i}'_u = \frac{\partial \psi^i}{\partial c^{ui}}$, ${\psi^i}'_h = \frac{\partial \psi^i}{\partial c^{hi}}$, with $i = 1, 2$

1.3 Individual choices

Parents choose family consumption of healthy and unhealthy good by maximizing expected utility (1) subject to their budget constraint:

$$\begin{aligned} \max_{c^{hi}, c^{ui}} \quad & \hat{U}(c^{hi}, c^{ui}) = u(c^{hi}, c^{ui}) + \psi^i(c^{hi}, c^{ui}) \\ s.t. \quad & w = p^u c^{ui} + p^h c^{hi} \quad ; \; i = 1, 2 \end{aligned} \tag{2}$$

with p^u and p^h, the prices of unhealthy and health good respectively. Equivalently, we have:

$$\max_{c^{hi}} \quad \hat{U}(c^{hi}, c^{ui}) = u(c^{hi}, \frac{w - p^h c^{hi}}{p^u}) + \psi^i(c^{hi}, \frac{w - p^h c^{hi}}{p^u}) \tag{3}$$

The first order condition writes[6]

$$\begin{aligned} \hat{U}'_h = \quad & u'_h(c^{hi}, \tfrac{w-p^h c^{hi}}{p^u}) + {\psi^i}'_h(c^{hi}, \tfrac{w-p^h c^{hi}}{p^u}) \\ & - \tfrac{p^h}{p^u}\left[u'_u(c^{hi}, \tfrac{w-p^h c^{hi}}{p^u}) + {\psi^i}'_u(c^{hi}, \tfrac{w-p^h c^{hi}}{p^u})\right] = 0 \end{aligned} \tag{4}$$

Each parent i chooses family consumption levels of healthy and unhealthy good such that the sum of the marginal satisfactions of healthy and unhealthy consumption and the perceived marginal health benefit associated to healthy consumption is equal to the perceived marginal health cost associated to unhealthy consumption.

The level of a type 1 family's consumption of healthy good will be higher than the level of a type 2 family's consumption of healthy good.

Proposition 1 *Family with more nutritional knowledge will consume more healthy good and less unhealthy good than family with less nutritional knowledge.*

Proof. See Appendix 1 ■

This result is consistent with the empirical findings suggesting that there is a positive relationship between children's dietary food intake and their mothers' nutritional knowledge (AL-Shookri et al. [2011]; Vereecken and Maes [2010]).

[6] We assume that the second order condition is satisfied (see Appendix 1)

2 Social optimum

We consider a central planner who has no misperceptions about the effects of diet on health and therefore makes decisions based on the effective probability of being in good health during adulthood ψ. We assume an utilitarian social central planner whose welfare function is expressed by the sum of individual utilities.

2.1 First best solution

The program of the utilitarian social central planner writes:

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

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

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

$$u'_h(c^{hi}, c^{ui}) + \psi'_h(c^{hi}, c^{ui}) = \lambda p^h \tag{6}$$

$$u'_u(c^{hi}, c^{ui}) + \psi'_u(c^{hi}, c^{ui}) = \lambda p^u \tag{7}$$

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

The optimal conditions of the central planner are such that all families consume the same level of healthy and unhealthy good with regard to their perceived child's probability of being in good health during adulthood, 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:

$$\begin{aligned} & u'_h(c^{h\star}, c^{u\star}) + \psi'_h(c^{h\star}, c^{u\star}) \\ -\frac{p^h}{p^u} & \left[u'_u(c^{h\star}, c^{u\star}) + \psi'_u(c^{h\star}, c^{u\star}) \right] = 0 \end{aligned} \tag{9}$$

and the budget constraint

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

The central planner chooses the optimal family consumption levels of healthy and unhealthy good such that the sum of the marginal satisfactions of healthy and unhealthy consumption and the effective marginal health benefit associated to healthy consumption is equal to the effective marginal health cost associated to unhealthy consumption (equation 9).

Proposition 2 *Families will consume more unhealthy good than the socially optimal level and less healthy good than the socially optimal level.*

Proof. See Appendix 2 ■

This result reveals that the individual choice solution is nonoptimal. The ineffectiveness 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. They do not completely account for the effect of their family consumption on the future generation through the child's probability of being in good health during adulthood, which justifies the need for public intervention to reduce health inequalities and against diet-related non-communicable diseases.

2.2 Optimal taxation policy

The ineffectiveness of the individual choice solution requires public intervention in order to restore the social optimum. The subsequent question that arises at this stage remains to know how the public decision-maker can implement the social optimum. In this section, we study the case of a policy of taxing the consumption of unhealthy good.

Suppose 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 foods (Ogden et al. [2011]; Best and Papies [2019]; Wang et al. [2010]) and therefore bear the burden of a tax on unhealthy goods. This may explain the fact these types of policies can be regressive. Nevertheless, several authors point out that such a problem is minimized if the revenues of the taxes on unhealthy foods are used in the benefit of the poor (Jacobson and Brownell [2000]; Brownell et al. [2009]). Moreover, there are empirical evidences that suggest that taxation of unhealthy food items is an effective means of reducing consumption of these foods (Epstein et al. [2012]; Block et al. [2010]), and so reducing the prevalence of obesity (Lin et al. [2011]; Hall et al. [2011]). Allcott et al. [2019] suggest that taxing an unhealthy good (soda) is probably a good idea.

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

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

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

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

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

We can rewrite the modified budget constraint of type i parent as follows:

$$c^{ui} = \frac{w + b^i - p^h c^{hi}}{p^u(1+\tau^u)} \tag{13}$$

By inserting the modified budget constraint of a type i parent into its maximization program, we obtain:

$$\max_{c^{hi}} \quad \hat{U}(c^{hi}, c^{ui}) = \quad u(c^{hi}, \frac{w + b^i - p^h c^{hi}}{p^u(1+\tau^u)}) + \psi^i(c^{hi}, \frac{w + b^i - p^h c^{hi}}{p^u(1+\tau^u)}) \tag{14}$$

The individual consumption level of healthy good under the implementation of the tax is then solution of the following first order condition:

$$
\begin{aligned}
&u'_h(c^{hi}, \tfrac{w+b^i-p^h c^{hi}}{p^u(1+\tau^u)}) - \tfrac{p^h}{p^u(1+\tau^u)} u'_u(c^{hi}, \tfrac{w+b^i-p^h c^{hi}}{p^u(1+\tau^u)}) \\
&+\psi^{i\prime}_h(c^{hi}, \tfrac{w+b^i-p^h c^{hi}}{p^u(1+\tau^u)}) - \tfrac{p^h}{p^u(1+\tau^u)} \psi^{i\prime}_u(c^{hi}, \tfrac{w+b^i-p^h c^{hi}}{p^u(1+\tau^u)}) = 0
\end{aligned} \tag{15}
$$

The individual consumption levels of healthy ($c^{hi\star}$) and unhealthy ($c^{ui\star}$) good under the implementation of the tax are implicitly obtained from equation (15) as a function of income w, prices p^h and p^u , tax τ^u, transfers b^i (i.e $c^{hi\star} = c^h(w, p^h, p^u, \tau^u, b^i)$ and $c^{ui\star} = c^u(w, p^h, p^u, \tau^u, b^i)$.

Equation (15) shows that each parent chooses its post-tax levels of healthy and unhealthy family consumption so as to equalize the sum of the marginal utilities of healthy and unhealthy consumption and the perceived marginal health benefit of healthy consumption to the new perceived marginal health cost of unhealthy consumption. The tax reduces the perceived marginal health cost of unhealthy consumption and thus increases the total health cost of unhealthy consumption perceived by a parent.

From equations (9), (10) and (15), we can deduce the tax rate and transfer amount of the decentralized solution.

Proposition 3 *The decentralized solution is only a second-best optimum. The tax rate and transfer amount of the decentralized solution are such that:*

$$
\tau^{u\star} = \frac{p^h}{p^u} \frac{u'_u(c^{h\star}, c^{u\star}) + \psi^{i\prime}_u(c^{h\star}, c^{u\star})}{u'_h(c^{h\star}, c^{u\star}) + \psi^{i\prime}_h(c^{h\star}, c^{u\star})} - 1 \tag{16}
$$

and

$$
b^{\star} = (w - p^h c^{h\star}) \left[\frac{p^h}{p^u} \frac{u'_u(c^{h\star}, c^{u\star}) + \psi^{i\prime}_u(c^{h\star}, c^{u\star})}{u'_h(c^{h\star}, c^{u\star}) + \psi^{i\prime}_h(c^{h\star}, c^{u\star})} - 1 \right] \tag{17}
$$

Proof. See Appendix 3 ■

The tax rate on unhealthy consumption, $\tau^{u\star}$, depends on the ratio of the perceived marginal utility of unhealthy consumption to the perceived marginal utility of healthy consumption and the price ratio. If the perceived marginal utility of unhealthy consumption is greater than the perceived marginal utility of healthy consumption, then the tax rate is positive. The higher the price differential between the healthy and unhealthy goods, the higher the tax rate. However, the tax rate can be negative if the perceived marginal utility of unhealthy consumption is lower than the perceived marginal utility of healthy consumption and the prices of the two types of good are roughly equal.

The level of transfers received by both family types, $b^{\star}$, is equal to the tax rate weighted by the share of income not allocated to the consumption of healthy good.

Given the differences in the perceived effects of food on future health, there are two possible levels of the tax rate. If the central planner sets the tax rate based on the perceived utility of a type 1 parent, then the tax rate will be sufficient to restore socially optimal family consumption for a type 1 family but too low to restore socially optimal family consumption for a type 2 family. On the other hand, if the central planner sets the tax rate based on the perceived utility of a type 2 parent, then this tax rate will be sufficient to restore socially optimal family consumptions for a family of type 2 but too high to restore socially optimal family consumptions for a family of type 1. If the central planner's goal is to achieve at least the socially optimal levels of healthy and unhealthy consumption, then the tax will be set at its highest level. In this case, the healthy and unhealthy consumption levels of the type 2 family will be socially optimal but the type 1 family will consume too much healthy good and less unhealthy good compared to the social optimum. The need for trade-off in setting the tax rate makes the decentralized solution only a second-best optimum.

3 Non-economic instruments

3.1 Nudge

We now study the case where the public decision-maker decides to implement a nudge to reduce parental misperceptions of food risks. The nudge we consider corresponds to information provided by the public authority concerning the effects of food on the child's probability of being in good health in during adulthood. The use of nudge therefore aims to improve individuals' health knowledge, and thus reducing the degree of individuals' misperception about the effects of diet on health. The nudge used in our model can be interpreted as information campaigns about the effects of food on the children's future health for example.

We suppose that the nudge ξ we use modifies the parent i's perceived child's probability of being in good health during adulthood (i.e. ψ^i passes from ψ^i to ψ^i_ξ) with $\mid {\psi^{i}_{\xi}}'_u \mid > \mid {\psi^{i}}'_u \mid$ and ${\psi^{i}_{\xi}}'_h > {\psi^{i}}'_h$[7]. In general, a nudge may also affect the agents' utility (Farhi and Gabaix [2020]). In our model, the nudge reduces the parent i's perceived utility by the unperceived part of the child's probability of being in good health during adulthood (i.e. $\psi - \psi^i_\xi$). The marginal disutility due to the nudge will be all the more important the higher the degree of parental misperception of the child's probability of being in good health during adulthood.

Following Farhi and Gabaix [2020], we suppose that the change in an agent's perceived utility due to the introduction of the nudge depends on his nudgeability.

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

$$\hat{U}(c^{hi}, c^{ui}) = u(c^{hi}, c^{ui}) + \psi^i_\xi(c^{hi}, c^{ui}) - \rho^i \left[\psi(c^{hi}, c^{ui}) - \psi^i_\xi(c^{hi}, c^{ui})\right] \quad (18)$$

where $\rho^i \geq 0$ captures the nudgeability of the agent i ; $\rho^i = 0$ corresponds to a non-nudgeable agent. Moreover, the higher the nudgeability (ρ^i) of an agent, the higher the sensitivity of its perceived child's probability of being in good health during adulthood to a variation in consumption levels.

Under the implementation of nudge, parents choose family consumption of healthy and unhealthy good by maximizing expected utility (18) subject to their budget constraint, i.e.

$$\begin{aligned} \max_{c^{hi}, c^{ui}} \quad & \hat{U}(c^{hi}, c^{ui}) = u(c^{hi}, c^{ui}) + \psi^i_\xi(c^{hi}, c^{ui}) - \rho^i \left[\psi(c^{hi}, c^{ui}) - \psi^i_\xi(c^{hi}, c^{ui})\right] \quad (19) \\ s.t. \quad & w = p^u c^{ui} + p^h c^{hi} \quad ; \ i = 1, 2 \end{aligned}$$

Equivalently, we have:

$$\begin{aligned} \max_{c^{hi}} \quad \hat{U}(c^{ui}, c^{hi}) = \quad & u(c^{hi}, \frac{w - p^h c^{hi}}{p^u}) + \psi^i_\xi(c^{hi}, \frac{w - p^h c^{hi}}{p^u}) \\ & -\rho^i \left[\psi(c^{hi}, \frac{w - p^h c^{hi}}{p^u}) - \psi^i_\xi(c^{hi}, \frac{w - p^h c^{hi}}{p^u})\right] \quad (20) \end{aligned}$$

[7]We denote by: ${\psi^{i}_{\xi}}'_u = \frac{\partial \psi^i_\xi}{\partial c^{ui}}$, ${\psi^{i}_{\xi}}'_h = \frac{\partial \psi^i_\xi}{\partial c^{hi}}$, with $i = 1, 2$

The individual consumption level of healthy good under the implementation of the nudge satifies the following first order condition:

$$\begin{aligned}\Big[u'_h(c^{hi},\tfrac{w-p^hc^{hi}}{p^u})+\psi^{i\,\prime}_{\xi_h}(c^{hi},\tfrac{w-p^hc^{hi}}{p^u})\Big]-\tfrac{p^h}{p^u}\Big[u'_u(c^{hi},\tfrac{w-p^hc^{hi}}{p^u})+\psi^{i\,\prime}_{\xi_u}(c^{hi},\tfrac{w-p^hc^{hi}}{p^u})\Big]\\ -\rho^i\Big[\psi'_h(c^{hi},\tfrac{w-p^hc^{hi}}{p^u})-\psi^{i\,\prime}_{\xi_h}(c^{hi},\tfrac{w-p^hc^{hi}}{p^u})\Big]\\ +\rho^i\tfrac{p^h}{p^u}\Big[\psi'_u(c^{hi},\tfrac{w-p^hc^{hi}}{p^u})-\psi^{i\,\prime}_{\xi_u}(c^{hi},\tfrac{w-p^hc^{hi}}{p^u})\Big]=0 \qquad (21)\end{aligned}$$

The individual consumption levels of healthy ($c^{hi\star}$) and unhealthy ($c^{ui\star}$) good under the implementation of nudge are implicitly obtained from equation (21) as a function of income w, prices p^h and p^u.

The first term of equation (21) represents the marginal utility of healthy consumption. The second term represents the marginal utility of unhealthy consumption. The third term measures the health benefit lost due to the gap between the perceived and effective child's probability of being in good health during adulthood. The last term represents the additional health cost associated to the gap between the perceived and effective child's probability of being in good health during adulthood.

Proposition 4 *The nudge allows for an improvement in the nutritional quality of families' diets but does not guarantee the possibility of reaching the first-best optimum.*

Proof. See Appendix 4 ■

If the correction of parental misperceptions of the effects of food on future health due to the implementation of nudge is quite high, the levels of healthy and unhealthy good consumption of each family are closer to the social optimum with the implementation of nudge than without nudge. But nudge only achieves socially optimal consumption levels if and only if individuals have a very high awareness of nudge. In other words, when nudge raises the health effects of food perceived by parents to the effective health effects of food.

3.2 Mixed policy : taxation and nudge

We now turn to the case of a mixed policy of supporting the tax with a nudge. We study the case of a simultaneous use of tax on the consumption of unhealthy good and the implementation of nudge. Indeed, we have previously shown that the tax rate that achieves at least the socially optimal levels of healthy and unhealthy family consumption is very high, and the implementation of nudge does not guarantee the possibility of achieving the social optimum either. The interest of studying the case of the mixed policy is to examine whether nudge can be used as an instrument to support the tax policy in order to reduce the tax rate that allows to reach at least the socially optimal levels of healthy and unhealthy family consumption.

Let us consider the decentralized problem with a tax τ^u on the consumption of unhealthy good. A fraction of the tax revenues is redistributed to families as a transfer b^i and the remainder is used to finance the implementation of the nudge (information campaigns) aiming to improve health knowledge, and thus reducing the degree of individuals' misperception about the effects of diet on health.

Under the implementation of the taxe and nudge, parent i's total expected utility is given by (18). Parents choose family consumption of healthy and unhealthy good by maximizing expected utility (18) subject to their budget constraint, i.e.

$$\begin{aligned} \max_{c^{hi},c^{ui}} \quad & \hat{U}(c^{hi},c^{ui}) = u(c^{hi},c^{ui}) + \psi^i_\xi(c^{hi},c^{ui}) - \rho^i\left[\psi(c^{hi},c^{ui}) - \psi^i_\xi(c^{hi},c^{ui})\right] \quad (22) \\ s.t. \quad & w + b^i = p^u(1+\tau^u)c^{ui} + p^h c^{hi} \quad ; \ i = 1,2 \end{aligned}$$

Equivalently, we have:

$$\begin{aligned} \max_{c^{hi}} \quad \hat{U}(c^{ui},c^{hi}) = \quad & u(c^{hi}, \frac{w + b^i - p^h c^{hi}}{p^u(1+\tau^u)}) + \psi^i_\xi(c^{hi}, \frac{w + b^i - p^h c^{hi}}{p^u(1+\tau^u)}) \\ & -\rho^i\left[\psi(c^{hi}, \frac{w + b^i - p^h c^{hi}}{p^u(1+\tau^u)}) - \psi^i_\xi(c^{hi}, \frac{w + b^i - p^h c^{hi}}{p^u(1+\tau^u)})\right] \quad (23) \end{aligned}$$

The individual consumption level of healthy good under the implementation of tax and nudge is then solution of the following first order condition:

$$\begin{aligned}&\left[u'_h(c^{hi},\tfrac{w-p^hc^{hi}}{p^u(1+\tau^u)})+\psi^{i\,\prime}_{\xi_h}(c^{hi},\tfrac{w-p^hc^{hi}}{p^u(1+\tau^u)})\right]\\&-\tfrac{p^h}{p^u(1+\tau^u)}\left[u'_u(c^{hi},\tfrac{w-p^hc^{hi}}{p^u(1+\tau^u)})+\psi^{i\,\prime}_{\xi_u}(c^{hi},\tfrac{w-p^hc^{hi}}{p^u(1+\tau^u)})\right]\\&-\rho^i\left[\psi'_h(c^{hi},\tfrac{w-p^hc^{hi}}{p^u(1+\tau^u)})-\psi^{i\,\prime}_{\xi_h}(c^{hi},\tfrac{w-p^hc^{hi}}{p^u(1+\tau^u)})\right]\\&+\rho^i\tfrac{p^h}{p^u(1+\tau^u)}\left[\psi'_u(c^{hi},\tfrac{w-p^hc^{hi}}{p^u(1+\tau^u)})-\psi^{i\,\prime}_{\xi_u}(c^{hi},\tfrac{w-p^hc^{hi}}{p^u(1+\tau^u)})\right]=0\end{aligned} \tag{24}$$

The individual consumption levels of healthy ($c^{hi\star}$) and unhealthy ($c^{ui\star}$) goods under the implementation of tax and nudge are implicitly obtained from equation (24) as a function of income w, prices p^h and p^u , tax τ^u, and transfers b^i, $c^{hi\star}=c^h(w,p^h,p^u,\tau^u,b^i)$ and $c^{ui\star}=c^u(w,p^h,p^u,\tau^u,b^i)$.

From equations (9), (10) and (24), we can deduce the tax rate and transfer amount of the mixed policy.

Proposition 5 *If the correction of parental misperceptions of the effects of food on future health due to the implementation of nudge is quite high, the mixed policy allows the tax rate to be set at a lower level compared to the simple tax policy to achieve at least the healthy and unhealthy family consumption levels. The tax rate and transfer amount of the mixed policy are such that:*

$$\tau_{\xi}^{u\star}=\frac{p^h}{p^u}\frac{u'_u(.)+\psi^{i\,\prime}_{\xi_u}(.)+\rho^i\left[\psi'_u(.)-\psi^{i\,\prime}_{\xi_u}(.)\right]}{u'_h(.)+\psi^{i\,\prime}_{\xi_h}(.)-\rho^i\left[\psi'_h(.)-\psi^{i\,\prime}_{\xi_h}(.)\right]}-1 \tag{25}$$

and

$$b_{\xi}{}^{\star}=\left[\frac{p^h}{p^u}\frac{u'_u(.)+\psi^{i\,\prime}_{\xi_u}(.)+\rho^i\left[\psi'_u(.)-\psi^{i\,\prime}_{\xi_u}(.)\right]}{u'_h(.)+\psi^{i\,\prime}_{\xi_h}(.)-\rho^i\left[\psi'_h(.)-\psi^{i\,\prime}_{\xi_h}(.)\right]}-1\right]\left[w-p^hc^{h\star}\right] \tag{26}$$

Proof. See Appendix 5 ■

The numerator of the mixed policy tax rate value is similar to that found in the decentralized solution to which is added the difference between the effective marginal effect and the perceived marginal effect of unhealthy consumption on the probability of being in good health during adulthood. Similarly, the denominator of the tax rate value of the mixed policy is similar to that of the decentralized solution to which is subtracted the difference between the effective marginal effect and the perceived marginal effect of healthy consumption on the probability of being in good health during adulthood.

If the change in a child's probability of being in good health during adulthood perceived by parents due to the implementation of the nudge is sufficiently large (i.e. $\psi^{i\prime}_{\xi_u} \to \psi'_u$ and $\psi^{i\prime}_{\xi_h} \to \psi'_h$), then supporting the tax with a nudge reduces the tax rate that achieves at least the socially optimal levels of healthy and unhealthy family consumption.

4 Conclusion

This paper theoretically studies the effectiveness of standard policies such as taxation of unhealthy goods and of a policy based on the use of nudge in a framework where parents have misperceptions about the effects of food consumption on their children's future health. The purpose of the paper is to determine which type of policy is more suitable to promote healthy eating within the family environment.

Using a theoretical model in which parents have misperceptions about the effects of food on their children's future health, we find that due to parents' misperception of the long-term consequences of their consumption patterns on their children's future health, the individual choice solution is suboptimal. In other words, families consume more unhealthy good and less healthy good compared to the social optimum.

We have shown that the decentralized solution of taxing the consumption of the unhealthy good and redistributing the tax proceeds in the form of transfers is only a second-best optimum. The tax therefore allows for an improvement in the nutritional quality of families' diets but the tax rate that achieves at least the socially optimal levels of healthy and unhealthy family consumption is very high. We also find that the nudge allows for an improvement in the nutritional quality of families' diets but does not guarantee the possibility of reaching the first-best solution.

Moreover, we find that the mixed policy allows the tax to be set at its lowest level to achieve at least the socially optimal levels of healthy and unhealthy family consumption.

The results of our model suggest that policy-makers should support their policies of taxing unhealthy good consumption with interventions aimed at increasing individuals' nutritional knowledge levels. Nutrition education programs, for example, would be desirable to improve the nutritional quality of families' diets. A further extension may consider differences in income between individuals in addition to their difference in nutritional knowledge. These extensions are left for future research.

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Appendix 1: proof of Proposition 1

We consider that the expected utility function is concave then the following second order condition is satisfied[8]:

$$\begin{aligned}\hat{U}^{i\prime\prime}_{hh} = \quad & u''_{hh} - \frac{p^h}{p^u}u''_{hu} - \frac{p^h}{p^u}u''_{uh} + (\frac{p^h}{p^u})^2 u''_{uu} \\ & + {\psi^{i}}''_{hh} - \frac{p^h}{p^u}{\psi^{i}}''_{hu} - \frac{p^h}{p^u}{\psi^{i}}''_{uh} + (\frac{p^h}{p^u})^2 {\psi^{i}}''_{uu} < 0 \end{aligned} \tag{27}$$

With $u''_{hu} = u''_{uh} = {\psi^{i}}''_{hu} = {\psi^{i}}''_{uh} = 0$, we obtain:

$$\hat{U}^{i\prime\prime}_{hh} = \quad u''_{hh} + {\psi^{i}}''_{hh} + (\frac{p^h}{p^u})^2 \left[u''_{uu} + {\psi^{i}}''_{uu}\right] < 0 \tag{28}$$

The individual consumption levels of healthy c^{hi*} and unhealthy c^{ui*} goods of a type i family are therefore implicitly given by equation (4) as a function of income w and prices p^h and p^u.

For a type 1 family, we have:

$$\begin{aligned}\hat{U}^{1\prime}_{h} = \quad & u'_h(c^{h1}, \tfrac{w-p^h c^{h1}}{p^u}) + {\psi^{1}}'_h(c^{h1}, \tfrac{w-p^h c^{h1}}{p^u}) \\ & -\tfrac{p^h}{p^u}\left[u'_u(c^{h1}, \tfrac{w-p^h c^{h1}}{p^u}) + {\psi^{1}}'_u(c^{h1}, \tfrac{w-p^h c^{h1}}{p^u})\right] = 0 \end{aligned} \tag{29}$$

For a type 2 family, we have:

$$\begin{aligned}\hat{U}^{2\prime}_{h} = \quad & u'_h(c^{h2}, \tfrac{w-p^h c^{h2}}{p^u}) + {\psi^{2}}'_h(c^{h2}, \tfrac{w-p^h c^{h2}}{p^u}) \\ & -\tfrac{p^h}{p^u}\left[u'_u(c^{h2}, \tfrac{w-p^h c^{h2}}{p^u}) + {\psi^{2}}'_u(c^{h2}, \tfrac{w-p^h c^{h2}}{p^u})\right] = 0 \end{aligned} \tag{30}$$

The difference between the equations (30) and (29) evaluated in $c^{h1\star}$ gives the equation (31) which is negative.

$$\left[{\psi^{2}}'_h(c^{h1\star}) - {\psi^{1}}'_h(c^{h1\star})\right] + \frac{p^h}{p^u}\left[{\psi^{1}}'_u(c^{h1\star}) - {\psi^{2}}'_u(c^{h1\star})\right] < 0 \tag{31}$$

[8]We add the following assumption to guarantee the existence of an interior solution: $\mid u''_{uu} \mid > {\psi^{i}}''_{uu}$.

Equation (30) is therefore negative in $c^{h1\star}$. This means that the level of healthy good consumption that maximizes the utility of type 1 family is higher than the level of healthy good consumption that maximizes the utility of type 2 family.

Appendix 2: proof of Proposition 2

By differentiating in $c^{h\star}$ between equation (4), which gives the individual choices of healthy and unhealthy consumption levels and equation (9), which gives the socially optimal levels of healthy and unhealthy consumption, we get equation (32).

$$u'_h(c^{h\star}) + {\psi^i}'_h(c^{h\star}) - \tfrac{p^h}{p^u}\left[u'_u(c^{h\star}) + {\psi^i}'_u(.)\right] - u'_h(c^{h\star}) - \psi'_h(c^{h\star}) \\ + \tfrac{p^h}{p^u}\left[u'_u(c^{h\star}) + \psi'_u(c^{h\star})\right]$$

$$\Rightarrow \left[{\psi^i}'_h(c^{h\star}) - \psi'_h(c^{h\star})\right] + \frac{p^h}{p^u}\left[\psi'_u(c^{h\star}) - {\psi^i}'_u(c^{h\star})\right] < 0 \tag{32}$$

Equation (32) is negative. This indicates that the socially optimal level of family consumption of healthy good is higher than the level of healthy good consumption of any family.

Appendix 3 : Proof of equation (3)

The social planner's objective is that the post-tax healthy and unhealthy consumption levels (15) to be equal to the healthy and unhealthy consumption levels of the first-best optimum (9). This means: $c^{hi\star}(\tau^u, b^1, b^2) = c^{h\star}$ and $c^{ui\star}(\tau^u, b^1, b^2) = c^{u\star} \quad \forall \;\; i = 1, 2$

Now we know that with the first-best optimum, the healthy and unhealthy consumption levels are the same for both types of families, i.e. $c^{h1\star} = c^{h2\star}$ and $c^{u1\star} = c^{u2\star}$.

$$c^{u1\star} = c^{u\star} \Leftrightarrow \frac{w + b^1}{p^u(1+\tau^u)} - \frac{p^h c^{h\star}}{p^u(1+\tau^u)} = \frac{w}{p^u} - \frac{p^h c^{h\star}}{p^u}$$

$$\Rightarrow w - p^h c^{h\star} + b^1 = (w - p^h c^{h\star})(1+\tau^u)$$

$$\Rightarrow \tau^u = \frac{b^1}{w - p^h c^{h\star}} \tag{33}$$

Analogously, $c^{u2\star} = c^{u\star}$ gives:

$$\tau^u = \frac{b^2}{w - p^h c^{h\star}} \tag{34}$$

From equations (33) and (34) we obtain $b^1 = b^2 = b$. The amount of transfers will be the same for both types of families.

Replacing τ^u with its value in equation (15) gives:

$$u'_h(c^{h\star}, c^{u\star}) + {\psi^i}'_h(c^{h\star}, c^{u\star}) - \frac{p^h}{p^u(1 + \frac{b}{w - p^h c^{h\star}})} \left[u'_u(c^{h\star}, c^{u\star}) + {\psi^i}'_u(c^{h\star}, c^{u\star})\right] = 0$$

$$\Rightarrow \frac{p^h}{p^u(1 + \frac{b}{w - p^h c^{h\star}})} = \frac{u'_h(c^{h\star}, c^{u\star}) + {\psi^i}'_h(c^{h\star}, c^{u\star})}{u'_u(c^{h\star}, c^{u\star}) + {\psi^i}'_u(c^{h\star}, c^{u\star})}$$

$$\Rightarrow \frac{b}{w - p^h c^{h\star}} = \frac{p^h}{p^u} \frac{u'_u(c^{h\star}, c^{u\star}) + {\psi^i}'_u(c^{h\star}, c^{u\star})}{u'_h(c^{h\star}, c^{u\star}) + {\psi^i}'_h(c^{h\star}, c^{u\star})} - 1$$

$$\Rightarrow b^\star = (w - p^h c^{h\star}) \left[\frac{p^h}{p^u} \frac{u'_u(c^{h\star}, c^{u\star}) + {\psi^i}'_u(c^{h\star}, c^{u\star})}{u'_h(c^{h\star}, c^{u\star}) + {\psi^i}'_h(c^{h\star}, c^{u\star})} - 1\right] \tag{35}$$

and

$$\tau^{u\star} = \frac{p^h}{p^u} \frac{u'_u(c^{h\star}, c^{u\star}) + {\psi^i}'_u(c^{h\star}, c^{u\star})}{u'_h(c^{h\star}, c^{u\star}) + {\psi^i}'_h(c^{h\star}, c^{u\star})} - 1 \tag{36}$$

Appendix 4: proof of Proposition 4

Differentiating between equations (9),which gives the socially optimal levels of healthy and unhealthy consumption, and (21),which gives the individual choices of healthy and unhealthy consumption levels under the implementation of nudge, at the level of healthy good consumption $c^{h\star}$ that cancels equation (9), we obtain equation (37).

$$u'_h(c^{h\star}) + \psi'_h(c^{h\star}) - \tfrac{p^h}{p^u}\left[u'_u(c^{h\star}) + \psi'_u(c^{h\star})\right] - \left[u'_h(c^{h\star}) + \psi^{i\prime}_{\xi_h}(c^{h\star})\right]$$
$$+\tfrac{p^h}{p^u}\left[u'_u(c^{h\star}) + \psi^{i\prime}_{\xi_u}(c^{h\star})\right] + \rho^i\left[\psi'_h(c^{h\star}) - \psi^{i\prime}_{\xi_h}(c^{h\star})\right] -$$
$$\rho^i\tfrac{p^h}{p^u}\left[\psi'_u(c^{h\star}) - \psi^{i\prime}_{\xi_u}(c^{h\star})\right]$$

$$\Rightarrow \quad (1+\rho^i)\left[\psi'_h(c^{h\star}) - \psi^{i\prime}_{\xi_h}(c^{h\star})\right] + (1+\rho^i)\frac{p^h}{p^u}\left[\psi^{i\prime}_{\xi_h}(c^{h\star}) - \psi'_u(c^{h\star})\right] \geq 0 \qquad (37)$$

Equation (37) shows that nudge brings healthy and unhealthy consumption levels as close as possible to their socially optimal levels. If the change in a child's probability of being in good health during adulthood perceived by parents due to the implementation of the nudge is sufficiently large (i.e. $\psi^{i\prime}_{\xi_h} \rightarrow \psi'_h$ and $\psi^{i\prime}_{\xi_u} \rightarrow \psi'_u$), then, the nudge allows to reach the first-best optimum.

Differentiating between equations (4), which gives the individual choices of healthy and unhealthy consumption levels, and equation (21), which gives the individual choices of healthy and unhealthy consumption levels under the implementation of nudge, at the level of healthy good consumption $c^{h\star}$ that cancels equation (4), we obtain equation (38).

$$(1+\rho^i)\left[{\psi^i}'_h(c^{h\star}) - \psi^{i\prime}_{\xi_h}(c^{h\star})\right] + (1+\rho^i)\frac{p^h}{p^u}\left[\psi^{i\prime}_{\xi_h}(c^{h\star}) - {\psi^i}'_u(c^{h\star})\right] \leq 0 \qquad (38)$$

Equation (38) shows that the levels of healthy and unhealthy family consumption achieved with the implementation of the nudge are higher than the levels of healthy and unhealthy family consumption achieved without nudge. The nudge therefore allows for an improvement in the nutritional quality of the families' diets.

Appendix 5: proof of Proposition 5

The social planner's objective is that the healthy and unhealthy consumption levels of equation (24) to be equal to the healthy and unhealthy consumption levels of the first-best optimum (equation 9). This means: $c^{hi\star}(\tau^u, b^1, b^2) = c^{h\star}$ and $c^{ui\star}(\tau^u, b^1, b^2) = c^{u\star} \quad \forall \quad i = 1, 2$

Now we know that with the first-best optimum, the healthy and unhealthy consumption levels are the same for both types of families, i.e. $c^{h1\star} = c^{h2\star}$ and $c^{u1\star} = c^{u2\star}$.

$$c^{u1\star} = c^{u\star} \Leftrightarrow \frac{w + b^1}{p^u(1+\tau^u)} - \frac{p^h c^{h\star}}{p^u(1+\tau^u)} = \frac{w}{p^u} - \frac{p^h c^{h\star}}{p^u}$$

$$\Rightarrow w - p^h c^{h\star} + b^1 = (w - p^h c^{h\star})(1+\tau^u)$$

$$\Rightarrow \tau^u = \frac{b^1}{w - p^h c^{h\star}} \tag{39}$$

Analogously, $c^{u2\star} = c^{u\star}$ gives:

$$\tau^u = \frac{b^2}{w - p^h c^{h\star}} \tag{40}$$

From equations (39) and (40) we obtain $b^1 = b^2 = b$. The amount of transfers will be the same for both types of families.

Replacing τ^u with its value in equation (24) gives:

$$u'_h(.) + \psi^{i\,\prime}_{\xi_h}(.) - \rho^i \left[\psi'_h(.) - \psi^{i\,\prime}_{\xi_h}(.)\right]$$
$$- \frac{p^h}{p^u(1+\frac{b}{w-p^h c^{h\star}})} \left[u'_u(.) + \psi^{i\,\prime}_{\xi_u}(.) - \rho^i \left[\psi^{i\,\prime}_{\xi_u}(.) - \psi'_u(.)\right]\right] = 0$$

$$\Rightarrow b^\star_\xi = \left[\frac{p^h}{p^u} \frac{u'_u(.) + \psi^{i\,\prime}_{\xi_u}(.) - \rho^i \left[\psi^{i\,\prime}_{\xi_u}(.) - \psi'_u(.)\right]}{u'_h(.) + \psi^{i\,\prime}_{\xi_h}(.) - \rho^i \left[\psi'_h(.) - \psi^{i\,\prime}_{\xi_h}(.)\right]} - 1\right] \left[w - p^h c^{h\star}\right] \tag{41}$$

and

$$\Rightarrow \tau^{u\star}_\xi = \frac{p^h}{p^u} \frac{u'_u(.) + \psi^{i\,\prime}_{\xi_u}(.) - \rho^i \left[\psi^{i\,\prime}_{\xi_u}(.) - \psi'_u(.)\right]}{u'_h(.) + \psi^{i\,\prime}_{\xi_h}(.) - \rho^i \left[\psi'_h(.) - \psi^{i\,\prime}_{\xi_h}(.)\right]} - 1 \tag{42}$$