Cash Incentives and Unhealthy Food Consumption*

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Abstract

This paper studies the effectiveness of taxes, subsidies and cash incentives in reducing unhealthy food consumption. Using an inter-temporal rational choice model with habit, we calibrate and simulate the effect of those policies to US and UK data. Our findings suggest that cash incentives may be the most effective policy in reducing unhealthy food consumption. However, when comparing the reduction in costs for the social security system with the implementation costs, cash incentives can lead to significant monetary losses. Taxes are relatively ineffective in reducing unhealthy food consumption. Finally, subsidies have the best balance between effectiveness and monetary benefits to society.

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1 Introduction

Worldwide obesity has more than doubled since 1980 due to the increased intake of energy-dense foods with high levels of fat, salt and sugars with low fibre and vitamins, and a decrease in physical activity (World Health Organization (WHO)). In the US, 68% of the population over twenty years old was overweight or obese during 2007-2008.[1] In the UK, 57% of the population over sixteen years old was overweight or obese in 2008.

Overweight and obesity represent an economic problem for governments because they can cause negative externalities in terms of higher cost for the social security system. In the US, the obesity-attributable medical expenditures were 9.1% of total annual medical expenditures in 1998, and approximately *one-half* of these expenditures were financed by Medicare and Medicaid (Finkelstein et al. (2003)).[2] Most recently, Cawley and Meyerhoefer (2012) estimate that 20.6% of US national health expenditures are spent treating obesity-related illness. In the UK, the overweight and obesity attributable medical expenditures were 16.2% of the total costs for the National Health Service (NHS) in 2006-07 (Scarborough et al. (2011)).

In order to reduce overweight and obesity, governments have responded with a variety of interventions, including traditional public policies like product taxes (e.g. tax on sugary beverages), and educational and informational programmes (e.g. promoting the advertisement of the health consequences associated with unhealthy food consumption and adding nutritional intake information to food packages). The US has announced new rules for school meals in order to reduce childhood obesity; subsiding healthy meals (e.g. fruits and vegetables).[3] Some European countries, like Romania, Hungary and France, are promoting taxes on unhealthy foods.[4] In addition to taxes and subsidies, currently there is a discussion on the use of cash incentives to promote healthy behaviour both in the US (e.g. Volpp et al. (2008)) and UK.[5] This discussion has been motivated by some examples where local incentive schemes had been piloted, including people receiving cash for losing agreed amounts of weight, and children being rewarded with toys in exchange for eating more fruits and vegetables.

This paper aims to address the following questions: are taxes, subsidies and cash incentives effective to reduce unhealthy food consumption? If so, which one is the most appropriate policy to tackle the obesity problem? To answer these questions, we use a model where

[1]According to the WHO, a person is overweight when his Body Mass Index ($BMI = Kg/m^2$) is greater or equal to 25 and obese when his BMI is greater or equal to 30.

[2]Medicare is a social health insurance program for those aged 65 and over (or who meet other special criteria) and Medicaid is a social health insurance program for those eligible individuals with low incomes. Both of these programs are administered by the US government.

[3]The New York Times, January 25, 2012.

[4]See, for instance, BBC News October 01, 2011, www.bbc.co.uk/news/world-europe-15137948.

[5]NICE Citizens Council meeting, May 20-22, 2010, www.nice.org.uk.

consumers face an inter-temporal decision problem on the healthiness of the diet to follow. Consumers have a trade-off between present and future utility: choosing an unhealthy diet has the advantage that it is less expensive and more convenient than the healthy alternative; however, whilst the healthy diet has no long term consequences in future utility, the unhealthy diet decreases future utility as it causes the agent to be less healthy. We also consider the existence of habit: the marginal utility from eating either healthy or unhealthy food at any point in time depends on the consumer's past diet.

We study the effects of three different policies on the level of unhealthy food consumption within the population: a *tax* on unhealthy food, a *subsidy* to healthy food and *cash incentives* in the form of a monetary reward to those consumers who decrease their unhealthy food intake. We use a calibration approach to simulate the effect of these three policies in the US and UK.

Our results suggest that cash incentives may be the most effective policy to tackle the obesity problem as it ensures a greater reduction in the number of people with unhealthy diets. Given the discount factor and the presence of habit, most consumers' behaviour depends on their initial diets. Hence, since most consumers initially choose unhealthy diets (probably because of a failure to anticipate the long term negative effects on utility), motivating healthy food consumption via cash incentives has a significant negative effect on the aggregate level of unhealthy food consumption. Taxes in the form of a 10% value added tax are the least effective policy in reducing unhealthy food consumption. Subsidies in the form of a 10% value subsidy, on the other hand, are relatively effective in reducing unhealthy food consumption. This is because of the differences in prices between healthy and unhealthy food; given the low cost of unhealthy food, a percentage tax on unhealthy food has only a small effect on the relative price difference between the two types of food whilst the same percentage applied as a subsidy to healthy food has a much greater effect.

The comparison of the monetary benefits due to the reduction in costs for the social security system and the implementation costs of each policy suggest that cash incentives have very low net benefits (in most cases incentives have negative long term benefits). Thus, cash incentives as a desirable policy depends partly on the social, non-monetary, benefits of having a healthier population. Subsidies, on the other hand, can lead to a significant surplus considering the savings they cause in the long term to the social security system.

The remainder of the paper is organised as follows. Next we present the related literature. We describe the model in Section 2 and in Section 3 we calibrate the model and simulate the effect of the different policies on the level of unhealthy food consumption in a population. Finally, Section 4 concludes.

1.1 Related literature

Although there is an increasing literature studying the effect of particular policies on food choices and body weight, only few papers tried to analyse the effectiveness of different government policies targeting consumers' diets. Some papers focus on the effect of educational information on food choices and body weight. Variyam and Cawley (2006) show that the Nutrition Labeling and the Education Act caused a decrease in body weight and the probability of begin obese among non-Hispanic white women in US. Acs and Lyles (2007) suggest that providing calorie information to individuals may only have small effects on food choices. Downs et al. (2009) goes further in this line by suggesting that providing calorie information may produce perverse effects such as promoting higher calorie consumption among dieters. Other papers focus on taxes and subsidies: Cash et al. (2006) argue that subsidies to fruits and vegetables (thin subsidies) encourages the consumption of healthier foods. Richards et al. (2007) suggest that price-based policies, sin taxes, or product subsidies that change the expected future costs and benefits of consuming carbohydrate-intensive food can be effective in controlling excessive nutrient intake. Schroeter et al. (2008) argue that a small subsidy on diet soft drinks would be less weight-decreasing than a tax on caloric soft drinks. Yaniv et al. (2009) use a food-intake rational choice model to address the effect of a tax on junk food and a subsidy on healthy meals and show that a fat tax will reduce (increase) obesity for a non-weight-conscious (weight-conscious) individual, while a thin subsidy may increase obesity for a non-weight-conscious individual. Fletcher et al. (2010) show that soft drink taxation, as currently practiced in the US, leads to moderate reduction in soft drink consumption by children and adolescents. However, according to their study the reduction in soda consumption is completely offset by increases in consumption of other high-calorie drinks. Wansink et al. (2014) provide field experiment evidence that a 10% tax on soft drinks results in small reductions in sales of soft drinks in the first month, but there is no detectable change in such sales after 3 months or 6 months.

Volpp et al. (2008) argue that financial incentives can be effective in inducing initial weight loss. The authors show in an experiment that a group of obese people lost weight after 16 weeks when given financial incentives. Nevertheless, substantial amounts of weight were gained between the end of the weight loss phase and the follow-up three months later. Finally, there is evidence from field experiments showing that individual incentives can improve healthy consumption choices among children. Non-monetary incentives increase the choice of fruits in comparison to cookies (List and Samek (2015a)) and the selection of white milk relative to chocolate milk (List and Samek (2015b)) in the school lunchroom. Just and Price (2013) provide evidence that small cash rewards have a larger effect that cash-equivalent prizes in increasing fruit and vegetable consumption during school lunch. Similarly to previous studies in the US, Belot et al. (2014) find that incentive schemes have a positive effect on the consumption of fruit and vegetables in primary schools in England.

Our theoretical model builds on Becker and Murphy (1988) but focuses on the unhealthy food consumption problem instead of any general addictive behaviour. Our model is a simplification of BM's model where the main difference is that in our model time is discrete which allows us to obtain a more realistic calibration and interpretation of the model.

2 The Model

We start with individual behaviour by considering the inter-temporal decision problem of a single consumer. Time is discrete and denoted by $t = 0, 1, 2, \ldots$ Food can be of two types: healthy and unhealthy. We consider that unhealthy food is any food that would cause the consumer to become overweight given her life-style. Unhealthy food includes food that is high in fat, salt and sugar, and low in fibre and vitamins. Healthy food, on the other hand, includes food that is low in fat, salt and sugar, and high in fibre and vitamins. We assume that the total amount of food the consumer purchases at any given period is normalised to one. The decision of the consumer at any given point in time is how much of unhealthy food $x \in [0, 1]$ to purchase. Denote by x^t the value of x at time t. Thus, $1 - x^t$ is the intake of healthy food in period t. We refer to a *diet* as the value of x. When comparing two diets, we say that a certain diet is *healthier* than another one if its amount of the unhealthy food x is lower.[6]

To model the long term effects of the different diets, we assume that although both unhealthy and healthy food are equally useful in feeding the consumer, they differ in that the unhealthy food has a negative health effect in the future. The healthy food, on the other hand, has no long term consequences.[7] Even though unhealthy food has a negative effect in the future, it may be attractive because it is more convenient than the alternative, healthy food: unhealthy food may be cheaper in monetary terms (see, for instance, Monsivais (2010)), or takes less time to cook (pre-cooked meals instead of meals cooked at home), be easier to

[6]Note that instead of explicitly modeling the amount of food consumed and the life-style of the individual we summarise these two elements in the single variable x. The model abstracts food consumption in the following way: the consumer always consumes 1 unit of food, the question is how such unit is distributed between healthy consumption and unhealthy one. Eating healthy is interpreted as eating the right amount of calories of food that is not negative for the health. Eating unhealthy food is interpreted as eating more calories than needed, thus negatively affecting health in the future.

[7]Note that although eating healthy does not negatively affect future health, it does have long-term consequences as it creates a habit for eating healthy. Eating unhealthy has two long-term consequences, it decreases future utility and it creates a habit for eating unhealthy. We introduce the existence of habit formally later on.

find (fast food restaurant versus buying raw ingredients at the supermarket), or easier to dispose of (disposable packaging as opposed to doing the dishes). All these potential effects are introduced in the model by assuming that healthy food is more expensive than unhealthy food.[8]

In the health and medical science literature whether a consumer gains (or loses) weight is determined by what is known as the Energy Balance Equation: weight gain is equal to the difference between energy intake and energy expenditure. Given that empirical evidence for the US suggests that caloric expenditure has not changed significantly since 1980 while calories consumed have risen markedly (Cutler et al. (2003)), in the model the loss of future utility (which could be considered as a weight gain) is associated with an increase in the consumption of unhealthy food relative to healthy food.

Each time period the consumer faces a trade-off: consuming unhealthy food is cheaper than healthy food but it decreases future utility. We recreate this trade-off by following the standard economic modeling approach of endowing the consumer with an utility function. In particular, we assume that the utility function of the consumer at period t is given by

$$u\left(\{x^k\}_0^t, 1-x^t\right) = v\left(D\left(\{x^k\}_0^t, 1-x^t\right)\right) + m - p_x x^t - p_{1-x}(1-x^t)$$

where $\{x^k\}_0^t$ is the sequence of present and past consumption of unhealthy food. The function D is an aggregation of the consumer's present and past diet. We assume D is given recursively by

$$D\left(\{x^k\}_0^t, 1-x^t\right) = \frac{1-\gamma x^t + \gamma D\left(\{x^k\}_0^{t-1}, 1-x^{t-1}\right)}{1+\gamma}.$$

Let $x^0 \in [0,1]$ be the initial consumption of unhealthy food and $D(x^0, 1-x^0) = 1-\gamma x^0$ be the consumer's initial diet.[9] The function D is convenient for two reasons. First, it captures the effect of past consumption of unhealthy food and the current consumption of unhealthy food on current utility: at time t, past consumption of unhealthy food negatively affects current utility through the term $\frac{\gamma}{1+\gamma}D\left(\{x^k\}_0^{t-1}, 1-x^{t-1}\right)$. Second, D is analytically tractable and easy to interpret: if the consumption of unhealthy food has always been x, i.e. $\{x^k\}_0^t = \{x\}_0^t$, then the function D has the simple expression $D\left(\{x^k\}_0^t, 1-x^t\right) = 1-\gamma x$.

[8]Although there are different ways of measuring the cost of food we follow the standard approach which measures the price of food relative to the number of kilocalories.

[9]Note that if a consumer is used to eating healthy food before the policies are implemented then it will be the case that x^0 is small. This means that the consumer at time 1 has high utility from past consumption of food (via D) and the habit of low unhealthy food consumption (via v). Similarly, a consumer that is used to eating unhealthy before the policies are implemented will have a high x^0, which translated in the model into lower utility today and a habit of unhealthy eating.

The function v represents the effects of a certain diet on the consumer's utility. The function v is differentiable with $v' > 0$, $v'' > 0$; hence, there is habit formation: increasing the consumption of unhealthy food in the current period increases the future return of consuming unhealthy food. Similarly, increasing the consumption of healthy food in the current period increases the future return of consuming healthy food. Therefore, if a consumer increases her current consumption of unhealthy food then she is more likely to increase it even more in the future. The effect of a higher consumption of healthy food in the current period on the future consumption of healthy food is analogous.

The parameter $\gamma \in [0,1]$ captures the effects of past consumption of unhealthy food and also the effect of current unhealthy food consumption. The parameter γ represents the characteristics of the consumer in terms of genetics, etc. This means that, for a given amount of unhealthy food consumption, a consumer with a high γ derives less utility than other consumer with a lower γ. The parameter $m > 0$ represents the agent's endowment, and p_x, p_{1-x} with $0 < p_x < p_{1-x}$, are the prices of the unhealthy and healthy food respectively.

Each period t the consumer maximises the discounted sum of future utility by choosing a sequence $\{x^k\}_{k=t}^{\infty}$ with $x^k \in [0,1]$ for all $k \geq t$. If we disregard the constant terms the consumer's problem at time t is

$$\max_{\{x^k\}_{k=t}^{\infty}} \quad \sum_{i=t}^{\infty} \delta^{i-t} \left[v\left(D\left(\{x^k\}_0^i, 1-x^i \right) \right) + \left(p_{1-x} - p_x\right) x^t \right]$$

where $\delta \in [0,1]$ is the discount factor. The trade-off in the consumer's maximisation problem is clear: unhealthy food negatively affects consumer's future utility through the function v, however, it is cheaper than healthy food.

Notice that the consumer faces exactly the same problem at every t, hence it suffices to solve it for any arbitrary period t. For notational convenience define

$$U^t \;=\; \sum_{i=t}^{\infty} \delta^{i-t} \left[v\left(D\left(\{x^k\}_0^i, 1-x^i \right) \right) + \left(p_{1-x} - p_x\right) x^t \right].$$

Notice that the strength of habits is implicit in the functional form of v. In this section we keep a general functional form for v whilst in the next section we parametrise and calibrate the model.

Take any arbitrary period t. Since for all $\{x^k\}_0^{t-1}$ it is true that $D\left(\{x^k\}_0^{t-1}, 1-x^{t-1}\right) \in [0,1]$ for any $\gamma \in [0,1]$, there exists a $\bar{x}^{t-1} \in [0,1]$ such that $D\left(\{x^k\}_0^{t-1}, 1-x^{t-1}\right) = 1 - \gamma\bar{x}^{t-1}$. Notice that if past consumption has always been x, i.e. $\{x^k\}_0^{t-1} = \{x\}_0^{t-1}$, then $D\left(\{x^k\}_0^{t-1}, 1-x^{t-1}\right) = 1 - \gamma x$. Hence, we can interpret $\bar{x}^{t-1}$ as the weighted average diet the consumer has followed in the past up to $t-1$.

Using the previous definition and disregarding the constant terms, we can rewrite the maximisation problem at time t as

$$\max_{\{x^k\}_{k=t}^{\infty}} \quad \sum_{i=t}^{\infty} \delta^{i-t} \left[v\left(\frac{1-\gamma x^i + \gamma(1-\gamma \bar{x}^{i-1})}{1+\gamma} \right) + (p_{1-x} - p_x)\, x^t \right]. \tag{1}$$

Proposition 1. *Let $\bar{x} \in \mathbb{R}$ be such that*

$$v\left(\frac{1+\gamma\,(1-\gamma\bar{x})}{1+\gamma} \right) - p_{1-x} \quad = \quad v\left(\frac{1-\gamma+\gamma\,(1-\gamma\bar{x})}{1+\gamma} \right) - p_x.$$

The diet $\{x^k\}_{k=t}^{\infty} = \{x\}_{k=t}^{\infty}$ that maximises the discounted sum of utility is given by

$$x = \begin{cases} 0 & \textit{if } \bar{x}^{t-1} < \bar{x} \textit{ or } \delta \textit{ is sufficiently high} \\ 1 & \textit{if } \bar{x}^{t-1} > \bar{x} \textit{ and } \delta \textit{ is not sufficiently high.} \end{cases}$$

Proof: *see Appendix.*

Proposition 1 states that a consumer would follow a healthy diet if and only if either she is used to eating healthy or if she is patient enough with respect to future consumption. Notice that the proposition gives no explicit equation of either $\bar{x}$ or $\bar{\delta}$.[10] These two values depend on the specific function v and parameter values, which are computed later when we calibrate and simulate the model.

If we define $v_0 = v\left(\frac{1+\gamma(1-\gamma\bar{x})}{1+\gamma}\right)$ and $v_1 = v\left(\frac{1-\gamma+\gamma(1-\gamma\bar{x})}{1+\gamma}\right)$ we have that the comparative statics for the threshold $\bar{x}$ are as follows:

$$\begin{aligned} \frac{\mathrm{d}\bar{x}}{\mathrm{d}(p_{1-x}-p_x)} &= \frac{1+\gamma}{\gamma^2}\frac{1}{v_0'-v_1'}, \\ \frac{\mathrm{d}\bar{x}}{\mathrm{d}\gamma} &= \frac{1}{\gamma^2(1+\gamma)}\frac{1}{v_0'-v_1'}\left(v_1' - (v_0'-v_1')\frac{2\gamma+\gamma^2}{1+\gamma}\bar{x} \right). \end{aligned}$$

That is, if the price difference between the healthy and unhealthy food decreases, the value of $\bar{x}$ increases. This, by Proposition 1, implies that a consumer is then more likely to follow the healthy diet than the unhealthy one. This is reasonable as if the price difference decreases then healthy food becomes more attractive for the consumer. The comparative statics above also imply that how γ affects the threshold $\bar{x}$ is ambiguous. In particular, higher γ may decrease the threshold $\bar{x}$, making a consumer more likely to continue with an unhealthy diet. This may seem counter-intuitive at first, as more γ makes unhealthy food more harmful in the long run. However, there is a second effect that is caused by the fact that γ is also how past consumption aggregates into present utility. Higher γ increases the

[10]In principle the value of $\bar{x}$ could be outside the interval $[0,1]$. If $\bar{x} < 0$, the consumer follows a healthy diet regardless of her past consumption and discount factor. On the other hand, if $\bar{x} > 1$ then whether the consumer follows a healthy diet or not depends on her discount factor.

effect of habit and, hence, makes it harder for a consumer to change her diet. As we shall show in the simulations later on, it is then possible to have a non-monotonic relation between γ and how much unhealthy food a population consumes.

Proposition 1 states that a consumer either purchases only unhealthy food or only healthy food. This is a direct consequence of assuming that only one unit of food is consumed per period and that $v'' > 0$. This dichotomous result poses no problem for interpreting the model, rather the opposite, it makes interpretation easier and will allow us in the next section to classify the population between two groups with different eating habits. The link between the healthiness of the diet chosen by the consumer and her weight in this framework is as follows. When the consumer chooses to eat unhealthy ($x = 1$) we consider she is overweight. On the other hand, when the consumer chooses to eat healthy ($x = 0$) she is not overweight. This simplifies the interpretation in our model when we introduce a population of consumers (next section), so different agents will choose different diets with $x \in \{0, 1\}$. Therefore, on aggregate a certain percentage of the population will eat unhealthy and be overweight, and the rest of the population will eat healthy and not be overweight.

3 Policy Discussion

In order to study the effect of different policies on the unhealthy food consumption in a population, we assume that consumers differ in their parameter γ, which captures characteristics such as lifestyle, genetics, peer effect, etc. Hence, γ can be related to how individuals are concerned with their well being and how they look, whether they exercise regularly or not, how they deal with the consumption of unhealthy food or whether historically they have been more included towards healthier foods. In order to simplify the calculations we keep constant across agents the discount factor δ and the functional form of v.

The three policies we consider in this paper are a tax, a subsidy and cash incentives. A tax is represented in the model by an increase in the price of unhealthy food from p_x to $p_x(1 + t)$, where t is the size of the tax. Similarly, a subsidy is represented by a decrease in the price of healthy food from p_{1-x} to $p_{1-x}(1 - s)$, where s is the size of the subsidy. Finally, cash incentives consists of a monetary reward of I whenever the individual consumes healthy food. That is, with cash incentives we add to the utility of the consumer, U^t, the term $\sum_{i=t}^{\infty} \delta^{i-t} \mathbb{1}_{x^t} I$ where $\mathbb{1}_{x^t}$ equals 1 if $x^t = 0$ and 0 otherwise.

All three policies can reduce the population's consumption of unhealthy food and, therefore, they may have a permanent effect even if the policy is applied only temporarily. This can happen because by changing the optimal decision of a consumer at a certain point in time her habits changed, hence it is possible to also affect her future decisions. More specifically, consider a consumer who finds it is optimal to choose the unhealthy diet. Therefore, by proposition 1 we must have that $\bar{x}^{t-1} > \bar{x}$. When policy $P \in \{t, s, I\}$ is implemented, if we let $\bar{x}(P)$ be the value of $\bar{x}$ in proposition 1 when such policy is introduced, then given that $v', v'' > 0$ we have $\bar{x}(t), \bar{x}(s), \bar{x}(I) < \bar{x}$. Therefore, we could have that $\bar{x}^{t-1} < \bar{x}(P)$ with $P \in \{t, s, I\}$ and the consumer chooses the healthy diet when a policy is introduced. If this happens, then it is possible that a consumer moves from a situation where $\bar{x}^{t-1} > \bar{x}$ to a situation where $\bar{x}^{T+t-1} < \bar{x}$ after the policy P has been in place for T periods. From time $T + t$ on, the consumer follows the healthy diet even if the policy is removed.

Note that both taxes and subsidies affect the consumer incentives in the same way. This is because they both narrow the price difference between unhealthy and healthy food, and both these prices enter linearly in the utility function of the consumer. This does not mean that the tax and the subsidy will have the same effects on the consumer, as they are both applied to different prices.

3.1 Calibration

To calibrate the model and simulate the effects of the three different policies for the US and the UK, we assume that the population is such that γ, the parameter that represents individual characteristics, follows a normal distribution truncated between 0 and 1. We write this as $\gamma \sim N_{[0,1]}(\mu, \sigma^2)$, where μ is the mean and σ^2 is the variance. We set $\sigma^2 = 0.1$ and consider three different possible values for the mean, $\mu \in \{0, 0.5, 1\}$.[11]

The initial consumption of unhealthy food, x^0, is random and equal to either 0 or 1. We use a Bernoulli distribution and set at random $x^0 = 1$ for 68% of the population and $x^0 = 0$ for 32% of the population in the case of the US, and $x^0 = 1$ for 57% of the population and $x^0 = 0$ for 43% of the population in the case of the UK. These values correspond to the WHO estimates whereby 68% of the US population and 57% of the UK population is overweight.[12]

Each time period is set equal to a quarter and the discount factor is assumed to take the value $\delta = 0.987$. Given that each time period represents a quarter, we have that $0.987^4 = 0.949$, which is in line with current studies where the annual discount rate is found to be around 0.95 (see for instance Laibson et al. (2008)).

Since each time period is a quarter, the prices p_x and p_{1-x} represent the quarterly spending on unhealthy and healthy food respectively. If a proportion y of the population is overweight

[11] Simulations show that the qualitative results are robust to different values of σ.

[12] We remind the reader that according to the WHO a person is overweight if her BMI is equal or above 25. Note that obese people ($BMI \geq 30$) are also overweight.

and e is the quarterly expenditure on food of an average consumer we have that

$$e = yp_x + (1-y)p_{1-x}.$$

Monsivais et al. (2010) estimate that the ratio between the price of healthy food and unhealthy food is between 1 and 8.3, depending on the nutrient density of the food under consideration. Using the fact that in our model all consumers purchase the same amount of food per period we focus on an intermediate value for this ratio and set $4.5p_x = p_{1-x}$. Thus,

$$p_x = \frac{e}{y + 4.5(1-y)}. \quad (2)$$

For the US, using data from the Bureau of Labor Statistics[13] we obtain that $e = \$1,610.75$. According to the WHO the proportion of overweight people in the US is $y = 0.68$. Hence, if we harmonise to 2010 US dollars[14], we have that $p_x(US) = \$769.50$ and $p_{1-x}(US) = \$3,462.76$.

For the UK, the quarterly food spending is £659.10.[15] According to the WHO the proportion of overweight people in the UK is $y = 0.57$. Hence, if we harmonise to 2010 British pounds[16], we have that $p_x(UK) = £277.65$ and $p_{1-x}(UK) = £1,249.41$.

We assume the function v to be such that

$$v(D) = N(D^n)$$

where the exponent $n > 1$ and the scaling factor $N > 0$ are free parameters and their values are set to match the data of the country under consideration. In particular, we are looking at values of n and N such that two conditions are satisfied. First, in the absence of any policy the percentage of consumers choosing the unhealthy diet equals 68% for the US and 57% for the UK. Second, amongst these consumers whose optimal consumption can be changed from the unhealthy diet to the healthy one, i.e. consume $x = 1$ but would consume $x = 0$ if their diet had been healthy in the past ($x^0 = 0$), the maximum number of quarters needed for such a change is six (a year and a half). We have found no empirical reference for the average time it takes for an overweight person to achieve a BMI below 25. Nevertheless, medical literature suggests that a key challenge in weight loss interventions is to both attain initial weight loss and to maintain that weight loss over periods of 12 months or more (Volpp et al. (2008)).

Using the values of δ, p_x, p_{1-x} and the distribution $\gamma \sim N_{[0,1]}(\mu, \sigma^2)$ with $\sigma^2 = 0.1$ and $\mu \in \{0, 0.5, 1\}$, we find that a habit parameter of $n = 50$ and scaling factors of $N = 2740$

[13] Consumer Expenditures in 2008, U.S. Bureau of Labor Statistics.
[14] CPI index, U.S. Bureau of Labor Statistics.
[15] Living Costs and Food Survey 2008, Office for National Statistics.
[16] CPI index, Office for National Statistics.

for the US and $N = 990$ for the UK fulfil our two desired requirements.[17] Notice that the calibrated habit parameter, $n = 50$, is in line with the literature supporting addiction to calories from food. Indeed, Richards et al. (2007) show empirical evidence of strong addiction to carbohydrates, Liu and Lopez (2012) provide evidence that carbonated soft drinks are rationally addictive, and List and Samek (2015a) provide field experiment evidence of habit formation in children healthy food consumption.

With respect to the different policies, we consider the value of the tax and the subsidy fixed at 10%. This value is greater than the 1.5% to 7.25% soft drink and snack food tax applied in different US states (Jacobson and Brownell (2000)). We choose a higher tax (and subsidy) given that, as argued by Jacobson and Brownell (2000), current tax levels are too small to affect unhealthy food consumption. Moreover, Wansink et al. (2014) also use a 10% tax on soft drinks in their field experiment.

When considering cash incentives, we assume that the amount of money given to each consumer per quarter equals to the difference between the quarterly cost of consuming healthy food and the quarterly cost of consuming unhealthy food. This ensures that all consumers find it optimal to follow a healthy diet for at least as long as the policy lasts. Given the numerical values derived above, we have that the quarterly amount of cash given must equal $\$2,693.26$ in case of the US and £971.76 in case of the UK. We could assume instead that each consumer receives exactly the amount of cash needed to have the healthy diet as optimal choice. However, this poses a problem from the applied policy point of view because it may not be possible or feasible to discriminate amongst consumers.

The costs of implementing each policy are calculated as follows. We assume that taxing unhealthy food has no implementation costs.[18] The cost of implementing the subsidy is given by the amount of the subsidy itself. The cost of implementing cash incentives equals the amount of cash to be given per quarter to each consumer times the number of quarters needed to change the habits of the consumer being targeted. We assume that cash incentives are given only to those consumers who can successfully change their unhealthy habits.

The benefit of each policy is calculated by looking at the expense that does not occur if a particular policy is implemented (avoidable costs). In our model, the avoidable cost is the money that the social security system saves because of the reduction in the number of overweight people. In the case of a tax, in addition to the avoidable costs the revenue from the tax is also considered as a benefit.

[17]We stress here that neither N nor the strength of the habit parameter n are chosen freely, their values are calibrated using the data described above.

[18]This assumption is made to simplify the analysis. Moreover, we have found no empirical evidence on the implementation cost of unhealthy food taxation.

Note that each policy changes the utility of the population. In case of subsidies and cash incentives, this change is positive while in the case of taxes this change could potentially be negative. We have chosen not to consider the changes in utility as a benefit/cost for the society for several reasons. First, we would be adding utility to money, which makes no sense from the methodological point of view even though the utility function assumed is quasi-linear in wealth. Second, we would need to aggregate the utilities of different consumers. Finally and most importantly, we want to take the conservative approach of focusing only on the monetary benefits of each policy.

To calculate the amount of money the social security system saves per overweight patient we proceed as follows. The total saving per overweight patient is equal to the total cost per overweight patient (avoidable cost). The total cost per overweight patient is equal to the cost per overweight patient per year times the number of years each overweight patient receives medical treatment. By total cost per overweight patient we mean the additional cost that an overweight patient imposes on the social security system when compared to a non-overweight patient.

In the US, the cost to Medicare per overweight patient per year is, on average, \$600.00 extra when compared to a non-overweight patient (Finkelstein et al. (2009)).[19] We consider that patients receive treatment at Medicare for two years.[20] Thus, if we harmonize to 2010 US dollars and assume an annual interest rate of 3%, then each overweight person costs Medicare on average $\$1,768.87$.

In the UK, there is no evidence of the additional cost to the NHS of an overweight patient compared to a normal weight patient. The approach we take is to calculate the additional cost of an overweight patient for the NHS as the ratio between the total overweight cost and the number of overweight patients for the NHS. Since we do not have information on the number of overweight patients at the NHS we use instead the same proportion of enrollment/total population as in the US: 14.85%.[21] The costs to the NHS attributable to overweight patients equals $£5,146$ million per year[22] and the assumed number of enrollment in the NHS in the UK in 2008 is $9,117,603$. Therefore, the cost per overweight patient is £564.40 per year. We also assume that overweight patients receive medical treatment during two years in the NHS. Thus, if we harmonize to 2010 British pounds and assume an annual interest rate of 3% each

[19]Measured in 2008 US dollars. We found no data on overweight only patients (BMI between 25 and 30).

[20]Simulation results show that our qualitative results still hold for alternative time periods. In particular, we also considered a situation where patients receive treatment at enter Medicare at the age of 65 and live for an average of 77 years minus 3 years for being overweight (Moderate Obesity Takes Years Off Life Expectancy, University of Oxford (2009, March 20)) and found the same qualitative results.

[21]This is a sensible assumption given that all UK residents have the right to NHS treatment.

[22]Measured in 2007 British pounds (Scarborough et al. (2011)).

overweight person costs the NHS on average £1,796.31.

Altogether, then, the key features of the calibration can be summarised as in table 1.

Table 1: Calibration

γ	$\sim N_{[0,1]}(\mu, \sigma^2)$
μ	$\in \{0, 0.5, 1\}$
σ^2	0.1
t	quarter
x_0	Bernoulli(0.68) (US), Bernoulli(0.57) (UK)
δ	0.987
p_x	\$769.50 (US), £277.65 (UK)
p_{1-x}	\$3,462.76 (US), £1,249.41 (UK)
$v(D)$	$N(D^n)$
N	2740 (US), 990 (UK)
n	50
tax	10%
subsidy	10%
cash incentives	\$2,693.26 (US), £971.76 (UK)
S.S. costs per overweight	\$1,768.87 (US), £1,796.31 (UK)

3.2 Numerical Results

We simulate the model for both the US and the UK and the three different policies for a population of 100 consumers and then scale up the results to a population of 304.37 million in the case of the US and a population of 61.40 million in the case of the UK.[23] We proceed in this way so simulating the model is computationally more convenient.[24]

Tables 2 and 3 show the results of the simulations of our model given the calibration just described. By looking at both tables, we can conclude that:

1. Cash incentives is the most effective policy in reducing unhealthy food consumption.
2. However, cash incentives is the least profitable policy and can lead to significant monetary costs.

[23] Population in 2008, US Census Bureau (US) and Office for National Statistics (UK).

[24] The qualitative results are similar if we simulate the model for a population of 1,000 consumers and then scale up the results to the target population.

3. A 10% tax is relatively ineffective in reducing unhealthy food consumption.
4. A 10% subsidy is the most profitable policy and relatively effective in reducing unhealthy food consumption.

Table 2: Policy Comparison (US)

	$\mu = 0$	$\mu = 0.5$	$\mu = 1$
Overweight no policy (%)	68	68	68
Tax			
Overweight with policy (%)	36	57	68
Revenue	1,252	1,983	2,365
Benefit	25,345	8,795	0
Benefit + Revenue	26,597	10,777	2,365
Subsidy			
Overweight with policy (%)	13	8	18
Subsidies	13,617	14,400	12,834
Benefit	43,814	47,972	39,977
Benefit - Cost	30,197	33,572	27,142
Cash Incentives			
Overweight with policy (%)	21	1	1
Periods needed p.p. (average)	1.77	3.33	4.75
Cost	100,613	271,413	387,121
Benefit	37,418	53,569	53,569
Benefit - Cost	-63,195	-217,905	-333,552

2010 million US dollars unless stated otherwise. Revenue: Money collected from the tax. Benefit: Avoidable cost to Medicare. Subsidies: Expense for subsidising healthy food. Periods needed p.p. (average): Average number of periods per person during which beneficiaries of cash incentives receive the monetary payment. Cost: Total amount of money given to beneficiaries of cash incentives.

Cash incentives is the most effective policy to reduce the number of people with unhealthy diets. This result is due to the fact that, given the discount factor and the presence of habit, most consumers' behaviour depend on their initial diets. Moreover, the amount of cash incentives is such that those consumers with unhealthy habit find it is optimal to change to the healthy diet (at least) during when the policy is implemented. Hence, given the amount of

Table 3: Policy Comparison (UK)

	$\mu = 0$	$\mu = 0.5$	$\mu = 1$
Overweight no policy (%)	57	57	57
Tax			
Overweight with policy (%)	34	48	57
Revenue	86	122	144
Benefit	3,767	1,474	0
Benefit + Revenue	3,853	1,596	144
Subsidy			
Overweight with policy (%)	13	7	18
Subsidies	991	1,059	934
Benefit	7,206	8,189	6,387
Benefit - Subsidies	6,215	7,130	5,453
Cash Incentives			
Overweight with policy (%)	21	1	1
Periods needed p.p. (average)	1.89	3.00	4.74
Cost	6,035	14,885	23,503
Benefit	5,896	9,172	9,172
Benefit - Cost	-138	-5,713	-14,331

2010 million pounds unless stated otherwise. Revenue: Money collected from the tax. Benefit: Avoidable cost to NHS. Subsidies: Expense for subsidising healthy food. Periods needed p.p. (average): Average number of periods per person during which beneficiaries of cash incentives receive the monetary payment. Cost: Total amount of money given to beneficiaries of cash incentives.

cash incentives and that most consumers initially choose unhealthy diets, motivating healthy food consumption via cash incentives reduces significantly the aggregate level of unhealthy food consumption. Cash incentives, however, are relatively costly and can lead to significant monetary costs.

The reason behind the ineffectiveness of a tax is because, given the differences in prices between healthy and unhealthy food, a 10% change in the cost of unhealthy food has a small absolute effect. To illustrate this point, note that a 10% tax increases the quarterly cost of unhealthy food by \$76.95 in the US and £27.77 in the UK, while a 10% subsidy reduces the quarterly cost of healthy food by \$346.28 in the US and £124.94 in the UK.

Notice that although higher values of μ imply higher long term loss in utility from eating unhealthy food, higher values of μ also make it harder to change from an unhealthy diet to a healthy one. This is the reason why there is a non-monotonic relation between μ and the total consumption of unhealthy food when subsidies are considered. We not always observe such non-monotonicity when the tax is considered because, as already argued, its absolute effect is lower than that of the subsidy.

We acknowledge the limitations of our study. It considers a linear relationship between caloric intake and weight, which can lead to an overestimation in the amount of weight lost compared with a non-linear relationship between caloric intake and weight. Another limitation is due to the fact that we considered only two types of food, so our model leaves out more complex substitution patterns across food types. Nevertheless, our focus is on whether and to which extent the three policies are effective in reducing unhealthy food consumption in the population.

However, the qualitative results still hold if we consider alternative modifications in the calibration procedure. Previous results are based on overweight people (BMI equal or above 25), and the first modification was to calibrate and simulate the model with only obese people (BMI equal or above 30) and the results of such calibration (Appendix B) enforces the idea that subsidies seem the best alternative to tackle the obesity problem. The main results for the US are based on the extra cost for Medicare of 600 (in 2008 US dollars) for an overweight patient per year compared to a non-overweight patient (Finkelstein et al. (2009)). We also calibrated and simulated the model with the alternative extra medical care cost of \$2,418 (in 2005 US dollars) estimated by Cawley and Meyerhoefer (2012), and the results also suggest that subsidies are the most cost-effective policy (Appendix C). Finally, in order to analyse the duration of the cash incentives we have run numerical simulations where the maximum number of quarters needed for changing the consumer's habits is either five or seven and found that results are very similar to those obtained when such number equals six. However, the effectiveness of cash incentives seems to depend slightly negatively on the number of quarters considered. Details of this extension are available from the authors upon request.

4 Concluding remarks

To handle the obesity problem, governments have responded with a variety of interventions, including product taxes, banning private advertising of foods that are high in fat, salt and sugar, and promoting advertising of the consequences of unhealthy food consumption. Most recently, the US has implemented healthy meal subsidies to reduce child obesity and there is an ongoing discussion on the use of cash incentives to promote healthy behaviour both in the US and UK. Within this context, we studied whether taxes, subsidies or cash incentives are effective to reduce unhealthy food consumption and, if so, which is the most appropriate policy to tackle the obesity problem.

Our results suggest that cash incentives can be the most effective policy in reducing unhealthy food consumption. Taxes, on the contrary, are relatively ineffective in reducing unhealthy food consumption. The comparison of the monetary benefits due to the reduction in costs for the social security system and the implementation costs of each policy suggest that cash incentives can lead to significant monetary losses. Finally, we found that subsidies have the best balance between effectiveness in reducing unhealthy food consumption and monetary benefits to the society.

This paper contributes to the economic analysis of unhealthy food consumption and to the public debate on how to tackle the obesity problem. We built, calibrated and simulated a theoretical model to US and UK data, thus quantifying the effects of the different policies. There are several issues left for possible future research, for instance considering hyperbolic discounting or assuming a non-separable utility function. Nevertheless, this paper sheds new light on the issue of how to tackle the obesity problem by suggesting subsides rather than taxes or cash incentives, as a potential solution.

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A Proof of Proposition 1

Proof. If we take the partial derivatives at time t with respect to x^k with $k \geq t$ in equation (1) we obtain

$$\frac{\partial U^t}{\partial x^k} = -\sum_{i=k}^{\infty} \delta^{i-t} \left[\left(\frac{\gamma}{1+\gamma} \right)^{i-k+1} v' \left(\frac{1 - \gamma x^i + \gamma(1 - \gamma \bar{x}^{i-1})}{1+\gamma} \right) \right] + \delta^{k-t} \left(p_{1-x} - p_x \right) \quad (3)$$

where v' is the derivative of v with respect to D at time i. If we now compute the second partial derivatives we have

$$\frac{\partial^2 U^t}{\partial^2 x^k} = \sum_{i=k}^{\infty} \delta^{i-t} \left(\frac{\gamma}{1+\gamma} \right)^{i-k+2} v'' \left(\frac{1 - \gamma x^t + \gamma(1 - \gamma \bar{x}^{t-1})}{1+\gamma} \right).$$

As $v'' > 0$ implies $\frac{\partial^2 U^t}{\partial^2 x^k} > 0$ the optimal sequence $\{x^k\}_{k=t}^{\infty}$ has $x^k \in \{0, 1\}$ for all $k = t, \ldots, \infty$. Moreover, if at the optimum $x^t = 1$ then it must be that

$$\sum_{i=t}^{\infty} \delta^{i-t} \left[v \left(\frac{1 - \gamma + \gamma(1 - \gamma \bar{x}^{i-1})}{1+\gamma} \right) - p_x \right] > \sum_{i=t}^{\infty} \delta^{i-t} \left[v \left(\frac{1 + \gamma(1 - \gamma \bar{x}^{i-1})}{1+\gamma} \right) - p_{1-x} \right].$$

Thus, since $v'' > 0$ and $x^t = 1$ implies $\bar{x}^t > \bar{x}^{t-1}$, we must have that

$$\sum_{i=t+1}^{\infty} \delta^{i-t} \left[v \left(\frac{1 - \gamma + \gamma(1 - \gamma \bar{x}^{i-1})}{1+\gamma} \right) - p_x \right] > \sum_{i=t+1}^{\infty} \delta^{i-t} \left[v \left(\frac{1 + \gamma(1 - \gamma \bar{x}^{i-1})}{1+\gamma} \right) - p_{1-x} \right].$$

Hence, if at the optimum $x^t = 1$ then at the optimum $x^{t+1} = 1$. Iterating on this reasoning we can conclude that if at the optimum $x^t = 1$ then it must be that at the optimum $x^k = 1$ for all $k = t, \dots, \infty$. Using similar steps, it can be shown that if at the optimum $x^t = 0$ then the optimum has $x^k = 0$ for all $k = t, \dots, \infty$. Therefore, the optimal sequence of unhealthy food consumption is such that $\{x^k\}_{k=t}^{\infty} = \{x\}_{k=t}^{\infty}$ with $x \in \{0, 1\}$.

If $\bar{x}^{t-1} < \bar{x}$ then given that $v' > 0$ and $v'' > 0$ it is true that $v\left(\frac{1+\gamma(1-\gamma\bar{x}^{t-1})}{1+\gamma}\right) - p_{1-x} > v\left(\frac{1-\gamma+\gamma(1-\gamma\bar{x}^{t-1})}{1+\gamma}\right) - p_x$. This implies that the consumer derives maximum one period utility if she consumes $x = 0$ at time t. Furthermore, for all two sequences $\{x^k\}_0^T$ and $\{x^{k'}\}_0^T$ with $T > t$ that are different only in that $x^t = 0$ and $x^{t'} > 0$, we have that $v\left(D\left(\{x^k\}_0^T, 1 - x^T\right)\right) > v\left(D\left(\{x^{k'}\}_0^T, 1 - x^T\right)\right)$. Thus, if $\bar{x}^{t-1} < \bar{x}$ then the optimum has $x^k = 0$ for all $k \geq t$.

If $\bar{x}^{t-1} > \bar{x}$ then by similar arguments as those used above, the consumer derives maximum one period utility if she consumes $x = 1$ at time t. However, it is still true that for all two sequences $\{x^k\}_0^T$ and $\{x^{k'}\}_0^T$ with $T > t$ that are different only in that $x^t = 0$ and $x^{t'} > 0$, we have that $v\left(D\left(\{x^k\}_0^T, 1 - x^T\right)\right) > v\left(D\left(\{x^{k'}\}_0^T, 1 - x^T\right)\right)$. Hence, although the consumer derives more one period utility at time t if she consumes $x^t = 1$, if δ is high enough the gain in utility from consuming $x^t = 1$ instead of $x^t = 0$ does not offset the long term loss in utility. In this case we have that there exists a threshold value $\bar{\delta}$ such that if $\delta < \bar{\delta}$ then the optimal diet is $x^k = 0$ for all $k \geq t$ whilst if $\delta > \bar{\delta}$ then the optimal diet is $x^k = 1$ for all $k \geq t$. □

B Obese Population

A reasonable question is whether we obtain the same results when only obese people are considered. That is, if we regard consumers whose BMI is between 25 and 30 as not following an unhealthy diet. This is the object of study in this subsection.

The parameters γ, μ, σ^2, t and δ are set to the same values as the ones used in the previous calibration. According to the WHO, 34% of the US population and 21% of the UK population is obese. According to this information we set at random $x^0 = 1$ for 34% of the population and $x^0 = 0$ for 66% of the population in the case of the US, and $x^0 = 1$ for 21% of the population and $x^0 = 0$ for 79% of the population in the case of the UK.

Using equation (2), the fact that $e = \$1,610.75$ for the US and £659.10 for the UK, and $y = 0.34$ for the US and $y = 0.21$ for the UK, we obtain that $p_x(US) = \$491.81$ and $p_{1-x}(US) = \$2,213.16$, and $p_x(UK) = £184.73$ and $p_{1-x}(UK) = £831.28$ (all values harmonised to 2010 prices). Note that in this case p_x and p_{1-x} represent the quarterly costs of following a diet that will lead to a person being obese and the quarterly costs of following a diet that would lead to a person not being obese, respectively.

As in subsection 3.1, values of n and N are identified such that the percentage of consumers choosing the unhealthy diet equals 34% for the US and 21% for the UK, and the maximum number of quarters needed for a consumer to change her habits equals six. Using the values of δ, p_x, p_{1-x} and the distribution $\gamma \sim N_{[0,1]}(\mu, \sigma^2)$, a habit parameter of $n = 50$ and scaling factors of $N = 1770$ for the US and $N = 668$ for the UK fulfill the two requirements.

With respect to the different policies under analysis, the same values are used as those employed in the previous calibration except for cash incentives. Given the numerical values derived above, the quarterly amount of cash given must equal \$1,721.35 in case of the US and £646.55 in the case of the UK. Note that we assume each obese consumer costs the social security system the same as the value used in the previous calibration.

The calibration when only obese consumers are considered is presented in table 4.

Table 4: Calibration, Obese Only

γ	$\sim N_{[0,1]}(\mu, \sigma^2)$
μ	$\in \{0, 0.5, 1\}$
σ^2	0.1
t	quarter
x_0	0.34 (US), 0.21 (UK)
δ	0.987
p_x	\$491.81 (US), £184.73 (UK)
p_{1-x}	\$2,213.16 (US), £831.28 (UK)
$v(D)$	$N(D^n)$
N	1,770 (US), 668 (UK)
n	50
tax	10%
subsidy	10%
cash incentives	\$1,721.35 (US), £646.55 (UK)

As before, we simulate the model and the three different policies for a population of 100 consumers and then scale up the results to a population of 304.37 million in the case of the US and 61.40 million in the case of the UK.[25] Tables 5 and 6 show the results of the simulations.

The calibration and simulation of the model when only obese consumers are considered also suggest that subsidies seem the best alternative to solve the obesity problem.

[25] We obtained similar qualitative results by simulating the model for a population of 1,000 consumers and then scale up the results to the target population.

Table 5: Policy Comparison (US), Obese Only

	$\mu = 0$	$\mu = 0.5$	$\mu = 1$
Obese no policy (%)	34	34	34
Tax			
Obese with policy (%)	21	28	32
Revenue	467	622	711
Benefit	10,394	4,797	1,599
Benefit + Revenue	10,861	5,420	2,310
Subsidy			
Obese with policy (%)	7	2	3
Subsidies	9,303	9,803	9,703
Benefit	21,587	25,585	24,785
Benefit - Subsidies	12,284	15,782	15,082
Cash Incentives			
Obese with policy (%)	13	5	1
Periods needed p.p. (average)	1.62	3.00	4.03
Cost	26,453	67,690	103,480
Benefit	16,790	23,186	26,385
Benefit - Cost	-9,663	-44,504	-77,096

2010 million US dollars unless stated otherwise. Revenue: Money collected from the tax. Benefit: Avoidable cost to Medicare. Subsidies: Expense for subsidising healthy food. Periods needed p.p. (average): Average number of periods per person during which beneficiaries of cash incentives receive the monetary payment. Cost: Total amount of money given to beneficiaries of cash incentives.

C Alternative Social Security Costs (US)

In a recent paper Cawley and Meyerhoefer (2012) provide an alternative measure of the marginal effect of obesity on medical care costs. They find that an obese person raises medical expenditures paid by third parties by $2,418 (in 2005 US dollars) relative to a non-obese person. Cawley and Meyerhoefer suggest that previous literature has underestimated the medical costs of obesity and, therefore, the economic rationale for government intervention to reduce obesity-related externalities. Table 7 shows the result of the simulations of our

Table 6: Policy Comparison (UK), Obese Only

	$\mu = 0$	$\mu = 0.5$	$\mu = 1$
Obese no policy (%)	21	21	21
Tax			
Obese with policy (%)	13	19	21
Revenue	22	32	35
Benefit	1,310	328	0
Benefit + Revenue	1,332	359	35
Subsidy			
Obese with policy (%)	5	2	1
Subsidies	720	743	750
Benefit	2,620	3,112	3,276
Benefit - Subsidies	1,900	2,369	2,525
Cash Incentives			
Obese with policy (%)	15	5	1
Periods needed p.p. (average)	1.67	3.06	3.95
Cost	590	2,889	4,657
Benefit	983	2,620	3,276
Benefit - Cost	393	-268	-1,381

2010 million pounds unless stated otherwise. Revenue: Money collected from the tax. Benefit: Avoidable cost to NHS. Subsidies: Expense for subsidising healthy food. Periods needed p.p. (average): Average number of periods per person during which beneficiaries of cash incentives receive the monetary payment. Cost: Total amount of money given to beneficiaries of cash incentives.

model considering the alternative obesity cost estimated by Cawley and Meyerhoefer (2012).

As it can be seen in table 7, most of our previous conclusions are still valid. The only difference is that with higher costs per obese person cash incentives no longer lead to a deficit in the social security budget. This is simply caused by the fact that now the benefits of reducing obesity are more acute. Nevertheless, we still find that subsidies are the most cost-effective policy.

Table 7: Policy Comparison (US), Obese Only - alternative cost

	$\mu = 0$	$\mu = 0.5$	$\mu = 1$
Obese no policy (%)	34	34	34
Tax			
Obese with policy (%)	21	28	32
Revenue	467	622	711
Benefit	53,969	24,909	8,303
Benefit + Revenue	54,436	25,531	9,014
Subsidy			
Obese with policy (%)	7	2	3
Subsidies	9,303	9,803	9,703
Benefit	112,090	132,848	128,696
Benefit - Subsidies	102,787	123,044	118,993
Cash Incentives			
Obese with policy (%)	13	5	1
Periods needed p.p. (average)	1.62	3.00	4.03
Cost	26,453	67,690	103,480
Benefit	87,181	120,393	136,999
Benefit - Cost	60,728	52,703	33,519

2010 million US dollars unless stated otherwise. Revenue: Money collected from the tax. Benefit: Avoidable cost to Medicare. Subsidies: Expense for subsidising healthy food. Periods needed p.p. (average): Average number of periods per person during which beneficiaries of cash incentives receive the monetary payment. Cost: Total amount of money given to beneficiaries of cash incentives.