University *of* Leicester

DEPARTMENT OF ECONOMICS

Cash Incentives and Unhealthy Food Consumption

Javier Rivas, University of Leicester, UK
Miguel Flores, University of Leicester, UK

Working Paper No. 11/47
October 2011
Updated January 2012

Cash Incentives and Unhealthy Food Consumption[*]

Miguel Flores
University of Leicester[†]

Javier Rivas
University of Leicester[‡]

January 27, 2012

Abstract

The costs associated with unhealthy food consumption are not only paid by those suffering from overweight but by all members of society in terms of higher costs for social security systems. With this in mind, we study the effectiveness of a tax, a subsidy 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 yet it can be the most costly one. Taxes are relatively ineffective in reducing unhealthy food consumption. Subsidies have the best balance between effectiveness and monetary benefits to the society.

JEL Classification: D04, D11, H31.

Keywords: Habit, Junk Food, Overweight, Public Policy, Rational Addiction.

[*]We would like to thank Gianni de Fraja, Piercarlo Zanchettin and seminar participants at the University of Leicester for useful comments and discussions.

[†]Department of Economics, University of Leicester, University Road, Leicester LE1 7RH, United Kingdom. maf28@le.ac.uk, `www.le.ac.uk/departments/economics/people/mflores`.

[‡]Corresponding author. Department of Economics, University of Leicester, University Road, Leicester LE1 7RH, United Kingdom. javier.rivas@le.ac.uk, `www.le.ac.uk/users/jr168`.

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 but 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[2] (Finkelstein et al. (2003)). Most recently, Cawley and Meyerhoefer (2011) suggest 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 sugared beverages), and educational and informational programs (e.g. promoting the advertisement of the health consequences of unhealthy food consumption and adding nutritional intake information on food packages). Lately, some governments (US, UK and Mexico among others) have proposed a ban on the sale of highly sugar-filled products in public schools in order to keep children away from unhealthy foods[3]. Local governments in the US, like Texas, New York and California, have already introduced such policies. Some European countries, like Denmark, Romania, Hungary and France, recently started taxing foods that have negative effects on healt[4]. In the UK, the government introduced in 2007 a banning on private advertising of foods that are high in fat, salt and sugar, in or around programmes specifically made for children[5]. Currently in the UK there is a discussion concerning the use of incentives to promote healthy behaviour[6]. This discussion has been motivated by some examples where local incentive schemes had been piloted. These included people receiving cash for losing

[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, February 07, 2010.

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

[5]Television Advertising of Food and Drink Products to Children, Ofcom Statement, February 2007.

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

agreed amounts of weight, and children being rewarded with toys in exchange for eating more fruit and vegetables.

This paper addresses the following questions: are taxes, subsidies and cash incentives effective in reducing unhealthy food consumption? If so, which one is the most appropriate policy to tackle the obesity problem?

In order to answer these questions, we use a model where consumers face an inter-temporal decision problem on the healthiness of the diet to follow. Choosing an unhealthy diet has the advantage that it is less expensive and more convenient than selecting the healthy alternative diet. 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. This trade-off between present and future consumption is further spiced up with 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. This means that, for instance, a consumer who is used to follow a healthy diet derives more utility from eating healthy foods than a consumer who is used to eat unhealthy.

Within the setting just described, we consider the effects of three different policies on the population level of unhealthy food consumption: 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 two countries, the US and the UK.

Our results suggest that cash incentives may be the most effective policy to tackle the obesity problem because it ensures a greater reduction in the number of people with unhealthy diets. This is because, given the discount factor and the presence of habit, most consumers' behavior depends on their initial diets. Hence, since most consumers initially choose unhealthy diets, motivating healthy food consumption via cash incentives has a significant positive effect on the aggregate level of unhealthy food consumption. However, when we consider the benefits due to the reduction in costs for the social security system and the implementation costs of each policy (net benefits), we find that cash incentives has lower net benefits. In fact, cash incentives may have negative long term benefits in the US and the UK. In this case, whether cash incentives is a desirable policy depends partly on the social, non-monetary, benefits of having a healthier population.

Taxes is the least effective policy 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 10% tax has a small effect on the relative price difference between unhealthy and healthy food.

Subsidies, on the other hand, are relatively effective in reducing unhealthy food consumption and can lead to a significant surplus when the savings to the social security system are considered. In particular, our calibration shows that with a 10% subsidy to healthy food the government can save in the long term up to $874 billion in the US and £56 billion in the UK.

The remaining of the paper is organized as follows. Next we present a discussion on the relevant literature. In section 2 we describe the model. A particular case of the model is presented in section 3 whilst section 4 analyses the general case. In section 5 we calibrate the model and simulate the effect of the different policies on the level of unhealthy food consumption in a population. Finally, in section 6 we present the conclusions.

1.1 Literature

Even though there is a large debate around eating habits and its health and economic consequences, not much work as been devoted to the issue of unhealthy food consumption. As Goel (2006) points out, the economics literature on obesity is still in its infancy. Only few papers have studied the agent's decision to consume unhealthy food while rationally considering the adverse effects on health. Levy (2002) considers a dynamic model of non-addictive eating to explain overweight, underweight and cyclical food consumption. He finds that when certain physiological, psychological, environmental and socio-cultural conditions are present an expected lifetime-utility maximiser chooses to be overweight. Yaniv (2002) uses a rational decision model to explain individual's deviation from a prescribed low-fat diet when there is the possibility that the consumer suffers a heart attack in the future. Yaniv finds that excess high-fat consumption may be due to the fact that the risk of a heart attack drives the individual to behave more oblivious of the future. Dragone and Savorelli (2011) study how social conformism can affect individual eating behavior within a framework where individuals are aware of how food consumption affects body weight. They show that it can be optimal to be on a diet despite being underweight, or to binge despite being overweight. The rest of the existing literature on this topic is empirical, and focuses mainly in the causes of the observed rise in overweight and obesity (see, for example, Cutler et al. (2003), Gruber and Frakes (2006), and Rashad et al. (2006)).

To our knowledge, only few papers analyse the economic implications of different government policies targeting consumers' diets. Acs and Lyles (2007) suggest that providing calorie information to individuals may only have small effects on food choices. 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. They 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) study how soft drink taxes combat the rising levels of child and adolescent obesity. They show that soft drink taxation, as currently practised in the US, leads to a 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.

Our theoretical model builds on Becker and Murphy (1988) but focuses on the unhealthy food consumption problem instead of any general addictive behaviour. The most salient difference is that in our model agents cannot over-eat; what makes an individual overweight in our model is not how much she eats but the lack of healthy foods in her diet. This implies that the consumer's problem is not one of choosing when to stop consuming unhealthy food but on how to balance unhealthy food consumption with healthy food consumption. Moreover, in our model time is discrete which allows us to better calibrate and interpret the model.

2 The Model

Before dealing with a population of agents, we first deal with the 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 is not regarded as being conducive to maintaining health, i.e. food that is high in fat, salt and sugar, and low in fibre and vitamins. We assume that the total amount of food the consumer purchases at any given period is normalized 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. Notice that our focus is to study the consumer's decision on how healthy she wants to eat and not on the total amount of food intake. That is, we are concerned about the composition of the consumers' diet, not about over-eating.

To capture the long term effects of the different diets, we assume that although both the unhealthy and the 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. 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 is cheaper in monetary terms (see, for instance, Monsivais (2010)), takes less time to cook (pre-cooked meals vs elaborated meals), is easier to find (fast food restaurant versus buying raw ingredients at the supermarket) and easier to dispose of (disposable packaging versus doing the dishes). All these effects are summarized by assuming that unhealthy food is more expensive than healthy food.

As just discussed, each time period the consumer faces a trade-off: healthy food is better in the long run but has a higher cost today. We use the standard economic modeling approach of endowing the consumer with an utility function that recreates this trade-off. In particular, we assume that the utility function of the consumer at period t is given by

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

where $\{x^k\}_0^t$ is the sequence of present and past consumption of unhealthy food. The function D is an aggregation of present and past consumption of unhealthy food. We assume D is given recursively by

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

where $D(x^0, 1-x^0)$ represents the consumers' initial diet and it is set to some arbitrary value in $[0,1]$. The parameter $\gamma \in [0,1]$ captures the effects of present and past consumption of unhealthy food, and represents the characteristics of the consumer in terms of lifestyle, genetics, etc. That is, at time t, past consumption of unhealthy food negatively affects current utility through the term $\gamma D\left(\{x^k\}_0^{t-1}, 1-x^{t-1}\right)$, and current consumption of unhealthy food negatively affects current utility via the term $-\gamma x^t$. Thus, 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 function D is assumed to be linear and in the form described above to simplify calculations. Notice that if the consumption of unhealthy food has always been x, i.e. $\{x^k\}_0^t = \{x\}_0^t$, then $D\left(\{x^k\}_0^t, 1-x^t\right) = 1-\gamma x$. The function v represents the effects of a certain diet on the consumer's utility. The function v is differentiable with $v' > 0$, $v'' \geq 0$. If $v'' > 0$ then there is habit formation as we discuss in detail in section 4. 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 maximizes 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 the consumer faces in its maximization problem is clear: unhealthy food negatively affects her future utility through the function v, yet at the present period it is cheaper than the healthy alternative.

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

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

Note that although our model builds on Becker and Murphy (1988), there are significant differences. The consumer's problem in our model is not one of choosing when to stop consuming unhealthy food but on how to balance unhealthy food consumption with healthy food consumption. This difference is due to the fact that we have normalized the amount of food the consumer purchases in order to focus on the healthiness of her diet. As a result, the consumer in our model does not face a budget constraint.

3 A Simple Case

As an initial step to understand individual behaviour, we study a particular case of our model where v is the identity function. If v is the identity function then the utility is linear in the consumption of unhealthy food. Thus, in this case there is no habit formation as the consumption of unhealthy food in the present period does not affect the marginal utility of consuming unhealthy food in future periods.

If we compute the partial derivative with respect to any x^k at a given t, we obtain the first order condition

$$\frac{\partial U^t}{\partial x^k} = \delta^{k-t} \left(p_{1-x} - p_x - \frac{\gamma}{1 + \gamma(1-\delta)} \right).$$

We have the following result:

Proposition 1. *Assume that v is the identity function. The diet that maximizes the discounted sum of utility is given by $\{x^k\}_{k=t}^{\infty} = \{x\}_{k=t}^{\infty}$ with*

$$x = \begin{cases} 1 & \text{if } p_{1-x} - p_x - \frac{\gamma}{1+\gamma(1-\delta)} > 0, \\ 0 & \text{if } p_{1-x} - p_x - \frac{\gamma}{1+\gamma(1-\delta)} < 0, \\ r & \text{otherwise} \end{cases}$$

for all $r \in [0, 1]$.

According to Proposition 1, the agent's optimal long run diet is to consume only unhealthy (healthy) food when the price difference between healthy and unhealthy food ($p_{1-x} - p_x$) is greater (smaller) than the discounted effect of unhealthy food consumption on future utilities $\frac{\gamma}{1+\gamma(1-\delta)}$.

4 Habit Formation

In this section and henceforth we assume $v'' > 0$. This means that increasing the consumption of unhealthy food increases the future return of consuming unhealthy food. Similarly, increasing the consumption of healthy food increases the future return of consuming healthy food. Therefore, if a consumer increases her consumption of unhealthy food then she is more likely to increase it even more in the future, and similarly if she increases the consumption of healthy food.

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 consumption has always been x, i.e. $\{x^k\}_0^{t-1} = \{x\}_0^{t-1}$, then $D\left(\{x^k\}_0^{t-1}, 1-x^{t-1}\right) = 1-\gamma x$. Thus, we can interpret $\bar{x}^{t-1}$ as the weighted average diet the consumer has followed in the past up to $t-1$.

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

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

We have the following result:

Proposition 2. *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 maximizes the discounted sum of utility is given by

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

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

$$\frac{\partial U^t}{\partial x^k} \quad = \quad -\sum_{i=k}^{\infty} \delta^{i-t} \left[\left(\frac{\gamma}{1+\gamma}\right)^{i-k+1} v'\left(\frac{1-\gamma x^i + \gamma(1-\gamma\bar{x}^{i-1})}{1+\gamma}\right)\right] + \delta^{k-t}\,(p_{1-x} - p_x) \tag{2}$$

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

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

As $v'' > 0$ implies $\frac{\partial^2 U^k}{\partial^2 x^k} > 0$ 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

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

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

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

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 $k = t, \ldots, \infty$. Using similar steps, it can be shown that if at the optimum $x^t = 0$ then the optimum has $x^k = 0$ for all $k = t, \ldots, \infty$. 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 $k \geq t$. □

Proposition 2 states that a consumer would follow a healthy diet if and only if either she is used to eat healthy or if she is patient enough with respect to future consumption. Notice that the proposition gives no explicit equation of neither $\bar{x}$ nor $\bar{\delta}$. These two values depend on the specific function v and the value of the parameters and, thus, are computed when we calibrate and simulate the model.

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.

Notice that proposition 2 states that a consumer either purchases only unhealthy food or only healthy food. This result 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 the interpretation easier. 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.

5 Policies

In order to study the effect of different policies on the unhealthy food consumption in a population, we assume that consumers are different in their parameter γ. As already mentioned, the parameter γ is meant to capture characteristics such as lifestyle, genetics, peer effect, etc. Hence, a population with a higher average γ can be interpreted as a society that is more concern towards its well being and how they look, exercise regularly, their bodies deal better with the consumption of unhealthy food, has been historically more inclined towards healthier foods, etc. 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 temporarily. This can happen because by changing the optimal decision of a consumer at a certain point in time her habits change and, thus, 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 2 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 2 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 implemented for T periods. From time $T + t$ on, the consumer follows the healthy diet even if the policy is removed.

5.1 Calibration

In this subsection we 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, a 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 as customary 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, $\mu \in \{0, 0.5, 1\}$.

The initial consumption of unhealthy food, x^0, is random and equal to $x^0 \in \{0, 1\}$. 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[7].

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)).

Given that 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 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,

$$p_x = \frac{e}{y + 4.5(1 - y)}. \quad (3)$$

[7]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.

For the US, using data from the Bureau of Labor Statistics[8] 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 harmonize to 2010 US dollars[9], 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[10]. According to the WHO the proportion of overweight people in the UK is $y = 0.57$. Hence, if we harmonize to 2010 British pounds[11], 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. We have found no empirical reference for the average time it takes for an overweight person to achieve a BMI below 25 but we believe that a maximum of a year and a half is a reasonable value.

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 $N = 2740$ for the US and $N = 990$ for the UK fulfil our two desired requirements.

With respect to the different policies, we consider the value of the tax and the subsidy is 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.

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 is 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

[8] Consumer Expenditures in 2008, U.S. Bureau of Labor Statistics.
[9] CPI index, U.S. Bureau of Labor Statistics.
[10] Living Costs and Food Survey 2008, Office for National Statistics.
[11] CPI index, Office for National Statistics.

$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. 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 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 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.

To calculate the amount of money the social security system saves per overweight patient we proceed as follows. In the US, according to Finkelstein et al. (2009) each obese patient, on average, costs Medicare $600.00 per year more compared to a normal-weight patient[12]. Patients enter Medicare at the age of 65 and live for an average of 77 years minus 3 years for being overweight[13]. Thus, if we harmonize to 2010 US dollars and assume an annual interest rate of 3%, then each overweight person costs Medicare on average $5,318.67.

In the UK, since we do not have information on the number of overweight people who are NHS patients we use instead the number of overweight people in the country. This is a sensible assumption because all UK residents have the right to NHS treatment[14]. The costs to the NHS attributable to overweight people equals £5,146 million per year[15] whilst the number of overweight people in the UK in 2008 was 35.00 million (WHO). Therefore, the cost per patient is £147.04 per year. Overweight people start receiving NHS attention at the age of 59[16] and live for an average of 77 years minus 3 years for being overweight. Thus, if we harmonize to 2010 British pounds and assume an annual interest rate of 3%, each overweight person costs the NHS on average £2,067.21.

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

[13]Oxford University research: http://www.ox.ac.uk/media/news_stories/2009/090317.html.

[14]UK Department of Health.

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

[16]We do not have information on the average age overweight people start receiving NHS attention. However, it was communicated to us by an NHS official in the Leicestershire Nutrition and Dietetic Service that the average age in their NHS weight loss groups is about 59 years old.

The calibration we just carried out is summarized 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	\$5,318.67 (US), £2,067.21 (UK)

5.2 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[17]. We proceed in this way so simulating the model is computationally more convenient.

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.
3. Taxes are relatively ineffective in reducing unhealthy food consumption.

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

4. Subsidies 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	8,432	13,350	15,927
Benefit	513,181	178,076	0
Benefit + Revenue	521,613	191,426	15,927
Subsidy			
Overweight with policy (%)	13	8	18
Subsidies	91,696	96,966	86,426
Benefit	887,140	971,321	809,434
Benefit - Cost	795,444	874,355	723,008
Cash Incentives			
Overweight with policy (%)	21	1	1
Periods needed p.p. (average)	1.77	3.33	4.75
Cost	677,522	1,828,089	2,606,856
Benefit	757,630	1,084,642	1,084,642
Benefit - Cost	80,108	-743,447	-1,522,214

2010 million US dollars unless stated otherwise. Revenue: Money collected from the tax. Benefit: Avoidable cost to Medicare. Subsidies: Expense for subsidizing healthy food. Periods 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' behavior depend on their initial diets. Hence, given that most consumers initially choose unhealthy diets, motivating healthy food consumption via cash incentives has a significant positive effect on the aggregate level of unhealthy food consumption.

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

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	580	818	972
Benefit	29,192	11,423	0
Benefit + Revenue	29,772	12,241	972
Subsidy			
Overweight with policy (%)	13	7	18
Subsidies	6,674	7,134	102
Benefit	55,846	63,461	49,500
Benefit - Subsidies	49,172	56,327	49,397
Cash Incentives			
Overweight with policy (%)	21	1	1
Periods needed p.p. (average)	1.89	3.00	4.74
Cost	40,636	100,236	158,266
Benefit	45,692	71,077	71,077
Benefit - Cost	5,056	-29,159	-87,189

2010 million pounds unless stated otherwise. Revenue: Money collected from the tax. Benefit: Avoidable cost to NHS. Subsidies: Expense for subsidizing healthy food. Periods 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.

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.

Cash incentives are relatively costly and can lead to significant monetary costs. This is specially relevant in the US, where cash incentives, although very effective in reducing unhealthy food consumption, can lead to a net long term expense of $\$1,522,214$ million dollars. The reason for this implication lies in the differences between both countries' social security systems. In the US an overweight person will generate costs to the public sector during 9 years, while in the UK an overweight person generates such costs during 15 years.

This explains why the monetary benefits for the public sector for reducing unhealthy food consumption are greater in the UK than in the US.

Finally, although higher values of μ imply higher long term loss in utility from eating unhealthy, 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 do not observe such non-monotonicity when the tax is considered because, as already argued, its absolute effect is lower than that of the subsidy.

5.3 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 (3), 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 harmonized 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 section 5.1, we look for values of n and N 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 fulfil the two requirements.

With respect to the different policies under analysis, we use the same values as those employed in the previous calibration except for two variables: cash incentives and social security benefits in the UK. 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. Moreover, taking into account that the number of obese people in the UK in 2008 was 12.89

million[18], then each obese person costs the NHS on average £2,507.83. Note that for the US we assume each obese Medicare patient costs \$5,318.67, which is the same 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. Tables 5 and 6 show the results of the simulations.

By comparing tables 2 and 3 with tables 5 and 6 we can see that subsidies are now the most effective policy in reducing the number of people with unhealthy diets. This is because the difference between p_x and p_{1-x} when only obese people are considered is smaller than the price difference when overweight people are considered. This implies that the effects of a 10% subsidy are more acute.

Given that the difference between p_x and p_{1-x} when considering obese people is smaller than with overweight people, the cost of cash incentives is also smaller with only obese people. This is the reason why the ratio of effectiveness of cash incentives (number of people with unhealthy diets) to their implementation costs is higher.

[18] Calculated as the percentage of obese people for UK in 2008 (WHO) to the population of the UK in mid-2008 (Office of National Statistics).

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	3,144	4,191	4,790
Benefit	210,453	97,132	32,377
Benefit + Revenue	213,596	101,324	37,168
Subsidy			
Obese with policy (%)	7	2	3
Subsidies	62,648	66,016	65,342
Benefit	437,094	518,038	501,849
Benefit - Subsidies	374,447	452,022	436,507
Cash Incentives			
Obese with policy (%)	13	5	1
Periods needed p.p. (average)	1.62	3.00	4.03
Cost	178,133	455,823	696,833
Benefit	339,962	469,472	534,227
Benefit - Cost	161,830	13,648	-162,607

2010 million US dollars unless stated otherwise. Revenue: Money collected from the tax. Benefit: Avoidable cost to Medicare. Subsidies: Expense for subsidizing healthy food. Periods 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.

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

5.4 Discussion: Alternative Social Security Costs (US)

In a recent paper Cawley and Meyerhoefer (2011) provide an alternative measure of the marginal effect of obesity on medical care costs. They find that an obese person raises medical expenditures by $\$2,418$ (in 2005 US dollars) relative to a non-obese person. Cawley and Meyerhoefer suggests that previous literature has underestimated the medical costs of obesity and, therefore, the economic rationale for government intervention to reduce obesity-

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	147	214	237
Benefit	12,318	30,080	0
Benefit + Revenue	12,465	3,294	237
Subsidy			
Obese with policy (%)	5	2	1
Subsidies	4,849	5,002	5,053
Benefit	24,636	29,255	30,795
Benefit - Subsidies	19,787	24,254	25,742
Cash Incentives			
Obese with policy (%)	15	5	1
Periods needed p.p. (average)	1.67	3.06	3.95
Cost	3,970	19,452	31,361
Benefit	9,239	24,636	30,795
Benefit - Cost	5,268	5,185	-565

2010 million pounds unless stated otherwise. Revenue: Money collected from the tax. Benefit: Avoidable cost to NHS. Subsidies: Expense for subsidizing healthy food. Periods 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.

related externalities. Table 7 shows the result of the simulations of our model considering the alternative obesity cost estimated by Cawley and Meyerhoefer (2011).

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	3,144	4,191	4,790
Benefit	934,992	431,535	143,845
Benefit + Revenue	938,135	435,726	148,635
Subsidy			
Obese with policy (%)	7	2	3
Subsidies	62,648	66,016	65,342
Benefit	1,941,906	2,301,518	2,229,596
Benefit - Subsidies	1,879,258	2,235,502	2,164,254
Cash Incentives			
Obese with policy (%)	13	5	1
Periods needed p.p. (average)	1.62	3.00	4.03
Cost	178,133	455,823	696,833
Benefit	1,510,371	2,085,751	2,373,441
Benefit - Cost	1,332,239	1,629,927	1,676,607

2010 million US dollars unless stated otherwise. Revenue: Money collected from the tax. Benefit: Avoidable cost to Medicare. Subsidies: Expense for subsidizing healthy food. Periods 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.

5.5 Policy Recommendations

Given our results, subsidies are superior to taxes because subsidies are both more effective in reducing unhealthy food consumption and they produce higher long term monetary benefits to the society. This suggests that governments should put their efforts into subsidizing healthy food rather than taxing unhealthy food as many countries are currently doing.

Cash incentives is in most circumstances the best policy in reducing unhealthy food consumption but it is an expensive alternative; cash incentives can lead to very significant long term looses for the government. Although subsidies are not as effective as cash incentives, subsidies can significantly reduce unhealthy food consumption and provide with the highest monetary benefits to the society. In our analysis we have not made any reference nor claim about the potential non-monetary benefits of having a healthier population. Thus, although cash incentives may lead to considerably monetary expenses and a deficit in the social security budget, it could be the case that the non-monetary benefits of this policy off-set or justify its implementation. That is an ethical and political issue that is not for us to discuss.

6 Conclusion

In order to handle the obesity problem governments have responded with a variety of interventions: product taxes, banning private advertising of foods that are high in fat, salt and sugar, promoting advertising of the consequences of unhealthy food consumption, banning sale of highly sugar-filled products in public schools, etc. Currently there is a discussion about using cash incentives to promote healthy behaviour. Within this context, we addressed the following questions: are taxes, subsidies or cash incentives effective to reduce unhealthy food consumption? 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. However, when we compare the benefits due to the reduction in costs for the social security system and the implementation costs of the policy, cash incentives can lead to significant monetary losses. Taxes are relatively ineffective in reducing unhealthy food consumption. Finally, we found that subsidies have the best balance between effectiveness and monetary benefits to the society.

Our work contributes to the economic analysis of unhealthy food consumption and to the public debate on how to tackle the obesity problem. The novelty of our paper is that within this topic 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 that are left for possible future research like considering hyperbolic discounting or assuming a non-separable utility function amongst other. Nevertheless, this paper sheds new light on the issue of how to tackle the obesity problem by suggesting that subsides, instead of taxes or cash incentives, may be the solution.

References

[1] Acs, Z. J. and A. Lyles (2007): “Obesity, Business and Public Policy”, Edward Elgar Publishing Ltd.

[2] Becker, G. S. and K. M. Murphy (1988): "A Theory of Rational Addiction", *Journal of Political Economy* 98, 675-700.

[3] Cawley, J. and C. Meyerhoefer (2011): "The Medical Care Costs of Obesity: An Instrumental Variables Approach", *Journal of Health Economics*, forthcoming.

[4] Cutler, D. M., E. L. Glaeser and J. M. Shapiro (2003): "Why Have Americans Become More Obese?", *Journal of Economic Perspectives* 17 (3), 93-118.

[5] Dragone D. and L. Savorelli (2011): "Thinness and Obesity: A Model of Food Consumption, Health Concerns, and Social Pressure", *Journal of Health Economics*, forthcoming.

[6] Finkelstein, E. A., I. C. Fiebelkorn and G. Wang (2003): "National Medical Spending Attributable To Overweight And Obesity: How Much, And Whos Paying?", *Health Affairs* W3, 219-226.

[7] Finkelstein, E. A., J. G. Trogdon, J. W. Cohen and W. Dietz (2009): "Annual Medical Spending Attributable To Obesity: Payer-And Service-Specific Estimates", *Health Affairs*, 822-831.

[8] Fletcher, J. M., D. E. Frisvold and N. Tefft (2010): "The Effects of Soft Drink Taxes on Child and Adolescent Consumption and Weight Outcomes", *Journal of Public Economics* 94, 967-974.

[9] Jacobson, M. F. and K. D. Brownell (2000): "Small Taxes on Soft Drinks and Snack Food to Promote Health", *American Journal of Public Health* 90 (6), 854-857.

[10] Goel, R. K. (2006): "Obesity: An Economic and Financial Perspective", *Journal of Economics and Finance* 30 (3), 317-324.

[11] Gruber, J. and M. Frakes (2006): "Does Falling Smoking Lead to Rising Obesity?", *Journal of Health Economics* 25 (2), 183-197.

[12] Laibson, D., A. Repetto and J. Tobacman (2008): "Estimating Discount Functions with Consumption Choices over the Lifecycle", NBER working paper.

[13] Levy, A. (2002): "Rational Eating: Can It Lead to Overweightness or Underweightness?", *Journal of Health Economics* 21, 887-899.

[14] Rashad, I., M. Grossman and S. Y. Chou (2006): "The Super Size of America: an Economic Estimation of Body Mass Index and Obesity in Adults", *Eastern Economic Journal*, 32 (1), 133-148.

[15] Scarborough, P., P. Bhatnagar, K. Wickramasinghe, S. Allender, C. Foster, M. Rayner (2011): "The Economic Burden of Ill Health due to Diet, Physical Inactivity, Smoking, Alcohol and Obesity in the UK: an Update to 2006-07 NHS Costs", *Journal of Public Health*, May, 1-9.

[16] Yaniv, G. (2002): "Non-Adherence to a Low-Fat Diet: an Economic Perspective", *Journal of Economic Behavior and Organization* 48, 93-104.

[17] Yaniv, G., O. Rosin and Y. Tobol (2009): "Junk-Food, Home cooking, Physical Activity and Obesity: The Effect of the Fat Tax and the Thin Subsidy", *Journal of Public Economics* 93, 823-830.