Journal of Agricultural and Applied Economics, 40,2(August 2008):507–521

The Effect of Food-Away-from-Home and Food-at-Home Expenditures on Obesity Rates: A State-Level Analysis

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Using state-level data from the Behavioral Risk Factor Surveillance System, we investigate the effects of household food-away-from-home and food-at-home expenditures on overweight rates, obesity rates, and combined rates. Our random effects model estimates suggest that food-away-from-home expenditures are positively related to obesity and combined rates, while food-at-home expenditures are negatively related to obesity and combined rates. However, the magnitudes of these effects, while statistically significant, are relatively small. Both food-at-home and food-away-from-home expenditures do not significantly influence overweight rates.

Key Words: food-at-home expenditures, food-away-from-home expenditures, obesity, overweight, random effects model, state-level analysis

JEL Classifications: I18

Recent evidence has shown that obesity rates have been increasing in the United States. Both national-level data from the National Health and Nutrition Examination Survey (NHANES) and state-level data from the Behavioral Risk Factor Surveillance System (BRFSS) indicate that the prevalence of obesity among adults continued to increase during the past decade. According to BRFSS, approximately 23.9% of U.S. adults in 2005 were obese, and the prevalence of obesity has increased in all states during the period 1995–2005 (Figure 1). Obesity is the second most important cause of premature death, and it increases the risk of many diseases, such as hypertension, dyslipidemia, type 2 diabetes, coronary heart disease, stroke, gallbladder disease, osteoarthritis, respiratory problems, and some cancers (endometrial, breast, and colon).

According to the National Health Interview Survey, the total economic cost attributable to obesity amounted to $117 billion in 2001, in which approximately $61 billion of those dollars were direct medical costs, which accounted for 9.1% of total U.S. medical expenses. Medicaid and Medicare paid approximately half of these costs. In 2003, medical expenditures in California reached $7.7 billion. To reverse this trend, a sustained and effective public health response is needed, including surveillance, research, policy analysis, and programs directed at improving environmental factors, increasing awareness, and changing behaviors to increase physical activity and decrease calorie intake.

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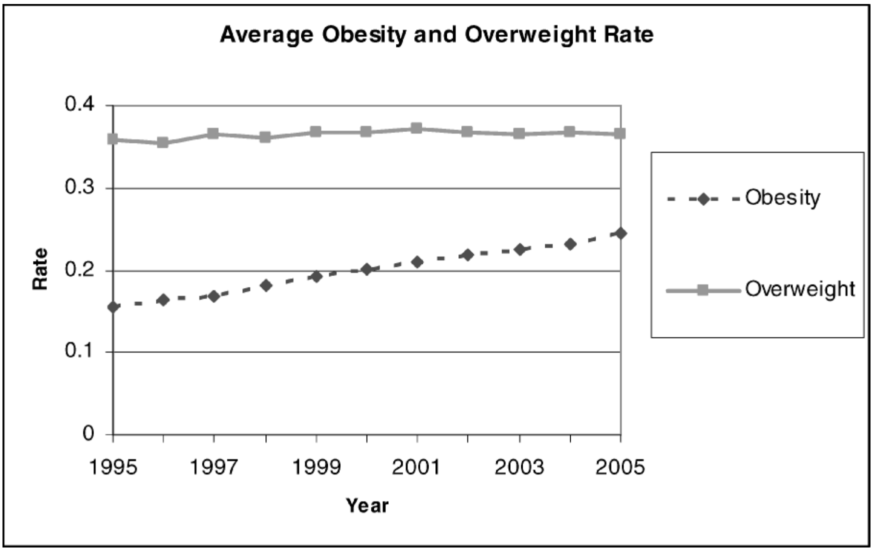

Figure 1. Average Obesity and Overweight Rate from 1995 to 2005. (Source: Centers for Disease Control and Prevention, Behavioral Risk Factor Surveillance System Survey Data)

In recent years, economists have examined the possible drivers of obesity. Among the drivers identified include physical activity, caloric consumption, and social and economic characteristics. Most studies on obesity have focused on the individual or household level, where predetermined variables (with prior knowledge in terms of its causal effects on obesity rates) have been utilized to explain the increasing obesity rates. The analyses were based on the premise that there are two major arguments addressing the cause of increasing obesity rates. The first argument centers on the increased calorie consumption, and the second is declining expenditure of calories in daily activities. However, most of the current research work has been focused on the individual level. Studies done at the aggregate (e.g., state-level) level are virtually dearth with the exception of, among others, a paper by Loureiro and Nayga that focused on cross-country effects. In this study, we focus on the state level in the United States, where historical data are available to allow for investigation of the period during which obesity rates increased substantially.

Several studies (Binkley, Eales, and Jekanowski; Chou, Grossman, and Saffer; French, Harnack, and Jeffery; Jeffery and French; McCrory et al.) have found that food away from home has been linked to the increasing rates of obesity in the United States. The proportion of money spent on food away from home as well as the number of restaurants, especially fast-food ones, has been increasing steadily since the second half of the 20th century. Nielsen, Siega, and Popkin pointed out that food consumption has shifted away from meals to snacks and from at home to away from home. According to the Economic Research Service (ERS 2003), since the late 1990s and projecting through 2004, U.S. households were spending approximately 46% of their total food budget on food consumed away from home. During the period 1994–1996, food consumed away from home, especially from restaurants and quick-service food establishments, contributed the following: 32% of daily intakes of energy calories, 32% of added sugars, and 37% of fat (ERS 2000).

Using state-level data from the 1995–2005 BRFSS, we examine the effects of food-away-from-home and food-at-home expenditures on three weight rate categories: overweight rates, obesity rates, and sum of both obesity and overweight rates (i.e., combined rate).

Literature Review

From past studies (Chou, Grossman, and Saffer; Rashad), the fundamental crux of the obesity framework centers on the classic energy balance approach where the energy balance at time t is the difference between calorie consumption and energy expenditure. Simply put, this can be written as

$$(1) \quad E_t = C_t - W_t,$$

where E_t is the energy balance at time t, C_t is the calorie intake, and the W_t is energy expenditure. This equation states that if the body mass index (BMI) at time t can be viewed as some sort of manifested stored energy, then it is a cumulative function of energy balance of all previous time periods. Furthermore, from the given equivalence relation, it can be deduced that a higher BMI can be attributed to either increased consumption of calories relative to the level of its expenditure or lower expenditure levels given a level of calorie consumption. This does not imply that the two explanations are symmetric; rather, both are mutually exclusive of one another. The reverse can also be stated in that given an index where there is a threshold of high BMI, a lower BMI can be attributed to lowering of calorie intake or increasing expenditures of calories. Hence, we can represent BMI as follows:

$$(2) \quad BMI = f\left(\sum E_t, X^*\right),$$

where BMI is a function of energy balance at all time periods and the various explanatory variables $\boldsymbol{X}^*$, which is an m vector. The vector of exogenous variables include demographic variables that are thought to exert influence either on the individual's level of caloric consumption intakes or on corresponding expenditures, thus affecting the person's BMI. In addition, the set of demographic variables such as age, sex, income, and education can motivate individual lifestyle preferences that may be based on health- and nutrition-induced reasons.

As previously mentioned, there are two main arguments put forth in the literature that attempt to explain the increasing rates of obesity worldwide. The first argument centers on the nature of increased caloric intake, and the other is the declining expenditure of calories in daily activities. Most of the literature on obesity centers on the various factors affecting individuals at the household level, and several of these studies explored the potential determinants of obesity.

On the side of increased calorie intake argument, several researches have argued that the major reason for the rising obesity rates for the past 20 years is that Americans now eat more frequently than they used to. A study done by Cutler, Glaeser, and Shapiro argued that the reason that Americans are more obese is primarily a result of increased food consumption rather than reduced exercise. Technological innovations in food production and transportation have also made it possible for firms to mass prepare food and ship it to consumers for ready consumption to take advantages of economies of scale, resulting in a significant price reduction in prepared food. Thus, the lowering of prices of convenience foods may have led to increased food consumption and ultimately increased weights, especially when people have issues of self-control.

Likewise, Chou, Grossman, and Saffer pointed out that fast-food and full-service restaurants are major factors that have resulted in undesirable weight outcomes. Increased labor market attachment has an indirect positive effect through restaurant availability. In addition, aside from increased calorie consumption, some argue that there may be limited and high disparities in terms of accessibility between healthy and energy-dense foods. Drewnowski and Darmon (2005a,b); Putnam, Allshouse, and Kantor; and Kant argue that foods rich in added sugars and fats (energy-dense foods) are more affordable than the healthy food alternatives consisting of lean meat, whole grains, and fresh vegetables and therefore help explain the prevalence of obesity-related diseases found among minorities and the working poor. They also pointed out that good taste, convenience, and energy-dense foods, coupled with large portions and extremely low eating satiation, are the main obesity culprits.

On the other hand, proponents of the low-calorie-expenditure argument suggest that systematic reduction in physical exertions in daily activities serves to magnify the problem of obesity. Lakdawalla and Philipson confirmed that technological change is a major factor that contributes to the rising obesity rate. Other potential reasons include the change from rural to urban society and changes in cultural habits. They also pointed out that approximately 40% of the total growth in obesity was due to the expanding and affordable food supply and that the remaining 60% was attributed to the systematic reduction of physical exertions in work and home-based activities.

On a broader viewpoint, Philipson suggested that alternative explanations such as advances in medicine, falling expenditures in food, greater substitution of market-produced food in relation to home-prepared food, and quite possibly addictive preferences are some of the major causal variables influencing the growth in obesity rates. Other peripheral explanations for rising obesity rates include antismoking campaign and state/federal excise cigarette tax hikes. These studies provide explanations for the growth of obesity mainly in the United States.

Analytical Framework

This paper follows the theoretical framework used by Lakdawalla and Philipson and Philipson and Posner. Suppose that an individual's utility $U(F, C, BMI, t)$ at period t depends on food consumption, F; other consumption, C; and his or her BMI, where U is increasing in food consumption F and other consumption C. For a given level of food and other consumption, the individual has an ideal BMI: BMI_0. When BMI is below BMI_0, he or she prefers to gain weight to increase BMI. But when BMI is above it, the individual prefers to lose weight to decrease BMI. The individual would try to maximize his or her utility over time by managing BMI; thus, BMI is a state variable. The individual's next period, BMI', is influenced by his or her current BMI, current food consumption F, and energy expenditure S. In effect, the individual's state equation would be $BMI' - BMI = \Delta BMI = g(F, S, t)$, where $g(F, S, t)$ is continuous and concave, increasing in food consumption but decreasing in energy expenditure. Therefore, the dynamic optimization problem becomes:

$$(3)\quad \begin{aligned} &\max_{F,C} \sum_t U(F,C,BMI,t) \\ &st.pF + C \le Y \\ &\Delta BMI = g(F,S,t), \end{aligned}$$

where p is the relative price of food to other consumption and Y is the individual's income. The Hamiltonian function would be:

$$(4)\quad H = U(F,Y - pF,BMI,t) + \lambda \times g(F,S,t),$$

where λ is the Lagrange multiplier which is equal to the marginal utility of an additional unit of the state variable BMI. Given the assumption that the utility function U and transition function g are continuous and concave, the optimality conditions associated with the Hamiltonian function are as follows:

$$(5)\quad \begin{aligned} \frac{\partial H}{\partial F} = {} & U_F(F,Y - pF,BMI,t) \\ & - p \times U_C(F,Y - pF,BMI,t) \\ & + \lambda \times g_F(F,S,t) = 0, \end{aligned}$$

$$(6)\quad \frac{\partial H}{\partial BMI} = U_{BMI}(F,C,BMI,t) = -\dot{\lambda},$$

$$(7)\quad \frac{\partial H}{\partial \lambda} = g(F,S,t).$$

Equation (5) implies that the marginal utility of other consumption must be equal to the overall marginal utility of food, which is the marginal utility of food plus the marginal value of the BMI change induced by eating. In Equation (6), λ is the rate of marginal value of BMI to the utility. Thus, Equation (6) states that the marginal value of additional BMI is equal to the marginal utility of BMI in the current period.

The steady-state *BMI* is then a function of *F*, *S*, *p*, and *Y*, and a higher *BMI* can be attributed to either increased food consumption or lower levels of energy expenditure. On the other hand, other factors, such as income and price, would shift *BMI* upward or downward.

Cutler, Glaeser, and Shapiro argued in their paper that energy expenditure occurs in three ways. The first is through basal metabolism, which accounts for 60% of energy used to keep the body alive and at rest. The most recent estimates (Schofield, Schofield, and James) express the basic metabolic rate as a linear function of weight, which indicates that the more a person weighs, the more energy is required to sustain basic bodily functions. The second source of energy expenditure is the thermic effect of food, accounting for only 10% of total energy expenditures during a day. The last type of energy is expended through physical activity. The energy requirement of a given type of physical activity is proportional to body weight and time spent: $Ep = \eta * Weight * time$, where η depends on the strength of physical activity (e.g., walking and light housework are classified as light activities, fast walking and gardening are moderate activities, while strenuous exercise and farmwork are heavy activities). Total physical activity in a period of time should be summed over the different type of physical activities.

Social demographic variables such as age, sex, race, and education may motivate individual lifestyle preferences that may be based on health- and nutrition-induced reasons. They are thought to exert an influence on either the individual's level of food consumption or energy expenditures, thus affecting the person's *BMI*.

Data

Based on the previous analysis, we postulate that food consumption, energy expenditure, price of food, income, and social demographic variables are some factors that may explain the rising obesity rate. Table 1 presents the definition and summary statistics of the variables used in the study. The obesity and overweight rates as well as the social demographic data from 1995 to 2005 were derived mainly from the BRFSS, while the food consumption, food price and income are from other sources as indicated here.

In order to obtain the information on the price of food and other goods, we collected data on general Consumer Price Index (CPI) for overall goods and specific CPIs for food at home and food away from home from the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor. The state per capita personal income was obtained from the Bureau of Economic Analysis of the U.S. Department of Commerce. This was subsequently deflated by the general CPI. Thus, the variable *RPincome* represents the real per capita personal income.

In general, fats, sugars, cereals, potatoes, and meat products are high-energy-dense foods, relative to vegetables, fruits, and whole grains, which contain less energy. Despite the rising obesity rate, Figures 2 and 3 shows that the real per capita expenditure on fat, sugar, and meat at home is stable and as such rules out the possibility of the link between rising obesity with the consumption of energy-dense food. However, factors such as growing consumption of snacks, fast foods, and soft drinks from food away from home may be the significant drivers that influence obesity rates. To accommodate these important considerations, we collected data for food expenditure at home and away from home from the Consumer Expenditure Survey of the BLS. These expenditures were then deflated using their corresponding CPIs. However, the data are available only by region; thus, the numbers assigned to states within that region have the same value. The average real per capita personal income is approximately $16,500, and approximately $3,060 is spent on food and $1,800 allotted for food-at-home expenditures. About $1,260 is spent for food away from home.

Although national estimates of obesity trends among U.S. adult populations have been periodically obtained through surveys conducted by the National Center for Health Statistics, these data are not available on a state-specific basis. This deficiency is viewed as

Table 1. Descriptive Statistics

Variable	Definition	Mean and Standard Deviation
RPincome	Real per capita personal income, $1,000	16.150 (2.647)
FoodExp	Real per capita food expenditure, $1,000	3.060 (0.202)
FoodhomeExp	Real per capita food expenditure at home, $1,000	1.795 (0.127)
FoodawayExp	Real per capita food expenditure away from home, $1,000	1.257 (0.111)
Obesity	Percentage of adult respondents in a state whose BMI is between 25.0 and 29.9	0.199 (0.038)
Overweight	Percentage of adult respondents in a state whose BMI is above 30.0	0.364 (0.016)
Combined	= obesity + overweight	0.563 (0.044)
Lobesity	= log(obesity/(1 − obesity))	−1.411 (0.245)
Loverweight	= log(overweight/(1 − overweight))	−0.557 (0.071)
LCombined	= log(combined/(1 − combined))	0.257 (0.178)
Noex	Percentage of adult respondents in a state who report no leisure-time physical activity during the past month	0.262 (0.059)
Smoke	Percentage of adult respondents in a state who have ever smoked 100 cigarettes in their lifetime and reported smoking every day or some days	0.228 (0.031)
Education		
LessHigh	Percentage of adult respondents who did not complete high school in a state	0.119 (0.039)
High	Percentage of adult respondents who completed high school in a state	0.324 (0.042)
PostHigh	Percentage of adult respondents who completed grade 12 or GED in a state	0.275 (0.035)
College	Percentage of adult respondents who completed college or above in a state	0.281 (0.057)
Race		
White	Percentage of white adult respondents in a state	0.787 (0.151)
Black	Percentage of black adult respondents in a state	0.087 (0.104)
Hispanic	Percentage of Hispanic adult respondents in a state	0.070 (0.081)
Other	Percentage of adult respondents who are not white, black, or Hispanic in a state	0.048 (0.075)
Age		
Age18_24	Percentage of adult respondents whose age is between 18 and 24 in a state	0.129 (0.013)
Age25_34	Percentage of adult respondents whose age is between 25 and 34 in a state	0.187 (0.019)
Age35_44	Percentage of adult respondents whose age is between 35 and 44 in a state	0.209 (0.015)
Age45_54	Percentage of adult respondents whose age is between 45 and 54 in a state	0.180 (0.015)
Age55_64	Percentage of adult respondents whose age is between 55 and 64 in a state	0.121 (0.011)
Age65	Percentage of adult respondents whose age is 65 or above in a state	0.173 (0.024)
Gender		
Female	Percentage of female adult respondents in a state	0.517 (0.010)
Male	Percentage of male adult respondents in a state	0.483 (0.010)

Table 1. Continued.

Variable	Definition	Mean and Standard Deviation
Region		
Midwest	Dichotomous variable that equals 1 if the state lies in Midwest, 0 otherwise	0.235 (0.425)
South	Dichotomous variable that equals 1 if the state lies in South, 0 otherwise	0.333 (0.472)
Northeast	Dichotomous variable that equals 1 if the state lies in Northeast, 0 otherwise	0.176 (0.382)
West	Dichotomous variable that equals 1 if the state lies in West, 0 otherwise	0.255 (0.436)

Note: Standard errors are in parentheses. Sample size is 561 including 50 states and Washington, D.C., from 1995 to 2005.

critical for state health agencies whose primary role is mobilizing resources to reduce rising trends in obesity and their consequent illnesses. The Center for Disease Control and Prevention (CDC) established the BRFSS to track health conditions and risk behaviors, including obesity, among adults in the United States. The BRFSS is the world's largest ongoing telephone health survey system, consisting of annual telephone surveys of persons 18 and older and conducted by state health departments in collaboration with the CDC. It collects data on actual behaviors rather than on attitudes or knowledge that would be especially useful for planning, initiating, supporting, and evaluating health promotion programs at the state level. Each year, the CDC publishes an annual report, "Health Risks in the United States Behavioral Risk Factor Surveillance System at a Glance." Therefore, BRFSS annual data from 1995 to 2005, rather than the NHANES data, are used in our study.

The CDC developed a standard questionnaire for states to use to provide data that could be compared across states. The dispro-

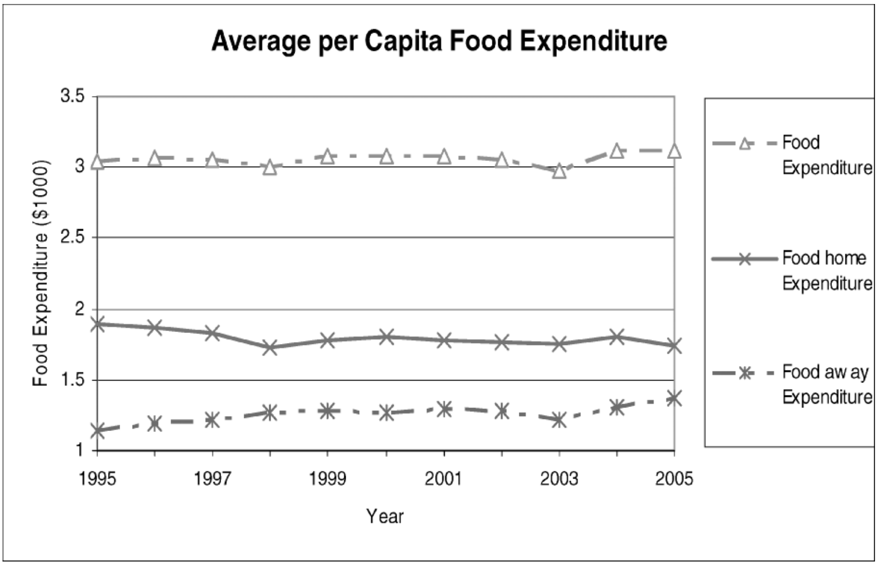

Figure 2. Average Per Capita Food Expenditure at Home and Away from Home from 1995 to 2005. (Source: Consumer Expenditure Survey, Bureau of Labor Statistics, U.S. Department of Labor)

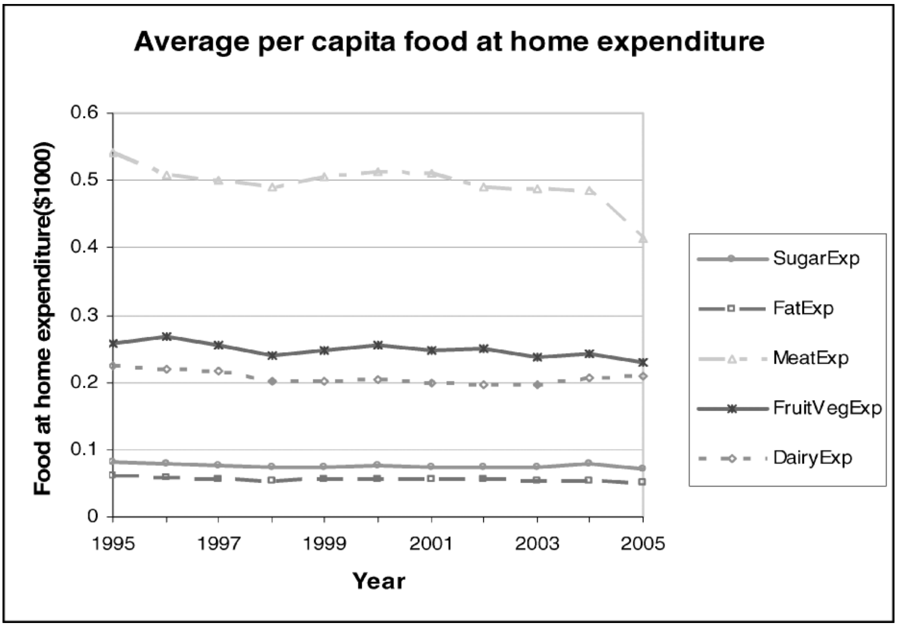

Figure 3. Average Per Capita Food-at-Home Expenditure by Major Food Group from 1995 to 2005. (Source: Consumer Expenditure Survey, Bureau of Labor Statistics, U.S. Department of Labor)

portionate stratified sample method was used so that the individual subpopulation groups are sampled in relation to both their size and their variability. Subgroups exhibiting more variability are sampled more than proportionately to their relative size, while homogeneous subgroups are sampled less than proportionately. Phone numbers are randomly selected throughout the state, and individuals are randomly selected from each household called. This sampling method ensures that enough cases are included in small strata so that meaningful analysis and comparability of data across states and over time can be performed. The average number of interviews per state ranged from 817 in 1984 to 2,250 in 1995. In 2006, the total number of interviews reached 355,710, and the average number of interviews per state was 6,700.

The overweight rate, obesity rate, physical activity, smoker rate, and other socio-economic and demographic characteristics used in this study were all derived from BRFSS. The BRFSS asks what the respondent's (18 and older) weight and height are. The BMI, defined as the ratio of a person's weight in kilograms over height in meters squared, is thus obtained and is used to determine if a person is overweight or obese. A person is classified as overweight if his or her BMI is between 25 and 30 and obese if it is over 30. *Overweight rate* is the percentage of respondents in a state who report their BMI to be between 25.0 and 29.9. The overweight rate is relatively stable across states during the period from 1995 to 2005, with an average of 36.4% in the United States.

Obesity rate is defined as the percentage of respondents in a state with a BMI above 30.0. The average obesity rate in the United States has been gradually increasing from 15.6% in 1995 to 24.5% in 2005. There is also some variability in the obesity growth rates across the states. For example, during the period 1995–2005, obesity rates increased more than 13.0% in Georgia, Louisiana, and Oklahoma, while they increased by only about 6.4% in Delaware and the District of Columbia.

The data for energy expenditure are not available by state. However, the BRFSS survey asks questions if respondents participate in any physical activities or exercises, such as running, calisthenics, golf, gardening, or walking, other than regular job during the past month, which would be used to proxy the energy expenditure variable. Thus, *NOEX* represents the percentage of respondents in the state who report no leisure-time physical activity during the past month. On average, 26.2% of adults have no leisure-time physical activity during the past month. During the 11-year period, the no-leisure-time physical activity rate has fluctuated around 21.1% to 51.2% in Arizona, while in Texas it has been relatively stable at 27.8%.

In 1990, the U.S. Surgeon General's Office determined that between 58% and 87% of those individuals who quit smoking gained weight and that, on average, those who quit gained four pounds more than those who continued to smoke. While these findings seem to indicate short-run weight gains, there is little evidence to show a direct link between smoking and steady state weight. Chou, Grossman, and Saffer reported that higher cigarette prices leads to increased body weight. Using cigarette tax rather than the cigarette price and controlling for nonlinear time effects, Gruber and Frakes found negative effects of cigarette taxes on body weight, implying that reduced smoking leads to lower body weight. This finding also motivated the study to examine the smoking effects on obesity. The BRFSS survey reports the percentage of respondents in a state who have smoked 100 cigarettes in their lifetime and who smoke every day or some days (*smoke*). These data were also obtained from the BRFSS, and, on average, 22.2% of the sample are smokers.

The four education variables are represented by the percentage of respondents in a state who have less than a high school education (*LessHigh*), who have a high school education (*High*), who have a general equivalency diploma (GED) or who completed 12th grade (*PostHigh*), and who completed college or higher (*College*). On average, about 12% of the sample have less than high school education, 32% of the sample completed high school, 28% received a GED or completed 12th grade, and 28% have a college degree.

Ethnicity is divided into four groups: white (*White*), black (*Black*), Hispanic (*Hispanic*), and others (*Other*). The numbers reflect the percentage of each race group in a state. Age is classified into five groups: 18–24, 25–34, 35–44, 45–54, 55–64, and over 65. Gender was included with the variable *Male* being the base. This denotes the percentage of male and female population in the state, respectively. Regional indicator variables, such as *Midwest*, *South*, *Northeast*, and *West*, were also included with the *West* variable serving as base.

Empirical Model

In this paper, a panel model with random effects was used. The general model notation for panel data format at the state level with variations in state i at time t is as follows:

$$(8)\quad \begin{aligned} &Y_{\mathrm{it}} = \beta \mathrm{X}_{\mathrm{it}} + c_i + u_{it}, \\ &\text{where}: \ i = 1, \ldots . N, t = 1, \ldots \ldots, T \end{aligned}$$

$$(9)\quad \mathrm{cov}(X_{it}, u_{it}) = 0,$$

$$(10)\quad \mathrm{cov}(X_{it}, c_i) = 0.$$

Assuming a general linear model for a panel data, Y_{it} and X_{it} are the response variable and its respective covariates indexed at state i at time period t. The variable c_i is the unobserved individual effect, which is a source of time-invariant heterogeneity, and u_{it} is an i.i.d random error term with zero mean and finite variance. In this model, strong exogeneity is assumed where the error term u_{it} is uncorrelated with the past, present, and future values of X_{it} (Equation [9]). Finally, the model assumes that the vector of regressors X_{it} is uncorrelated with the unobservable individual effects c_i (Equation [10]) such that random effects model is valid. The identification of the random effects model is obtained through taking the expectation of Equation (8) (Cameron and Trivedi; Wooldridge), thus obtaining the conditional expectation:

$$(11)\quad E[Y_{it}|X_{it}] = E[c_i|X_{it}] + \beta X_{it} + E[\mu_{it}|X_{it}].$$

Three dependent variables were used, and these are state-level obesity rates, overweight rates, and the combined rate (sum of obesity and overweight rates). The empirical model is as follows:

$$
\begin{aligned}
(12)\quad & obesity_{it}/overweight_{it}/combined_{it} \\
& = \beta_0 + \beta_1 FoodhomExp_{it} \\
& + \beta_2 FoodawayExp_{it} \\
& + \beta_3 Rpincome_{it} + \beta_4 Noex_{it} \\
& + \beta_5 Smoke_{it} + \beta_6 Female_{it} \\
& + \beta_7 White_{it} + \beta_8 Black_{it} \\
& + \beta_9 Hispanic_{it} + \beta_{10} Age18\_24_{it} \\
& + \beta_{11} Age25\_34_{it} + \beta_{12} Age35\_44_{it} \\
& + \beta_{13} Age45\_54_{it} + \beta_{14} Age55\_64_{it} \\
& + \beta_{15} Lesshigh_{it} + \beta_{16} High_{it} \\
& + \beta_{17} College_{it} + \beta_{18} Midwest_{it} \\
& + \beta_{19} South_{it} + \beta_{20} Northeast_{it} \\
& + c_i + u_{it},
\end{aligned}
$$

where obesity/overweight/combined rates are the three dependent variables and the explanatory factors include state-level expenditures on food at home and food away from home, real personal income, percentage of individuals who do not exercise, percentage of individuals who smoke, and gender, ethnicity, age, education, and region variables.

Since our dependent variables are measured in percentage terms, we used the log odds ratio; $\log P/(1 - P)$, where P is the overweight, obesity, or combined rate in our estimation. The proposed model was estimated by the generalized least squares estimator. We then calculated the marginal effects of the variables based on the estimated coefficients.

Several hypotheses were put forth in terms of the relevant drivers of obesity and overweight rates. First, food-away-from-home expenditures are hypothesized to be positively related to obesity rates, but food-at-home expenditures are negatively related to obesity rates. As for ethnicity, recent evidence shows that obesity is more prevalent among African Americans and Hispanics than among Whites and Asian Americans. Hence, we expect the variables representing the percentage of African Americans and the percentage of Hispanics to be positively related to obesity rates. The no exercise variable (*Noex*) is expected to also positively influence obesity rates. Since smoking usually inhibits overeating, we hypothesize the smoking variable to be negatively related to obesity rates. We also expect age to be positively related to obesity rates and education to be negatively related to obesity rates. As for the regions, recent studies point out that southern states have higher obesity incidence relative to other states.

Results

Table 2 presents the results obtained from the panel model with random effects estimation. As discussed previously, we estimated models for overweight rate, obesity rate, and combined rate, respectively. The estimates from these models are separately discussed next.

Overweight

As shown in Table 2, the per capita food-at-home expenditures, per capita food-away-from-home expenditures, per capita personal income, and percentage of no-leisure-time physical activity have positive but insignificant effects (5% significance level) on overweight rates. However, the percentage of smokers (*Smoke*) carries a significant negative coefficient, suggesting that percentage of smokers negatively affects state-level overweight rates. Specifically, a 1% increase in percentage of smokers decreases overweight rate by 0.127%. As for education, the percentage of adult population who completed high school (*High*) and the percentage of adult respondents who completed college and above (*College*) have negative effects on overweight rates. This result is consistent with the findings of Chou, Grossman, and Saffer.

As for the ethnic factors, the percentage of Hispanic population has positive effect on overweight rates, with overweight rate increasing by 0.47% for every 1% increase in percentage of adult Hispanics in a state. Age variables are insignificant except for the positive effect of percentage of adult respondents whose age is between 45 to 54 years old in a state. The regional factors indicate that the Midwest, Northeast, and South regions have higher overweight rates than the West region. In summary, our results suggest that the significant factors that positively affect overweight rates are percentage of respondents who are Hispanic (*Hispanic*) and percentage of respondents in the 45- and 54-year-old age-group (*Age45_54*). On the other hand, variables such as *Smoke*, high school completed (*High*), and *College* yield negative and significant effects, while food expenditure at home (*FoodhomeExp*) and away from home (*FoodawayExp*) do not significantly influence the overweight rates.

Obesity

Our results indicate that the real per capita food-at-home expenditures have a negative effect on obesity rates, while real per capita food-away-from-home expenditures have a positive effect on obesity rates. The marginal effects imply that a $1,000 increase in the per capita expenditure of food prepared at home (*Foodhomeexp*) will translate to a 0.045% decline in obesity rates, whereas a $1,000 increase in per capita expenditures on food prepared away from home (*Foodawayexp*) will result in a 0.053% increase in obesity rates.

The results also suggest declining positive marginal effects on obesity rates as education level increases. As for ethnicity, we find that percentages of whites, blacks, and Hispanics have positive effects on obesity rates, but the marginal effects are higher for blacks than whites and higher for Hispanics than blacks and whites. For age, we find age groupings 45–54 (*Age45_54*) and 55–64 (*Age55_64*) to be positively related to obesity rates. The results suggest that a 1% increase in percentage of individuals under these age-groups will increase obesity rates by 0.746% and 0.853%, respectively. Our results also indicate that percentage of females is negatively related to obesity rates. For every 1% increase in females, obesity rate declines by 1.40%. Finally, all the regional variables are statistically significant with the *South* having higher obesity rate than other regions.

Combined Rate

The combined rate is the sum of the overweight and obesity rates. The results show that food-away-from-home expenditures (*Foodawayexp*) have a positive effect on the combined rate, while the reverse is true for food-at-home expenditures (*Foodhomeexp*). The results are consistent with the obesity category, where in this case a $1,000 increase in per capita expenditures on food prepared at home will decrease the combined rate by 0.041%, while an increase of $1,000 in food-away-from-home expenditures will increase the combined rate by 0.051%.

The percentage of individuals who completed at least a college degree is negatively related to the combined rate. In contrast, percentages of individuals who are blacks and Hispanics are positively related to combined rate. For every 1% increase in number of blacks and Hispanics, there is 0.06% and 0.15% increase in percentage of overweight and obese individuals, respectively. Hence, the percentage of Hispanics has a slightly greater effect than percentage of blacks on the combined rate.

In terms of age, the percentages in the 18–24 age-group and 45–65 age-groups (*Age45_54 & Age55_64*) are positively related to the combined rate. The percentage of females (*Female*) is negatively related to the combined rate. All the regional variables are significant, suggesting higher combined rates than that of West region, with the South having the highest marginal effect. This result is consistent with the findings of the CDC that indicated higher obesity rates in the South relative to other parts in the country.

Concluding Remarks

Recent evidence has shown that obesity among adults has risen significantly in the United States during the past 20 years. This paper uses a panel model with random effects to examine the factors that may influence state-level obesity and overweight rates in the United States. Using state-level data from the 1995–2005 BRFSS, our study investigated the

Table 2. Random Effects Model

	Loverweight		Lobesity		LCombined	
	Coefficient	Marginal Effect	Coefficient	Marginal Effect	Coefficient	Marginal Effect
Intercept	−0.300 (−0.56)		0.729 (0.7)	0.116	1.819* (2.34)	
Rpincome	0.006 (1.87)	0.001	−0.002 (−0.4)	−0.000	0.001 (0.22)	0.000
Foodhomeexp	0.011 (0.22)	0.002	−0.283* (−3.72)	−0.045	−0.166* (−3.00)	−0.041
Foodawayexp	0.026 (0.66)	0.006	0.329* (5.26)	0.053	0.205* (4.5)	0.051
Noex	0.043 (0.54)	0.010	−0.694* (−5.23)	−0.111	−0.405* (−4.18)	−0.100
Smoke	−0.547* (−3.44)	−0.127	0.351 (1.27)	0.056	−0.343 (−1.69)	−0.084
Education						
Lesshigh	−0.263 (−1.48)	−0.061	1.201* (3.98)	0.191	0.147 (0.66)	0.036
High	−0.428* (−2.61)	−0.099	0.921* (3.32)	0.147	0.185 (0.91)	0.045
College	−0.866* (−5.17)	−0.200	0.733* (2.64)	0.117	−0.415* (−2.04)	−0.102
Race						
White	0.056 (1.04)	0.013	0.242* (2.21)	0.039	0.105 (1.28)	0.026
Black	−0.047 (−0.56)	−0.011	0.605* (4.00)	0.096	0.248* (2.21)	0.061
Hispanic	0.204* (2.28)	0.047	0.662* (3.65)	0.106	0.616* (4.5)	0.152
Age						
Age18_24	0.197 (0.51)	0.046	2.842* (4.03)	0.453	2.147* (4.09)	0.528
Age25_34	−0.618 (−1.65)	−0.143	−0.570 (−0.86)	−0.091	−0.430 (−0.87)	−0.106
Age35_44	0.672 (1.78)	0.156	−1.115 (−1.68)	−0.178	−0.125 (−0.26)	−0.031
Age45_54	1.207* (2.71)	0.279	4.680* (5.94)	0.746	4.055* (6.95)	0.998
Age55_64	0.136 (0.25)	0.031	5.353* (5.99)	0.853	4.177* (6.37)	1.028
Gender						
Female	−0.508 (−0.65)	−0.118	−8.792* (−5.9)	−1.401	−5.897* (−5.3)	−1.451
Region						
Midwest	0.083* (4.02)	0.019	0.272* (6.44)	0.043	0.266* (8.29)	0.066
South	0.073* (2.9)	0.017	0.308* (6.26)	0.049	0.288* (7.76)	0.071
Northeast	0.051* (2.37)	0.012	0.116* (2.52)	0.019	0.148* (4.21)	0.036

Table 2. Continued.

	Loverweight		Lobesity		LCombined	
	Coefficient	Marginal Effect	Coefficient	Marginal Effect	Coefficient	Marginal Effect
σ_u	0.027		0.068		0.053	
σ_e	0.052		0.078		0.057	
P	0.214		0.431		0.468	
R^2: within	0.15		0.844		0.838	
between	0.487		0.626		0.592	
overall	0.287		0.762		0.74	
Wald chi-square	134		2,641		2,515	
Prob > chi-square	0		0		0	

Note: t-statistics are in parentheses.
[*] indicates statistically significant at 0.05 level.

effects of real food expenditures at home and away from home on three different weight-level categories, namely, obesity rates, overweight rates, and sum of both obesity and overweight rates (combined rate). Our results indicate that food-at-home expenditures are negatively related to obesity and combined rates. On the other hand, food-away-from-home expenditures are positively related to obesity and combined rates. This implies that food away from home plays an important role in increasing overweight and obesity rates. Our results point out to the importance of increasing expenditures on food at home and decreasing expenditures on food away from home in reducing obesity rates in the United States. Hence, policymakers may improve the effectiveness of nutrition and education programs by emphasizing the importance of food-at-home preparation and advising individuals to be more conscious about the potential effects of eating away from home on weight.

There are two caveats that need to be mentioned, however. First, our results are based on associations and not causal links. Future studies should develop a robust identification strategy to establish possible causal links between food expenditure types and obesity rates. Second, the magnitudes of the effects we found, although statistically significant, are relatively small. Hence, policies based on our findings will have quite limited effect on obesity rates, at least in the short run.

References

Binkley, J.K., J. Eales, and M. Jekanowski. "The Relation Between Dietary Change and Rising US Obesity." *International Journal of Obesity* 24(2000):1032–39.

Cameron, A.C., and P.K. Trivedi. *Microeconometrics: Methods and Applications*. New York: Cambridge University Press, 2005.

Centers for Disease Control and Prevention, Behavioral Risk Factor Surveillance System Survey Data, Atlanta: U.S. Department of Health and Human Services, Internet site: www.cdc.gov/brfss.

Chou, S.Y., M. Grossman, and H. Saffer. "An Economic Analysis of Adult Obesity: Results from the Behavioral Risk Factor Surveillance System." *Journal of Health Economics* 23(2004): 565–87.

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

Drewnowski, A., and N. Darmon. "The Economics of Obesity: Dietary Energy Density and Energy Cost." *American Journal of Clinical Nutrition* 82(Suppl. 2005a):265–73.

———. "Food Choices and Diet Costs: An Economic Analysis." *Journal of Nutrition* 135(April 2005b):900–904.

Economic Research Service. "Table 1: Food and Alcoholic Beverages: Total Expenditures." *Food CPI, Prices, and Expenditures*. Washington, DC: Economic Research Service, 2003.

———. "Table 5: Daily Food Consumption at Different Locations: All Individuals Ages 2 and Older." *Daily Diet and Health: Food Consumption and Nutrient Intake Tables*. Washington, DC: Economic Research Service, 2000.

French, S.A., L. Harnack, and R.W. Jeffery. "Fast Food Restaurant Use Among Women in the Pound of Prevention Study: Dietary, Behavioral and Demographic Correlates." *International Journal of Obesity* 24(2000):1353–59.

Gruber, J., and M. Frakes. "Does Falling Smoking Lead to Rising Obesity?" *Journal of Health Economics* 25,2(March 2006):183–97.

Jeffery, R.W., and S.A. French. "Epidemic Obesity in the United States: Are Quick-Service Foods and Television Viewing Contributing?" *American Journal of Public Health* 88(1998): 277–80.

Kant, A.K. "Consumption of Energy-Dense, Nutrient-Poor Foods by Adult Americans: Nutritional and Health Implications: The Third National Health and Nutrition Examination Survey, 1988–1994." *American Journal of Clinical Nutrition* 72(2000):929–36.

Lakdawalla, D., and T. Philipson. "The Growth of Obesity and Technological Change: A Theoretical and Empirical Examination." National Bureau of Economic Research Working Paper no. 8946, 2002.

Loureiro, M., and R.M. Nayga. "International Dimensions of Obesity and Overweight Related Problems: An Economics Perspective." *American Journal Agricultural Economics* 87(2005): 1147–53.

McCrory, M.A., P.J. Fuss, N.P. Hays, A.G. Vinken, A.S. Greenberg, and S.B. Roberts. "Overeating in America: Association Between Restaurant Food Consumption and Body Fatness in

Healthy Adult Men and Women Ages 19 to 80." *Obesity Research* 7(1999):564–71.

Nielsen, S.J., R.A.M. Siega, and B.M. Popkin. "Trends in Energy Intake in U.S. Between 1977 and 1996: Similar Shifts Seen Across Age Groups." *Obesity Research* 10(2002):370–78.

Philipson, T. "The World-Wide Growth in Obesity: An Economic Research Agenda." *Health Economics,* 2001.

Philipson, T., and R.A. Posner. "The Long Growth in Obesity as a Function of Technological Change." National Bureau of Economic Research Working Paper no. 7423, 1999.

Putnam, J., J. Allshouse, and L.S. Kantor. "U.S. Per Capita Food Supply Trends: More Calories, Refined Carbohydrates and Fats." *Food Review* 25(2002):2–15.

Rashad, I. "Structural Estimation of Caloric Intake, Exercise, Smoking, and Obesity." *Quarterly Review of Economics and Finance* 46(2006): 268–83.

Schofield, W.N., C. Schofield, and W.P.T. James. "Basal Metabolic Rate—Review and Prediction Together with Annotated Bibliography of Source Material." *Human Nutrition: Clinical Nutrition* 39C(Suppl. 1, 1985):5–96.

The Surgeon General's Call to Action to Prevent and Decrease Overweight and Obesity. Washington, DC: U.S. Department of Health and Human Services, 2001.

U.S. Department of Commerce, Bureau of Economic Analysis. *State Annual Personal Income, SA1-3*. Internet site: www.bea.gov/regional/spi/default.cfm?satable=summary.

U.S. Department of Labor, Bureau of Labor Statistics. *Consumer Expenditure Survey*. Internet site: www.bls.gov/cex.

———. Consumer Price Index—All Urban Consumers, Internet site: www.bls.gov/cpi.

Wooldridge, J. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press, 2002.