Received: 22 February 2019 | Revised: 9 October 2019 | Accepted: 14 November 2019

DOI: 10.1002/hec.3987

RESEARCH ARTICLE

WILEY Health Economics

A sales tax is better at promoting healthy diets than the fat tax and the thin subsidy

Zarko Kalamov

Faculty of Economics and Management, University of Technology Berlin, Straße des 17. Juni 135, H51, Berlin, 10623, Germany

Correspondence
Zarko Kalamov, Faculty of Economics and Management, University of Technology Berlin, Straße des 17. Juni 135, H51, 10623 Berlin, Germany.
Email: zarko.y.kalamov@tu-berlin.de

Summary

We analyze how a sales tax levied on all food products impacts the consumption of healthy food, unhealthy food, and obesity. The sales tax can stimulate the consumption of healthy meals by lowering the time costs of food preparation. Moreover, the sales tax lowers obesity under more general conditions than a tax on unhealthy food (fat tax) and a subsidy on healthy food (thin subsidy). We calibrate the model using recent consumption and time use data from the US. The thin subsidy is counterproductive and increases weight. While both the sales tax and the fat tax mitigate obesity, the former imposes a lower excess burden on consumers.

KEYWORDS

fat tax, obesity, sales tax, thin subsidy

JEL CLASSIFICATION

D11; I12; I18; H31; H51

1 | INTRODUCTION

Many countries tax unhealthy foods to address the obesity epidemic: Chile, France, Ireland, Mexico, and the UK among others tax sugar-sweetened beverages (SSBs), Finland taxes sweets and non-alcoholic beverages, while Hungary taxes food products with health risks.

However, these policies may be ineffective or even counterproductive in reducing obesity, as consumers may substitute to untaxed unhealthy food alternatives (Schroeter, Lusk, & Tyner, 2008). To minimize this problem, governments can broaden the tax base (Finkelstein, Zhen, Nonnemaker, & Todd, 2010; Harding & Lovenheim, 2017; Miao, Beghin, & Jensen, 2013). Therefore, nutrient taxes (such as a sugar tax or a fat tax) are more effective than product taxes (such as a tax on SSBs).

This article is the first to propose a sales tax on all food products as an instrument that promotes healthy diets. A sales tax may stimulate healthy consumption by lowering the opportunity cost of cooking time. Moreover, a sales tax imposes a low excess burden on consumers, measured both per kcal reduction in consumption and per dollar of tax revenues.

We model a representative consumer in a model akin to that of Yaniv, Rosin, and Tobol (2009) and take explicitly into account the higher opportunity cost in terms of time of healthy consumption. The individual chooses between consumption of healthy and unhealthy food and has a fixed out-of-work time constraint, which she can spend on cooking meals and leisure. The individual consumes unhealthy meals away-from-home (defined as food prepared away-from-home), and their preparation is not time-consuming. Healthy food is produced at home using both time and ingredients.

We show that the sales tax lowers the opportunity cost of time in food preparation and may thus stimulate healthy consumption. If the elasticity of substitution between healthy and unhealthy food is sufficiently high, the sales tax exerts a positive effect on the demand for healthy meals. A tax on unhealthy foods (called for simplicity a fat tax) and a subsidy to healthy consumption (called a thin subsidy) have qualitatively similar effects on the demand for healthy and unhealthy food. Moreover, we show that the policy, which reduces obesity under the least restrictive conditions, is a positive sales tax in the absence of a fat tax and a thin subsidy.

Our model builds on the empirical observation that home-cooked meals are healthier than away-from-home food. Compared to the consumption of away-from-home meals, intake of home-cooked food is associated with higher intake of fiber, iron, and calcium; lower intake of fat, sodium, and cholesterol; lower calorie density (Guthrie, Lin, & Frazao, 2002; Lin & Frazao, 1997; Lin & Frazao, 1999) and lower weight (Chou, Grossman, & Saffer, 2004; French, Harnack, & Jeffery, 2000). Furthermore, a higher frequency of food preparation raises the consumption of fruits and vegetables and lowers the intake of fat, SSBs and fast-food (Larson, Perry, Story, & Neumark-Sztainer, 2006; Laska, Larson, Neumark-Sztainer, & Story, 2012; McLaughlin, Tarasuk, & Kreiger, 2003; Monsivais, Aggarwal, & Drewnowski, 2014; Wolfson & Bleich, 2015b). The positive dietary impact of frequent cooking occurs irrespectively of the weight-loss intentions of individuals (Wolfson & Bleich, 2015a). Kolodinsky and Goldstein (2011) estimate that ten additional minutes of cooking time lower BMI by 0.13 points. Zick, Stevens, and Bryant (2011) find that ten minutes food preparation lower the BMI of women by 0.17 points and do not affect the BMI of men, who, however, are a small share of the meal preparers in their data.

In Section 4, we calibrate the model according to recent U.S. consumption and time allocation data. We estimate the home production function, the dietary characteristics of at-home- and away-from-home-food and the time allocation decisions such that they match data from the National Health and Nutrition Examination Survey (NHANES) 2009-2010 (CDC, 2010) and the American Time Use Survey (ATUS) 2010 (BLS, 2010). The simulated model makes predictions regarding the own- and cross-price elasticities of healthy and unhealthy food that match existing empirical data on these elasticities.

We find in the benchmark case of our simulation that a 10% sales tax lowers away-from-home consumption of men and women by 7.9% and 4.8%, respectively. On the other hand, men's at-home consumption declines by just 0.01% and that of women rises by 0.01%. Hence, the intake of at-home food remains almost unaffected. As a result, men lose 4% of their weight and women 1.8%. On the other hand, a 10% fat tax induces a stronger substitution of at-home for away-from-home consumption. Consequently, it leads to a lower weight decrease. Moreover, the excess burden of the sales tax, measured using the compensating variation, is lower than that of the fat tax, irrespective of whether we calculate the excess burden as the welfare loss per dollar of tax revenues or per reduction in calorie intake. Furthermore, the sales tax's excess burden is also small in absolute value. It equals around $1-1.7$ cents per dollar of tax revenues and $2-2.9$ cents per 100 kcal reduction in consumption. Lastly, an introduction of a thin subsidy stimulates strong substitution of healthy for unhealthy food, such that weight slightly increases following the subsidy's implementation.

The article from Yaniv et al. (2009) is most related to our paper. They analyze the fat tax and thin subsidy under consideration of the time costs of home-food preparation. Neither policy instrument is unambiguously obesity-reducing because of indeterminate substitution effects on away-from-home food consumption and physical activity.

Bishai (2015) considers the welfare implications of a tax plus subsidy system that raises (lowers) the price of unhealthy (healthy) nutrients but leaves the final product prices unchanged. He shows that such a system may improve welfare.

There is strong empirical evidence that a fat tax does not necessarily reduce weight, because of a possible switch to untaxed alternatives (Chouinard, Davis, LaFrance, & Perloff, 2007; Fletcher, Frisvold, & Tefft, 2010b; Schroeter et al., 2008; Zhen, Finkelstein, Nonnemaker, Karns, & Todd, 2014). Schroeter et al. (2008) estimate that a tax on food-away-from-home and a subsidy on fruit and vegetables may increase obesity. Zhen et al. (2014) show that a tax on SSBs can reduce their consumption at the cost of higher intake of fat and sodium. Furthermore, Fletcher, Frisvold, and Tefft (2010a),Fletcher et al. (2010b) find empirical support that such taxes have a significant effect on SSB consumption, but an insignificant effect on weight. Jeffery, French, Raether, and Baxter (1994) and French et al. (1997) find a significant short-term impact of subsidizing fruits and salads at university and high school cafeteria, which vanishes after the removal of the subsidy.

The rest of the paper is organized as follows. Section 2 develops the model and solves for the optimal consumption mix and time allocation of the representative individual. Section 3 determines the impacts of the fat tax, the thin subsidy and the sales tax on away-from-home and at-home food consumption, and obesity and compares them. In Section 4 we calibrate the model, while Section 5 discusses the policy implications of the results and concludes.

2 | THE MODEL

We consider a one-period model of obesity similar to the framework developed by Yaniv et al. (2009).[1] The representative agent is overweight and may consume either healthy meals H, or unhealthy (away-from-home) meals F.[2] The calorie intake per meal is denoted by δ and ε for unhealthy and healthy food, respectively. Furthermore, we impose $\delta > \varepsilon$, i.e., away-from-home food has more calories per meal (a meal is defined as the food consumed on one eating occasion). The individual burns calories while at rest, which is due to the functioning of the body and is measured by the basal metabolic rate (BMR). We denote the weight gain in the period as S and use it as a measure of obesity. It is given by

$$S = \xi \left(\delta F + \varepsilon H - BMR\right), \tag{1}$$

where $\xi > 0$ is a parameter that converts calorie intake in the corresponding weight change.

The individual purchases unhealthy meals at a restaurant. Thus, their preparation does not require time. On the other hand, healthy meals are prepared at home and require healthy ingredients and time.

Denote the healthy ingredients and time spent cooking by G and k, respectively. We characterize the production of H by the following Leontief production function:

$$H(G,k) = \min\left\{\frac{G}{\alpha}, \frac{k}{\beta}\right\}, \tag{2}$$

where $\alpha > 0$ and $\beta > 0$ determine the quantity of ingredients and time needed to prepare a healthy meal.[3]

Furthermore, the away-from-home meals F and the healthy ingredients G are produced under perfect competition, and their net prices equal the constant marginal costs of production p_F and p_G, respectively. Their gross prices are given by $\tilde{p}_F \equiv p_F(1+\tau_C+\tau_F)$ and $\tilde{p}_G \equiv p_G(1+\tau_C-\sigma)$, respectively, where $\tau_C > 0$ denotes a sales tax, which applies to all food products, $\tau_F > 0$ is a fat tax levied on unhealthy food, and $\sigma > 0$ is a thin subsidy on the healthy ingredients. The individual also purchases a composite good Z with a gross price normalized to equal one. She has an exogenous income I and receives her tax payments back from the government in the form of a lump-sum transfer $TR = (\tau_C+\tau_F)p_F F + (\tau_C-\sigma)p_G G$. Hence, the budget constraint is given by

$$\tilde{p}_F F + \tilde{p}_G G + Z = I + TR. \tag{3}$$

The out-of-work time of the individual is constant and equals T hours. She divides it among time devoted to food preparation k and genuine leisure ℓ. Thus, the time constraint is given by

$$k + \ell = T. \tag{4}$$

The individual derives utility from the total meal consumption C, which is a CES basket of home-cooked and away-from-home meals

$$C = \left(aH^{\rho} + (1-a)F^{\rho}\right)^{\frac{1}{\rho}}, \tag{5}$$

where $a \in [0,1]$ determines the weight of home-prepared meals and $\epsilon_C = 1/(1-\rho) \geq 0$ is the elasticity of substitution between H and F. Furthermore, genuine leisure ℓ is the only welfare-enhancing allocation of time, while time spent cooking k does not give direct utility benefits. Thus, utility is given by

$$U(C,\ell,Z) = C^{1-\eta}\ell^{\eta} + V(Z), \quad \eta \in]0,1[, \tag{6}$$

[1]Additional supporting information containing Appendices A-E may be found online in the Supporting Information section at the end of the article.
[2]The focus on an overweight individual does not affect the results. It is, however, important for their interpretation, as policies beneficial to overweight consumers may be detrimental to under- and normalweight individuals.
[3]The assumption of a Leontief production function does not affect qualitatively the results. In Appendix C, we replace the Leontief function by a CES production function. The main results remain unchanged.

where $V_Z > 0 \geq V_{ZZ}$.

Due to our focus on an obese individual, a positive weight gain $S(F, H)$ has negative health consequences. We define the net utility of the individual as

$$NetU = U(C, \ell, Z) - bS(F, H), \quad b \geq 0, \tag{7}$$

where $bS(F, H)$ is a proxy for the health problems associated with weight gain. Alternatively, one can interpret the parameter b as the weight that the consumer pon health in her objective function. Higher values of b denote a greater degree of weight consciousness of the individual. The consumer makes optimal consumption and time allocation choices to maximize Equation 7.

Before we solve the utility maximization problem, we derive the price of time, which is an important determinant of the demand for home-prepared meals.

2.1 | Opportunity Cost of Time

To derive the price of time, we consolidate the two constraints. First, we use the constant returns property of aggregate consumption C to express it as $C = C_H H + C_F F$ and replace F in Equation 3 by $F = (C - C_H H)/C_F$, where $C_i, i = H, F$ denotes a partial derivative. Furthermore, we express G as αH. Lastly, we use the time constraint to rewrite H as $H = k/\beta = (T - \ell)/\beta$. Thus, we can rewrite Equation 3 as

$$\frac{\tilde{p}_F}{C_F} C + \frac{1}{\beta}\left(\frac{C_H}{C_F}\tilde{p}_F - \alpha\tilde{p}_G\right)\ell + Z = I + TR + \frac{1}{\beta}\left(\frac{C_H}{C_F}\tilde{p}_F - \alpha\tilde{p}_G\right)T. \tag{8}$$

The integrated budget constraint (8) presents the total expenditures in terms of spending on aggregate food consumption, leisure, and the composite good. Total income is composed of the exogenous income I, the transfer TR and the monetary value of the time endowment T. The term in front of ℓ gives the relative price of time in terms of the numéraire Z and represents its opportunity cost. If ℓ goes up, then the time available for cooking declines, which lowers the consumption of healthy meals H by a factor $1/\beta$. This effect saves payments on healthy ingredients amounting to $\alpha\tilde{p}_G/\beta$. However, the individual needs more away-from-home food to consume a given amount of C and, thus, additional payments equal to $(C_H/C_F)\tilde{p}_F/\beta$ arise. Hence, the opportunity cost of time is $(C_H\tilde{p}_F/C_F - \alpha\tilde{p}_G)/\beta$. We assume $C_H\tilde{p}_F/C_F > \alpha\tilde{p}_G$, which guarantees a positive price of leisure and an interior solution to the utility maximization problem.

2.2 | Optimal Consumption and Time Allocation

The consumer maximizes the utility function (7) with respect to healthy consumption H and unhealthy food F subject to the time and budget constraints.

We simplify the utility maximization problem by expressing leisure ℓ and the expenditures on Z as functions of H and F. Solving the budget constraint for Z and using $G = \alpha H$, we get

$$Z = I + TR - \tilde{p}_F F - \tilde{p}_G \alpha H. \tag{9}$$

Using the production function for healthy meals (2), we can rewrite the time spent cooking as $k = \beta H$, which together with the time constraint (4) gives

$$\ell = T - \beta H. \tag{10}$$

Hence, we can express the consumer's problem as the maximization of the net utility function (7) over healthy meals H and unhealthy meals F subject to the constraints (1), (5), (9), and (10). The first-order conditions are given by

$$\frac{\partial NetU}{\partial H} = U_C C_H - U_\ell \beta - V_Z \tilde{p}_G \alpha - b\xi\varepsilon = 0, \tag{11}$$

$$\frac{\partial NetU}{\partial F} = U_C C_F - V_Z \tilde{p}_F - b\xi\delta = 0. \tag{12}$$

Equation 12 shows that healthy consumption has four effects on net utility. First, an increase in H raises aggregate consumption C and, thus, utility at the rate $U_C C_H$. Second, its preparation requires time, such that time devoted to leisure declines and lowers utility according to the term $-U_\ell \beta$. Third, the preparation of H also requires ingredients G which lowers the spending on the composite good. This effect reduces utility by the amount $V_Z\tilde{p}_G\alpha$. Lastly, H raises weight at the rate $\xi\varepsilon$, which lowers utility, if the individual is weight-conscious ($b > 0$). The interpretation of Equation (12) is analogous.

3 | TAXES AND OBESITY

The impact of the tax rates on the demand for H depends not only on their effect on the price of ingredients G but also on the price of cooking time k which is the opportunity cost of foregone leisure. Therefore, a derivation of the policy instruments' effects on the price of leisure is crucial for the understanding of their effects on consumption. Denote the relative price of leisure from Equation 8 as π. Taking the partial derivatives of π with respect to τ_F, τ_C, and σ, we get

$$\pi_{\tau_F} = \frac{C_H p_F}{\beta C_F} > 0, \tag{13a}$$

$$\pi_{\sigma} = \frac{\alpha p_G}{\beta} > 0, \tag{13b}$$

$$\pi_{\tau_C} = \frac{1}{\beta}\left(\frac{C_H}{C_F}p_F - \alpha p_G\right) > 0, \quad \text{if} \quad \tau_F = \sigma = 0. \tag{13c}$$

According to Equations (13a) and (13b), the fat tax and the thin subsidy have a positive effect on the price of leisure. Both τ_F and σ increase the additional expenditures on F that are necessary in order to keep aggregate consumption constant following an increase in leisure time. Hence, they raise the opportunity cost of leisure. A sales tax has the same impact in the absence of a fat tax or a thin subsidy. In this case, the effect of a sales tax is proportional to the price of leisure, i.e. $\pi_{\tau_C}(\tau_F = \sigma = 0) = \pi/(1 + \tau_C)$.

Consider now the effects of the policy instruments on F^* and H^*, where a superscript * denotes the optimal values. We derive these effects by totally differentiating the first-order conditions (11) and (12) with respect to H, F, and the policy parameters. In Appendix A we derive the following results:

Proposition 1.

(i) *An increase in the fat tax τ_F lowers away-from-home consumption F^*. There exists an elasticity of substitution $\overline{\epsilon}_C > 0$, such that a rise in the fat tax raises healthy consumption H^* if $\epsilon_C > \overline{\epsilon}_C$, and lowers it if $\epsilon_C < \overline{\epsilon}_C$.*
(ii) *An increase in the thin subsidy σ raises healthy consumption H^*. A rise in the thin subsidy lowers away-from-home consumption F^* if $\epsilon_C > \overline{\epsilon}_C$, and raises it if $\epsilon_C < \overline{\epsilon}_C$.*
(iii) *In the absence of a fat tax and a thin subsidy, an increase in the sales tax τ_C lowers away-from-home consumption F^*. There exists an elasticity of substitution $\tilde{\epsilon}_C > 0$, such that a rise in the sales tax raises healthy consumption H^* if $\epsilon_C > \tilde{\epsilon}_C$, and lowers it if $\epsilon_C < \tilde{\epsilon}_C$.*

Proof. See Appendix A. □

First, we interpret the effects of the introduction of a fat tax. It imposes three different effects on the demand for H and F. First, it raises the monetary price of away-from-home consumption F relative to at-home food H. Hence, the individual substitutes H for F in order to consume cost-effectively, i.e., to achieve a higher consumption C per one dollar spent on food. Second, τ_F increases the price of leisure according to Equation (13c). Thus, it lowers the opportunity cost of cooking time and stimulates food preparation H^*. Third, aggregate consumption C becomes more expensive relative to non-food products, i.e., there is a negative substitution effect on C, which lowers the demand for both H and F. If the two types of meals are not too complementary, i.e., if the elasticity of substitution between H and F is high enough ($\epsilon_C > \overline{\epsilon}_C$), then H^* goes up despite the decline in aggregate consumption C. On the other hand, if the elasticity of substitution is sufficiently close to zero, the decrease in C requires that both F and H go down.

A thin subsidy also leads to substitution of H for F due to the change in their relative price. Moreover, it stimulates healthy consumption by lowering the opportunity cost of cooking time according to Equation (13b). However, it also lowers the price of aggregate consumption C relative to the composite good Z. Thus, it imposes a positive substitution effect on C which raises both at- and away-from-home food demand. While all three effects increase the demand for H, away-from-home consumption may increase or decline. If the food basket exhibits sufficiently high elasticity of substitution ($\epsilon_C > \bar{\epsilon}_C$), then F^* goes down. On the other hand, if H and F are sufficiently complementary, then unhealthy consumption also goes up.

Lastly, the sales tax works qualitatively in the same way as the fat tax. It imposes negative substitution effects on leisure ℓ and consumption C. While the first effect stimulates H and lowers the demand for F, the latter effect impacts negatively both at- and away-from-home consumption. If H and F are sufficiently substitutable in the basket of goods C, i.e., if $\epsilon_C > \tilde{\epsilon}_C$, the consumption of home-cooked meals is an increasing function of the sales tax.

Proposition 1 is derived under the assumption that the tax revenues are returned to the consumer, and, thus, there are no income effects. It is straightforward to analyze the potential impact of income effects in the absence of the transfer TR. If both leisure ℓ and consumption C are normal goods, then a higher tax τ_F or τ_C lowers income and imposes negative income effects. Lower C would tend to decrease the demand for both H and F, while the negative impact on leisure works in the same direction as the substitution effect on leisure: it stimulates home production H. Therefore, both τ_F and τ_C impose a negative income effect on away-from-home consumption F and an ambiguous income effect on H. Thus, parts (i) and (iii) of Proposition 1 remain qualitatively unchanged. Moreover, a subsidy σ imposes a positive income effect on both C and ℓ, which unambiguously stimulates away-from-home demand and may increase or lower demand for at-home meals. Thus, in the presence of income effects, σ has ambiguous effects on both H^* and F^*.

Next, we consider how the taxes affect obesity. If the change in one policy instrument induces consumers to substitute H for F, then the impact on weight may be minimal or even positive. We derive the following results:

Proposition 2.

(i) *An increase in the fat tax τ_F lowers obesity if $\delta(C_H + C\beta/\ell) > \varepsilon C_F$ and $\delta\alpha p_G > \varepsilon p_F$. Otherwise, its effect on obesity is ambiguous.*

(ii) *An increase in the thin subsidy σ lowers obesity if $\delta(C_H + C\beta/\ell) > \varepsilon C_F$, $\delta\alpha p_G > \varepsilon p_F$, and $\epsilon_C \to \infty$. Otherwise, its effect on obesity is ambiguous.*

(iii) *An increase in the sales tax τ_C in the absence of a fat tax and a thin subsidy lowers obesity if $\delta(C_H + C\beta/\ell) > \varepsilon C_F$. Otherwise, its effect on obesity is ambiguous.*

Proof. See Appendix B. □

Each policy parameter mitigates obesity if it lowers the net calorie intake. First, we interpret the effect of the sales tax on obesity. It is negative if $\delta(C_H + C\beta/\ell) > \varepsilon C_F$. This condition states that the reduction in away-from-home consumption lowers obesity (at a rate δ) by more than a (possible) increase in H raises it (at a rate ε). It derives from the specific relation in which at- and away-from-home food must be consumed for the individual to achieve her optimal consumption-leisure choice. To understand this condition, consider without loss of generality the case where H and F are perfect substitutes (i.e., $\rho = 1$), such that $C_H = a$ and $C_F = (1 - a)$. Using the definition of the consumption bundle C in (5), we get

$$\frac{dC^*}{d\tau_C} = C_H \frac{dH^*}{d\tau_C} + C_F \frac{dF^*}{d\tau_F}. \tag{14}$$

Now use the first-order conditions (11) and (12) to derive the optimal consumption-leisure choice:

$$\frac{U_\ell}{U_C} = \frac{C_F}{\tilde{p}_F}\pi + \frac{b\xi(\delta\alpha\tilde{p}_G - \varepsilon\tilde{p}_F)}{U_C\beta\tilde{p}_F}. \tag{15}$$

This equation states that the marginal rate of substitution between leisure ℓ and consumption C equals the sum of the relative monetary price of leisure, $\pi/(\tilde{p}_F/C_F)$, and the marginal change in utility due to the effect of a substitution between leisure and consumption on weight. In the absence of a fat tax and a thin subsidy, the terms containing the sales tax in (15) cancel out. Hence, the sales tax vanishes from the above equation. Since both marginal utilities U_C and U_ℓ depend only on the ratio C/ℓ, we conclude that C/ℓ must be independent of the sales tax τ_C (in the absence of other taxes). This results translates in $dC^*/d\tau_C = (C/\ell)d\ell^*/d\tau_C$. Using this expression together with $d\ell^* = -dk^* = -dH^*/\beta$ and (14), we get

$$C_F \frac{dF^*}{d\tau_C} = -\left(C_H + \beta\frac{C}{\ell}\right)\frac{dH^*}{d\tau_C}. \tag{16}$$

Hence, the reduction in F is proportional to the increase in at-home consumption H. Moreover, a reduction in F lowers weight at a rate δ, while an increase in H raises it at a rate ε according to $dS = \delta dF^* + \varepsilon dH^*$. Combining this expression with (16) gives the condition $\delta(C_H + C\beta/\ell) > \varepsilon C_F$ for a reduction in obesity. While in the special case $\rho = 1$ this is a necessary condition, when $\rho < 1$ it is only a sufficient condition (as imperfect substitutability unabiguously lowers both dH^* and dF^*).

Consider now τ_F and σ. Both policy instruments may impact the weight gain S negatively if $\delta(C_H + C\beta/\ell) > \varepsilon C_F$ for the same reason as the sales tax. However, they also change the monetary price of F relative to H which leads to a substitution from F to H. The weight gain is a declining function of this relative price if $\delta\alpha p_G > \varepsilon p_F$. Obesity declines following an increase in the fat tax if both conditions are satisfied, while the thin subsidy requires additionally a sufficiently high elasticity of substitution to affect weight negatively. Therefore, we conclude that the sales tax lowers obesity under more general conditions than the fat tax and the thin subsidy.

3.1 | The Government

In this section, we motivate the government's objective of addressing obesity and the criterion we use for the choice of a tax rate. There are two motivations in the literature for the introduction of policies against obesity. First, obesity imposes an externality on society because health insurance companies bear most of the costs of treating obesity-related illnesses (Cawley & Meyerhoefer, 2012). Second, individuals may suffer from self-control problems and develop eating habits that they regret later. Such individuals do not fully take into account the obesity-related health costs and impose an internality on their future selves (O'Donoghue & Rabin, 2006).

Suppose the government aims to internalize either the externality or the internality of obesity or both. It must choose the most appropriate instrument. Following Miao et al. (2013),Harding and Lovenheim (2017), we assume that the government's objective is to choose the tax instrument that lowers obesity at the lowest welfare loss for consumers.[4] Therefore, our next step is to compare the three tax instruments according to their welfare costs. Unfortunately, a comparison of these costs is intractable in the theoretical model. To gain more intuition regarding their effects, we calibrate the model in the next section.

4 | CALIBRATION

We calibrate the model so that it fits consumption and time use data from the US during 2009-2010. We simulate the model separately for men and women, as they differ in both their dietary and time allocation choices.

In this section, we assume that utility derived from the consumption of the composite good Z is logarithmic, i.e., $V(Z) = \ln(Z)$. Furthermore, we follow Buttet and Dolar (2015) and assume that the basal metabolic rate BMR is a linear function of weight

$$\mathrm{BMR}^i = \nu_0^i + \nu_1^i W^i, \tag{17}$$

where the index $i = m, f$ denotes the gender of the individual (male or female), $\nu_0^i > 0, \nu_1^i > 0$ are constants, and W^i represents weight.

4.1 | Data

We use the survey data from the National Health and Nutrition Examination Survey (NHANES) 2009-2010 (CDC, 2010). NHANES is a program of the National Center for Health Statistics and uses interviews and physical examinations to determine the health and nutritional status of the US population. NHANES provides dietary data that includes the number of meals consumed at home H, away-from-home F, the quantity of ingredients G, and calories per meal (ε and δ in our model). We report this data in Table 1. Per day the average male (female) has 3.76 (4.08) eating occasions at home and 1.79 (1.56) away-from-home. The calories per meal ε and δ appear in Panel B of Table 1. The reported estimates confirm our initial assumption that away-from-home food is more calorie-dense, i.e., $\delta^i > \varepsilon^i$.[5] Figure E.1 in Appendix E plots the values of δ^i and ε^i with 95% confidence intervals, while Figures E.2-E.4 present the same values for different BMI, age, and income groups. The differential $\delta^i - \varepsilon^i$ remains positive in all sub-groups but loses significance in some of them.

[4] Miao et al. (2013) compare two nutrient taxes: on added sugars and solid fat. Harding and Lovenheim (2017) consider different product and nutrient taxes.

[5] A Wald test rejects the Null hypothesis $\delta^i = \varepsilon^i$ with p-values < 0.0001 for both genders.

When looking at the BMI sub-populations, the difference between the kcal per meal is largest for the overweight and obese individuals, and smaller for the under- and normalweight. The next parameter in Panel B is the multiplier ξ that translates calorie intake in weight change. Hall, Guo, Dore, and Chow (2009) estimate that a weight gain of 10 kg is associated with a rise in consumption of around 220 kcal/day above what is needed to maintain an individual's current weight. Thus, we set $\xi = 10/220 \approx 0.045$ kg/kcal/day. In addition, Panel B reports two parameters that are not part of the calibration but are nevertheless important for an assessment of the healthiness of different meals: added sugar and saturated fat per meal consumed at- and away-from-home. Both are significantly larger in away-from-home food. The weights of the representative male and female individuals are reported in Panel C of Table 1 and come from the NHANES survey 2009-2010. To calculate the BMR parameters, we use data from Trumbo, Schlicker, Yates, and Poos (2002) who find that men need additional 15.91 kcal per extra kg to maintain a constant weight, while this parameter is 9.36 kcal per extra kg for women. Therefore, we choose $\nu_1^m = 15.91, \nu_1^f = 9.36$. We set the value of the parameter ν_0^i such that the representative consumer has a steady state weight, i.e., the weight change S^i is zero:

$$S^i = 0 = \xi(\delta^i F^i + \varepsilon^i H^i - \nu_0^i - \nu_1^i W^i), \quad i = m, f.$$

The resulting values for ν_0^i are reported in Table 1.

We use time allocation data from the 2010 American Time Use Survey (ATUS) conducted by the Bureau of Labor Statistics (BLS, 2010). It provides nationally representative estimates of the time use of the U.S. population. Panel D of Table 1 reports the time use data. Cooking time k refers to the ATUS category "food preparation and cleanup", while leisure time ℓ refers to the category "leisure and sports" and includes socializing, relaxing, leisure, attending sporting events and exercising. We estimate the total out-of-work time T as the sum of the cooking and leisure time.[6]

In Panel E of Table 1 we estimate the parameters of the home production function for each gender such that they satisfy the dietary and time use data from panels A and D.

Next, we turn to the estimation of the gross food prices $\tilde{p}_G$ and $\tilde{p}_F$. We derive them in two steps. First, we follow the approach of Buttet and Dolar (2015) for estimation of the price per calorie for at-home consumption $\tilde{p}_G\alpha/\varepsilon$ and for away-from-home consumption $\tilde{p}_F/\delta$. The second step consists in using the mean values for α, ε and δ to derive the gross prices. Buttet and Dolar (2015) use the following expression to define the per calorie prices:

$$\text{Price per calorie}_i = \frac{\text{Per capita daily expenditures for food } i}{\text{Per capita daily calories produced of food } i}, \quad i = H, F. \tag{18}$$

The data used in the estimation of Eq. 18 is presented in Table 2. We derive the prices for the year 2010. We calculate the per-capita daily spending on the food of type i by multiplying the expenditure share of type i (provided by the U.S. Department of Agriculture Food Expenditure Series USDA/ERS, 2010b) by the per-capita daily income I = \$97.76 (BEA, 2010). To estimate the produced calories of food of type i, we use the total per-capita calorie production per day in 2010 which amounts to 2481 kcal (USDA/ERS, 2010a). We allocate it to each type of food according to their shares in calorie consumption. We report the resulting prices in Table 2.

We now have all the necessary parameters for the estimation of the model except for the preference parameters a, ϵ_C, η, b. There are several estimates of the elasticity of substitution ϵ_C. While an early study of Benhabib, Rogerson, and Wright (1991) finds $\epsilon_C = 5$, Aguiar, Hurst, and Karabarbounis (2011) report that $\epsilon_C = 2.5$ can best explain the allocation of time of U.S. households. Karabarbounis (2014) finds $\epsilon_C = 3.9$, while estimates by Rupert, Rogerson, and Wright (1995), McGrattan, Rogerson, and Wright (1997), Chang and Schorfheide (2003) are in the range between 1.8 and 2.3. Therefore, it is plausible to assume that the actual elasticity of substitution is in the interval [2, 5]. In the benchmark model, we use the estimate of Karabarbounis (2014) (see Panel A of Table 3).[7] Moreover, Karabarbounis (2014) estimates the share of home-produced goods in the basket C to be equal to approximately two-thirds, and we set $a = 0.67$.

[6]Note that the total out-of-work time T is larger for men than it is for women. The reason is that the two genders allocate their time differently to other uses. Whether and how the taxes considered in this paper affect other time uses (such as, e.g., the labor supply) is beyond the scope of this paper and left for future research.

[7]All of the cited studies estimate ϵ_C as the elasticity of substitution between home- and market-produced goods and are, thus, more general than the definition of ϵ_C in our model. Because the elasticity of substitution between at-home and away-from-home food may differ from the general elasticity, we perform robustness checks in Appendix D for $\epsilon_C = 2$ and $\epsilon_C = 5$, i.e., the high- and low-estimates in the literature. Our results remain qualitatively unchanged.

TABLE 1 Dietary data, weight, time use data and food preparation parameters for U.S. adults age 15 years and older (standard error in parenthesis)

	Male	Female
A. Dietary Data[a]		
H:	3.76 (0.054)	4.08 (0.059)
F:	1.79 (0.044)	1.56 (0.056)
G in thousand grams:	2.59 (0.05)	2.17 (0.039)
B. Dietary Parameters[b]		
ε:	467 (7.80)	326 (5.27)
δ:	561 (14.02)	400 (12.73)
ξ:	0.045	0.045
added sugar in grams/meal (H):	14.23 (0.46)	11.06 (0.29)
added sugar in grams/meal (F):	21.48 (0.92)	15.61 (0.78)
saturated fat in grams/meal (H):	8.34 (0.27)	5.73 (0.12)
saturated fat in grams/meal (F):	10.06 (0.47)	7.14 (0.33)
C. Weight[a] **and BMR Parameters**[c]		
Weight in kg:	88.02 (0.63)	74.75 (0.38)
v_0:	1359.77	1254.69
v_1:	15.91	9.36
D. Time Use Data[d]		
k in hours:	0.32	0.79
ℓ in hours:	5.57	4.82
T in hours:	5.89	5.61
E. Food Preparation Parameters[e]		
α:	0.688	0.533
β:	0.085	0.194

[a]Source: Author's calculations based on NHANES 2009 – 2010 (CDC, 2010).

[b]Sources: ε and δ from author's calculations based on NHANES 2009 – 2010 (CDC, 2010), ξ from Hall et al. (2009).

[c]Source: Trumbo et al. (2002) and author's calculations.

[d]Source: Bureau of Labor Statistics ATUS 2010 Table A-1 BLS (2010).

[e]Source: Author's calculations.

To capture the different dietary and time allocation data for men and women, we allow for gender-specific values of the share of leisure in the utility function η and the degree of weight-consciousness b. We estimate these parameters by inserting all parameters from Tables 1, 2 and Panel A of Table 3 in the first-order conditions (11) and (12) separately for each gender. The values of η and b that solve the first-order conditions are reported in Panel B of Table 3.[8] Note that the parameter b is much higher for women than for men. One possible explanation for this result is that women are more weight-conscious than men (see Parmenter, Waller, and Wardle (2000) for empirical evidence). Moreover, obese women are more likely to have weight loss intentions than obese men (Assari & Lankarani, 2015). Furthermore, a higher b value may also indicate additional health costs of being obese for women, such as higher probability of infertility (Silvestris, de Pergola, Rosania, & Loverro, 2018) and higher risk of developing breast cancer (Picon-Ruiz, Morata-Tarifa, Valle-Goffin, Friedman, & Slingerland, 2017).[9] Moreover, obesity impacts negatively womens' wages but not mens' (Cawley, 2004). However, one additional possible explanation for this result may be the choice to model the utility costs of obesity linearly in the weight-gain. Since women weigh on average less, a given absolute weight gain translates in a larger relative change for them and, thus, larger health costs.

Before we proceed to the effects of tax rate changes, we evaluate the suitability of our model for analyzing consumption choices. We use the model to predict the own-price, and cross-price elasticities of H and F, as well as the elasticity of non-food purchases with respect to food prices. The estimates are weighted averages of the elasticities for men and women, where we use the gender shares in the consumption of each good as weights. We report them in the second column of Table 4, where $\epsilon_{ij}, i = H, F, Z, j = H, F$ denotes the elasticity of good i with respect to the price of food of type j. These predictions are evaluated against recent elasticity estimates for the U.S. from Okrent and Alston (2012). Okrent and Alston determine the elasticities separately for six food groups of type H, and we aggregate them according to the expenditure shares of each group (see Appendix D for details). The aggregated estimates of Okrent and Alston (2012) are

[8]In the derivation of the parameters η and b, we estimate the expenditures for the composite good as $Z^i = I - \tilde{p}_G G^i - \tilde{p}_F F^i, \quad i = f, m$.
[9]The author would like to thank an anonymous referee for this interpretation.

TABLE 2 Income and price estimates

Year	2010
A. Food Expenditures and Calorie Production[a]	
Daily real disposable income I (2009 dollars):	\$97.76
Expenditure Share H:	0.055
Expenditure Share F:	0.04
Calorie production:	2481
Calorie Share H:	0.668
Calorie Share F:	0.332
B. Price Estimates[b]	
Price per thousand kcal H ($\tilde{p}_G \alpha/\epsilon$):	3.26
Price per thousand kcal F ($\tilde{p}_F/\delta$):	4.77
$\tilde{p}_G$:	2.12
$\tilde{p}_F$:	2.29

[a]Sources: Expenditure shares data from USDA Food Expenditure Series (USDA/ERS, 2010b), income data from Bureau of Economic Analysis - NIPA Table 2.1 Personal Income and its Disposition (BEA, 2010), calorie production from USDA Food Availability Data System (USDA/ERS, 2010a), shares in calorie production from NHANES 2009 – 2010 (CDC, 2010).

[b]Source: Author's calculations.

TABLE 3 Preference parameters

	Male	Female
A. Consumption Basket C[a]		
$\epsilon_C = 1/(1-\rho)$:	3.9	3.9
a:	0.67	0.67
B. Calibrated Parameters[b]		
η:	0.88	0.72
b:	1.99×10^{-3}	6.89×10^{-3}

[a]Source: Karabarbounis (2014).

[b]Source: Author's calculations.

TABLE 4 Evaluation of the model

	Empirical Data[a]		Model Predictions[b]	
	Male	Female	Male	Female
ϵ_{HH}:	−0.076		−0.134	
ϵ_{HF}:	0.24		0.14	
ϵ_{FH}:	0.29		0.16	
ϵ_{FF}:	−0.71		−0.89	
ϵ_{ZH}:	−0.16		−0.055	
ϵ_{ZF}:	−0.06		−0.012	

[a]Sources: Expenditures shares data from USDA Food Expenditure Series (USDA/ERS, 2010b), price elasticity data from Okrent and Alston (2012).

[b]Source: Author's calculations.

reported in the first column of Table 4. The model's predictions both coincide in sign with the empirical data and are very close in absolute values. Okrent and Alston (2012) find H to be highly inelastic ($\epsilon_{HH} = -0.076$), while the model predicts $\epsilon_{HH} = -0.134$. The own-price elasticities for F are also similar with $\epsilon_{FF} = -0.71$ according to Okrent and Alston (2012) and $\epsilon_{FF} = -0.89$ from the model. Both the empirical estimates and the model report slightly positive cross-price elasticities of the food products and slightly negative elasticities of non-food purchases with respect to both food prices. Therefore, the model matches the empirical observations that (i) H and F and gross substitutes and (ii) food and non-food products are gross complements.

4.2 | Evaluation of tax policy

In this section, we evaluate tax policy according to its impact on the consumption of healthy meals H, unhealthy meals F, weight W and excess burden EB. The weight change is measured as a percentage change relative to the initial weight, i.e.

TABLE 5 Simulation of the tax policy effects on consumption and weight

	$\tau_F = 10\%$		$\sigma = 10\%$		$\tau_C = 10\%$	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
Consumption, weight and utility effects[a]:						
$\%\Delta F$:	−10.4	−5.77	−2.74	−1.04	−7.89	−4.78
$\%\Delta H$:	1.96	0.79	2.04	0.74	−0.014	0.005
$\%\Delta W$:	−3.59	−1.54	0.42	0.2	−4.06	−1.75
CV ($/day):	0.39	0.35	−0.55	−0.46	0.94	0.81
EB/TR:	0.057	0.03	0.01[b]	0.004[b]	0.017	0.01
$EB/kcal$ (cent/kcal):	0.03	0.04	–[c]	–[c]	0.02	0.029

[a]Source: Author's calculations.

[b]Excess burden measured as a proportion of the absolute value of tax revenues.

[c]Due to the increase of calorie intake in this case, the excess burden per reduction in calorie intake is not defined.

$\%\Delta W^i = S^i/W^i, i = f, m$, where the initial weight W^i is reported in Table 1. The welfare effect of taxation is measured by the compensating variation (CV). We calculate the CV of a tax rate increase as the transfer that equates the after-tax net utility of the consumer to its pre-tax level. Next, we compute the excess burden of taxation as $EB = CV - TR$. Then, we compare the tax instruments according to two criteria: (i) excess burden per dollar of tax revenue and (ii) excess burden per kcal reduction in consumption.

We report the results in Table 5. The first scenario considers a 10% fat tax. It results in a substantial decline in away-from-home consumption (−5.77% for women and −10.4% for men) and an increase in at-home consumption (0.79% for women and 1.96% for men). The latter effect mitigates the impact of the tax, and the overall weight reduction is −3.59% for men and −1.54% for women. These weight losses amount to an absolute decline of 3.2 kg for men and 1.15 kg for women. The compensating variation of this tax equals 0.39 $/day (0.35 $/day) for men and women, respectively.

On the other hand, a 10% subsidy σ leads to an almost identical increase in the number of healthy meals H but a much smaller reduction in the number of unhealthy meals F. As a result, the thin subsidy is counterproductive and increases weight slightly. The thin subsidy creates a negative CV (utility gain). However, since this policy is counterproductive, we view it as the worst alternative with respect to the objective of mitigating obesity. Nevertheless, the subsidy is likely to be beneficial for underweight individuals, as well as for poor and undernourished individuals.

We report the impact of a 10% sales tax in the last two columns of Table 5. It results in an intermediate decline in F (−7.89% for men and −4.78% for women) and leaves the number of healthy meals almost unchanged: the decline in H^m amounts to 0.014%, while H^f increases by 0.005%. Since the consumption of food-at-home does not change, this policy results in the most substantial weight loss: −4.06% (3.57 kg) and −1.75% (1.31 kg) for men and women, respectively. While the CV of this policy is higher than the CV of a fat tax, it is much more efficient in reducing weight. The excess burden of τ_C as a proportion of tax revenues is less than half of the same measure for the fat tax. The excess burden per kcal of the sales tax is about two-thirds of the same deadweight loss measure for τ_F. Moreover, the excess burden of τ_C is very low in absolute value. The sales tax imposes a deadweight loss of $1 - 1.7$ cents per dollar of tax revenues and $2 - 2.9$ cents per 100 kcal change in consumption.

As an extension, we consider a combination of the fat tax and the thin subsidy (see Table E.1 in Appendix E). The fat tax equals 10% and the thin subsidy is chosen such that the system is self-financing and equals approximately 6.7%. In calculating the revenue neutral tax reform, we assume equal proportions of male and female consumers. The combination is more effective at lowering away-from-home consumption than any of the other scenarios but also results in the largest increase in at-home consumption. The resulting weight changes are −3.2% for men and −1.4% for women. However, the excess burden per kcal change in consumption is higher than in the case of a fat tax only. The reason for the high excess burden is the fact that the strong substitution for at-home meals mitigates the impact of this scenario on weight.

According to Proposition 1, the effects of the policy instruments depend on the exact value of the elasticity of substitution between F and H. The results in Table 5 are derived under the assumption $\epsilon_C = 3.9$. However, the empirical estimates of the elasticity of substitution are in the range between 2 and 5. Therefore, in Appendix E we perform a sensitivity analysis by considering both $\epsilon_C = 2$ and $\epsilon_C = 5$. The results remain qualitatively unchanged (see Table E.2 Appendix E). Moreover, when $\epsilon_C = 5$, the sales tax raises the consumption of home-prepared meals by 0.5% and 0.3% for men and women, respectively. Thus, the threshold value $\tilde{\epsilon}_C$ above which healthy consumption is increasing in the sales tax is within the range of empirical estimates for ϵ_C. Additionally, Figures E.5 and E.6 plot the excess burden per kcal reduction in consumption and per dollar of tax revenues for both the fat tax and the sales tax as functions of ϵ_C. The two figures show that as the degree of substitutability declines, the excess burden values get nearer and intersect at ϵ_C values slightly above one. Hence, when the elasticity of substitution is less than unity, the calibration predicts lower efficiency costs of the fat tax. Nevertheless, such values lie outside the range of empirical estimates for ϵ_C.

As an additional robustness check, we compare the excess burden of the fat tax and the thin subsidy for different kcal per meal values ε^i and δ^i in Figures E.7 and E.8. We let ε^i and δ^i vary simultaneously between the lower and upper bounds of their 95% confidence intervals. The fat tax exerts higher excess burden than the sales tax for all combinations of ε^i and δ^i values.

5 | CONCLUSIONS

This paper has compared three different policy instruments, which can be used to address the problem of rising obesity levels: a fat tax (levied on food-away-from-home), a thin subsidy (levied on groceries that enter home food preparation) and a sales tax on all food items. First, we show that a sales tax may stimulate time-intensive healthy consumption by lowering the opportunity cost of time spent on food preparation. Therefore, it may exert a positive effect on the demand for healthy meals. If healthy and unhealthy meals are perfect substitutes, then all three policy instruments have the same qualitative impact on the consumer's demand: they reduce the consumption of unhealthy meals and raise the consumption of healthy food. Second, the policy which reduces obesity under the most general conditions is a sales tax in the absence of the fat tax and the thin subsidy.

A calibration of the model shows that the sales tax mitigates obesity at the lowest welfare cost for consumers. Furthermore, the deadweight cost of the sales tax is small is absolute value. It imposes an excess burden of less than 2 cents per dollar of tax revenues and 3 cents per 100 kcal reduction in the calorie-intake.

Our results open ample opportunities for future research. While this article extends the model of Yaniv et al. (2009) to include a general elasticity of substitution between food at-home and away-from-home and the possibility of non-food purchases, we do not consider the choice of physical exercise. Including it may produce further interesting results on the effects of a sales tax.

Additionally, this article hightlights the role of the price of time in consumption choices. It explains the higher time spent cooking by women through lower opportunity cost of leisure. Gender differences in the price of time are likely caused by the gender wage gap, as documented by Zick et al. (2011). These authors use wage regressions from the March Supplement of the Current Population Survey (CPS) and find the opportunity cost of time for men and women to be 20.57 $/hour and 16.84 $/hour, respectively. The gender wage gap is also likely to contribute to unequal distribution of cooking time in non single-adult households. Moreover, closing of the gap is likely to affect this distribution. Hence, more research is necessary to analyze how different opportunity costs of time and the elimination of these differences may affect household production.

Moreover, future work should compare the sales tax to nutrient-specific taxes such as a tax on sugar or fat content. The sales tax may be more efficient in promoting healthy diets as it targets several unhealthy nutrients at once by lowering away-from-home consumption. Furthermore, a comparison to the tax plus subsidy system of Bishai (2015) along the same lines is necessary.

This paper has contributed to the literature by emphasizing the time costs of healthy consumption and showing their importance for the optimal policy design. Future research should focus on analyzing other policies that lower the opportunity cost of home food preparation or provide other incentives for cooking. Two public health programs that have already been implemented in the US are the Supplemental Nutrition Assistance Program (SNAP) Healthy Incentives Pilot which provides financial incentives for the purchase of fruits and vegetables and the Women, Infants, and Children (WIC) Farmer's Market Nutrition program which issues coupons to participants to buy foods from farmers (Smith, Ng, & Popkin, 2013). An evaluation of the effects of these programs on the participants' cooking habits is an important research agenda.

Taxing all food products may be regressive, as poor households spend a larger proportion of their income on food relative to rich households. As a result, an important agenda for future research is to quantify this effect and analyze how governments should spend the tax receipts, such that the tax becomes less regressive. Additionally, it is well-known that a fat tax is also regressive (see, e.g., Chouinard et al. (2007)). Therefore, future work should compare the regressivity of a fat tax to that of a sales tax.

ORCID

Zarko Kalamov https://orcid.org/0000-0002-1016-3415

REFERENCES

Aguiar, M. A., Hurst, E., and Karabarbounis, L. (2011). Time Use During Recessions. NBER Working Papers 17259, National Bureau of Economic Research, Inc.

Assari, S., & Lankarani, M. M. (2015). The association between obesity and weight loss intention weaker among Blacks and men than Whites and women. *Journal of Racial and Ethnic Health Disparities*, *2*(3), 414–420. https://doi.org/10.1007/s40615-015-0115-x

BEA (2010). Table 2.1 Personal income and its disposition. https://www.bea.gov/national/index.htm (Access February 10, 2017), U.S. Bureau of Economic Analysis.

Benhabib, J., Rogerson, R., & Wright, R. (1991). Homework in macroeconomics: Household production and aggregate fluctuations. *Journal of Political Economy*, *99*(6), 1166–1187. https://doi.org/10.1086/261796

Bishai, D. (2015). Generalized nutrient taxes can increase consumer welfare. *Health Economics*, *24*(11), 1517–1522. https://doi.org/10.1002/hec.3101

BLS (2010). American Time Use Survey Table A-1. https://www.bls.gov/tus/tables.htm (Access February 10, 2017), Bureau of Labor Statistics, United States Department of Labor.

Buttet, S., & Dolar, V. (2015). Toward a quantitative theory of food consumption choices and body weight. *Economics and Human Biology*, *17*, 143–156. https://doi.org/10.1016/j.ehb.2014.10.001

Cawley, J. (2004). The impact of obesity on wages. *Journal of Human Resources*, *39*(2), 451–474. https://doi.org/10.2307/3559022

Cawley, J., & Meyerhoefer, C. (2012). The medical care costs of obesity: An instrumental variables approach. *Journal of Health Economics*, *31*(1), 219–230. https://doi.org/10.1016/j.jhealeco.2011.10.003

CDC (2010). National Health and Nutrition Examination Survey 2009-2010. https://wwwn.cdc.gov/Nchs/Nhanes/ContinuousNhanes/Default.aspx?BeginYear=2009 (Access February 10, 2017), Centers for Disease Control and Prevention, National Center for Health Statistics.

Chang, Y., & Schorfheide, F. (2003). Labor-supply shifts and economic fluctuations. *Journal of Monetary Economics*, *50*(8), 1751–1768. https://doi.org/10.1016/j.jmoneco.2003.02.001

Chou, S.-Y., Grossman, M., & Saffer, H. (2004). An economic analysis of adult obesity: Results from the behavioral risk factor surveillance system. *Journal of Health Economics*, *23*(3), 565–587. https://doi.org/10.1016/j.jhealeco.2003.10.003

Chouinard, H. H., Davis, D. E., LaFrance, J. T., and Perloff, J. M. (2007). Fat taxes: Big money for small change. Forum for Health Economics and Policy.

Finkelstein, E. A., Zhen, C., Nonnemaker, J., & Todd, J. E. (2010). Impact of targeted beverage taxes on higher- and lower-income households impact of targeted beverage taxes on households. *Archives of Internal Medicine*, *170*(22), 2028–2034. https://doi.org/10.1001/archinternmed.2010.449

Fletcher, J. M., Frisvold, D., & Tefft, N. (2010a). Can soft drink taxes reduce population weight? *Contemporary Economic Policy*, *28*(1), 23–35. https://doi.org/10.1111/j.1465-7287.2009.00182.x

Fletcher, J. M., Frisvold, D., & Tefft, N. (2010b). The effects of soft drink taxes on child and adolescent consumption and weight outcomes. *Journal of Public Economics*, *94*(11-12), 967–974. https://doi.org/10.1016/j.jpubeco.2010.09.005

French, S. A., Harnack, L., & Jeffery, R. W. (2000). Fast food restaurant use among women in the pound of prevention study: Dietary, behavioral and demographic correlates. *International Journal of Obesity*, *24*, 1353–1359. https://doi.org/10.1038/sj.ijo.0801429

French, S. A., Story, M., Jeffery, R. W., Snyder, P., Eisenberg, M., Sidebottom, A., & Murray, D. (1997). Pricing strategy to promote fruit and vegetable purchase in high school cafeterias. *Journal of the American Dietetic Association*, *97*(9), 1008–1010. https://doi.org/10.1016/S0002-8223(97)00242-3

Guthrie, J. F., Lin, B.-H., & Frazao, E. (2002). Role of food prepared away from home in the american diet, 1977-78 versus 1994-96: Changes and consequences. *Journal of Nutrition Education and Behavior*, *34*(3), 140–150. https://doi.org/10.1016/S1499-4046(06)60083-3

Hall, K. D., Guo, J., Dore, M., & Chow, C. C. (2009). The progressive increase of food waste in america and its environmental impact. *PLoS ONE*, *4*(11), 1–6.

Harding, M., & Lovenheim, M. (2017). The effect of prices on nutrition: Comparing the impact of product- and nutrient-specific taxes. *Journal of Health Economics*, *53*, 53–71. https://doi.org/10.1016/j.jhealeco.2017.02.003

Jeffery, R., French, S., Raether, C., & Baxter, J. (1994). An environmental intervention to increase fruit and salad purchases in a cafeteria. *Preventive Medicine*, *23*(6), 788–792. https://doi.org/10.1006/pmed.1994.1135

Karabarbounis, L. (2014). Home production, labor wedges, and international business cycles. *Journal of Monetary Economics*, *64*(C), 68–84. https://doi.org/10.1016/j.jmoneco.2014.02.001

Kolodinsky, J., & Goldstein, A. (2011). Time use and food pattern influences on obesity. *Obesity*, *19*(12), 2327–2335. https://doi.org/10.1038/oby.2011.130

Larson, N. I., Perry, C. L., Story, M., & Neumark-Sztainer, D. (2006). Food preparation by young adults is associated with better diet quality. *Journal of the American Dietetic Association*, *106*(12), 2001–2007. https://doi.org/10.1016/j.jada.2006.09.008

Laska, M. N., Larson, N. I., Neumark-Sztainer, D., & Story, M. (2012). Does involvement in food preparation track from adolescence to young adulthood and is it associated with better dietary quality? Findings from a 10-year longitudinal study. *Public Health Nutrition*, *15*(7), 1150–1158. https://doi.org/10.1017/S1368980011003004

Lin, B. H. and Frazao, E. (1999). Away-from-home foods increasingly important to quality of american diet. USDA Agricultural Information Bulletin No. 749.
Lin, B.-H. and Frazao, E. (1997). Nutritional quality of foods at and away from home. *Food Review: The Magazine of Food Economics*, *20*(2).
McGrattan, E. R., Rogerson, R., & Wright, R. (1997). An equilibrium model of the business cycle with household production and fiscal policy. *International Economic Review*, *38*(2), 267–290. https://doi.org/10.2307/2527375
McLaughlin, C., Tarasuk, V., & Kreiger, N. (2003). An examination of at-home food preparation activity among low-income, food-insecure women. *Journal of the American Dietetic Association*, *103*(11), 1506–1512. https://doi.org/10.1016/j.jada.2003.08.022
Miao, Z., Beghin, J. C., & Jensen, H. H. (2013). Accounting for product substitution in the analysis of food taxes targeting obesity. *Health Economics*, *22*(11), 1318–1343. https://doi.org/10.1002/hec.2885
Monsivais, P., Aggarwal, A., & Drewnowski, A. (2014). Time spent on home food preparation and indicators of healthy eating. *American Journal of Preventive Medicine*, *47*(6), 796–802. https://doi.org/10.1016/j.amepre.2014.07.033
O'Donoghue, T., & Rabin, M. (2006). Optimal sin taxes. *Journal of Public Economics*, *90*(10-11), 1825–1849. https://doi.org/10.1016/j.jpubeco.2006.03.001
Okrent, A. M. and Alston, J. M. (2012). The demand for disaggregated food-away-from-home and food-at-home products in the United States. Economic Research Service ERR-139, U.S. Department of Agriculture.
Parmenter, K., Waller, J., & Wardle, J. (2000). Demographic variation in nutrition knowledge in England. *Health Education Research*, *15*(2), 163–174. https://doi.org/10.1093/her/15.2.163
Picon-Ruiz, M., Morata-Tarifa, C., Valle-Goffin, J. J., Friedman, E. R., & Slingerland, J. M. (2017). Obesity and adverse breast cancer risk and outcome: Mechanistic insights and strategies for intervention. *CA: a Cancer Journal for Clinicians*, *67*(5), 378–397. https://doi.org/10.3322/caac.21405
Rupert, P., Rogerson, R., & Wright, R. (1995). Estimating substitution elasticities in household production models. *Economic Theory*, *6*(1), 179–193. https://doi.org/10.1007/BF01213946
Schroeter, C., Lusk, J., & Tyner, W. (2008). Determining the impact of food price and income changes on body weight. *Journal of Health Economics*, *27*(1), 45–68. https://doi.org/10.1016/j.jhealeco.2007.04.001
Silvestris, E., de Pergola, G., Rosania, R., & Loverro, G. (2018). Obesity as disruptor of the female fertility. *Reproductive Biology and Endocrinology*, *16*(1), 1–13.
Smith, L. P., Ng, S. W., & Popkin, B. M. (2013). Trends in us home food preparation and consumption: Analysis of national nutrition surveys and time use studies from 1965–1966 to 2007–2008. *Nutrition Journal*, *12*(1), 1–10.
Trumbo, P., Schlicker, S., Yates, A. A., & Poos, M. (2002). Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. *Journal of the American Dietetic Association*, *102*(11), 1621–1630. https://doi.org/10.1016/S0002-8223(02)90346-9
USDA/ERS (2010a). Food Availability (Per Capita) Data System. https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/ (Access February 10, 2017), U.S. Department of Agriculture, Economic Research Service.
USDA/ERS (2010b). Food expenditure series. https://www.ers.usda.gov/data-products/food-expenditures/ (Access February 10, 2017), U.S. Department of Agriculture, Economic Research Service.
Wolfson, J., & Bleich, S. (2015a). Is cooking at home associated with better diet quality or weight-loss intention? *Public Health Nutrition*, *18*(8), 1397–1406. https://doi.org/10.1017/S1368980014001943
Wolfson, J. A., & Bleich, S. N. (2015b). Fruit and vegetable consumption and food values: National patterns in the United States by supplemental nutrition assistance program eligibility and cooking frequency. *Preventive Medicine*, *76*, 1–7. https://doi.org/10.1016/j.ypmed.2015.03.019
Yaniv, G., Rosin, O., & Tobol, Y. (2009). Junk-food, home cooking, physical activity and obesity: The effect of the fat tax and the thin subsidy. *Journal of Public Economics*, *93*(5-6), 823–830. https://doi.org/10.1016/j.jpubeco.2009.02.004
Zhen, C., Finkelstein, E. A., Nonnemaker, J. M., Karns, S. A., & Todd, J. E. (2014). Predicting the effects of sugar-sweetened beverage taxes on food and beverage demand in a large demand system. *American Journal of Agricultural Economics*, *96*(1), 1–25. https://doi.org/10.1093/ajae/aat049
Zick, C. D., Stevens, R. B., & Bryant, W. K. (2011). Time use choices and healthy body weight: A multivariate analysis of data from the american time use survey. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), 1–14.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: Kalamov Z. A sales tax is better at promoting healthy diets than the fat tax and the thin subsidy. *Health Economics*. 2020;29:353–366. https://doi.org/10.1002/hec.3987