Can Changing Economic Factors Explain the Rise in Obesity?

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Abstract

A growing literature examines the effects of economic variables on obesity, typically focusing on only one or a few factors at a time. We build a more comprehensive economic model of body weight, combining the 1990-2010 Behavioral Risk Factor Surveillance System with 27 state-level variables related to general economic conditions, labor supply, and the monetary or time costs of calorie intake, physical activity, and cigarette smoking. Controlling for demographic characteristics and state and year fixed effects, changes in these economic variables collectively explain 37% of the rise in BMI, 43% of the rise in obesity, and 59% of the rise in class II/III obesity. Quantile regressions also point to large effects among the heaviest individuals, with half the rise in the 90th percentile of BMI explained by economic factors. Variables related to calorie intake – particularly restaurant and supercenter/warehouse club densities – are the primary drivers of the results.

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I. Introduction

Obesity, defined as a body mass index (BMI) of at least 30, is associated with adverse health conditions such as heart disease, diabetes, high blood pressure, and stroke (Strum, 2002).[1] The adult obesity rate in the United States skyrocketed from 13% in 1960 to 35% in 2011-2012, with most of this increase occurring since 1980 (Flegal et al., 1998; Ogden, et al. 2014). Obesity has become a major public health and public finance concern. Estimates of its annual costs include 112,000 lives and $190 billion, with about half of the medical expenses borne by Medicare and Medicaid (Flegal et al., 2005; Cawley and Meyerhoefer, 2012; Finkelstein et al., 2003).

This trend has prompted economists to ask whether obesity is an economic phenomenon involving individuals' responses to incentives. Technological progress has resulted in an environment in which food is cheaper and more readily available, while physical activity is increasingly easy to avoid. Philipson and Posner (1999) formalize this notion by modeling weight as the result of eating and exercise decisions made through a utility-maximization process.[2] Individuals trade-off the disutility from excess weight with the enjoyment of eating and having a sedentary lifestyle, subject to a budget constraint. The model predicts that lower food prices and reduced on-the-job physical activity increase weight, while the effect of additional income on weight varies across the income distribution. Cutler et al. (2003) point out that time costs of eating should matter in addition to monetary costs, and discuss how innovations such as vacuum packing, improved preservatives, and microwaves have reduced the time cost of food preparation. Later theoretical models (e.g. Komlos, 2004; Ruhm, 2012; Courtemanche et al., 2015) add an intertemporal dimension, noting that the enjoyment from eating and sedentary

[1] BMI=weight in kilograms divided by height in squared meters.
[2] The paper was later published as Philipson and Posner (2003), but we focus on the working paper version as it contains a more detailed model.

activities occurs in the present but the health costs occur in the future. The prediction that the weights of at least some individuals respond to economic incentives persists in these models, regardless of whether or not preferences are time consistent.

Motivated by these theoretical considerations, a large number of empirical studies investigate links between various economic factors and obesity.[3] Lakdawalla and Philipson (2002) document an inverted U-shaped association between income and BMI in individual fixed effects models. Lindahl (2005) and Cawley et al. (2010) find no evidence that income affects weight using lottery prizes and variations in Social Security payments as natural experiments, while Schmeiser (2009) finds that Earned Income Tax Credit benefits increase weight.

Several papers document a connection between the costs of eating and BMI. Lakdawalla and Philipson (2002), Chou et al. (2004), Lakdawalla et al. (2005), Goldman et al. (2011), and Courtemanche et al. (2015) find an inverse association between food prices and obesity, while the results from Baum and Chou (forthcoming) and Finkelstein et al. (2012) are less clear. Evidence on the role of restaurants is mixed. Chou et al. (2004), Rashad et al. (2006), Dunn (2008), and Currie et al. (2010) find a positive relationship between restaurant prevalence and BMI; but Anderson and Matsa (2011), Baum and Chou (forthcoming), and Finkelstein et al. (2012) find no evidence of a connection. Cutler et al. (2003) argues that lower time costs of food preparation are partly responsible for trends in weight. Additionally, several studies investigate whether food stamps lead to obesity, with mixed results.[4]

A variety of other economic factors have been linked to BMI. Chou et al. (2004), Baum (2008) and Rashad et al. (2006) estimate that higher cigarette prices increase obesity; however,

[3] A separate but related literature studies how economic factors affect childhood obesity. Since our study focuses on adult obesity, we do not discuss this literature. See Anderson and Butcher (2006) for a survey of this literature, and Cawley and Ruhm (2011) for a detailed discussion of research on both adult and childhood obesity.

[4] See Baum (2011), Baum and Chou (forthcoming), Beydoun et al. (2008), Chen et al. (2005), Fan (2010), Gibson (2003 and 2006); Meyerhoefer and Pylypchuck (2008), Kaushal (2007), and Ver Ploeg et al. (2007).

Gruber and Frakes (2006) and Nonnemaker et al. (2009) find that this result disappears using different methodologies, and Courtemanche (2009b) and Wehby and Courtemanche (2011) suggest the long-run relationship might even be negative. The effect of urban sprawl is also the subject of debate, with Ewing et al. (2003), Frank et al. (2004), and Zhou and Kaestner (2010) obtaining a positive relationship with obesity but Plantinga and Bernell (2007) and Eid et al. (2008) arguing otherwise. Other factors that have been linked to adult obesity include on-the-job physical activity (Lakdawalla and Philipson, 2002; Lakdawalla et al., 2005; Baum and Chou, forthcoming), state unemployment rates (Ruhm, 2000 and 2005), work hours (Courtemanche, 2009a), gasoline prices (Rashad et al., 2006; Courtemanche, 2011), and the proliferation of Walmart Supercenters (Courtemanche and Carden, 2011).

Most of the aforementioned papers examine only one or a few factors, and it is difficult to use their results to answer the big-picture question of how well "the economic explanation" of people responding to changing incentives can account for the rise in obesity. Simply adding the percentage of the trend explained by separate studies of each potential contributor does not produce a reliable answer. One reason is because these investigations span different time periods. Perhaps more importantly, many of the economic variables are highly correlated with each other, so including only a small subset of them might lead to omitted variable bias. Summing the effects would then lead to double counting some of their contributions to the rise in obesity. For example, the number of stores selling food likely affects food prices; so if one study estimates the impact of grocery stores while another estimates the role of food prices, the portion of food stores' effect that occurs via prices will be double counted. Other examples include the influences of restaurant density on restaurant prices, gas prices on urban sprawl, and income on various aspects of the built environment. To underscore our point, Table 1 shows that adding estimates from the literature suggests that economists have already explained 177% of the rise in average BMI.

Chou et al. (2004) provide the first attempt at a comprehensive economic model of obesity that includes several economic factors. They use the 1984-1999 Behavioral Risk Factor Surveillance System (BRFSS) combined with state-level prices of grocery food, restaurant meals, cigarettes, and alcohol as well as restaurant density and clean indoor air laws. In models that control for individual demographic characteristics and state fixed effects, these state-level economic factors explain essentially all of the growth in BMI and obesity during the period. However, Chou et al. (2004) do not control for time in any way, which – as noted by Gruber and Frakes (2006) and Nonnemaker et al. (2009) – likely introduces bias due to the strong upward trend in weight. In the original working paper version of their work, Chou et al. (2002) show that adding a quadratic time trend reduces the coefficient estimates. When we estimate their model with our data (through 1999, the last year of their sample), adding year fixed effects substantially attenuates the estimates. Appendix Table 1 reports these results.

Recognizing this issue, two recent papers aim to develop comprehensive economic models of obesity while controlling for time. Finkelstein et al. (2012) forecast obesity through 2030 based on a model that includes individual demographic characteristics as well as state-level unemployment rate, alcohol price, gasoline price, fast food and grocery food prices, the relative price of healthy to unhealthy foods, restaurant density, and internet access. They find scant evidence that these state-level economic factors influence obesity. Baum and Chou (forthcoming) perform a Blinder-Oaxaca decomposition using data from the 1979 and 1997 cohorts of the National Longitudinal Survey of Youth in an effort to explain differences in BMI between the two cohorts. They include economic factors related to employment, on-the-job physical activity, smoking, food stamp receipt, urban sprawl, food prices, cigarette prices, and restaurant prevalence, but find that these variables explain very little of the rise in obesity, at least among their sample of young adults.

We provide several contributions to this literature. First, we estimate a comprehensive model that includes more economic factors than Finkelstein et al. (2012) or Baum and Chou (forthcoming), enabling us to account for a larger share of the growth in BMI and obesity. Specifically, we combine individual-level survey data from the 1990-2010 waves of the Behavioral Risk Factor Surveillance System with 27 state-level variables reflecting general economic conditions; labor supply; and the monetary or time costs of eating, physical activity, and smoking. Factors related to general economic conditions include the unemployment rate, median income, and measures of income inequality. Our labor supply variables are female and male labor force participation rates, average work hours, and proportions of physically active and blue collar jobs. Factors influencing the monetary or time costs of caloric intake include restaurant, grocery food, and alcohol prices; the relative price of fruits and vegetables to other foods; restaurant, supercenter/warehouse club, supermarket, convenience store, and general merchandiser densities; and per-capita food stamp spending. Variables influencing the relative costs of physical activity are gasoline prices, fitness center density, and a proxy for urban sprawl. Cigarette prices and smoking bans capture variation in the costs of smoking. Controlling for demographic characteristics as well as state and year fixed effects, we find that changes in these economic factors collectively explain 37% of the rise in average BMI and 43% of the growth in obesity. The variables related to caloric intake – particularly supercenters/warehouse clubs and restaurants – are the primary drivers of the results. Several robustness checks and falsification tests support the validity of the model.

Our second contribution is to examine not only average BMI and obesity, but also whether the effects of economic factors are especially large in the right tail of the BMI distribution. This is an important question since the relationship between BMI and health is highly nonlinear. Weight gain can improve health at low levels of BMI and have no discernable effect at intermediate levels, with the strong mortality and morbidity consequences of excessive weight not emerging until around the Class II obesity threshold (Flegal et al., 2013). We find that changes in the 27 economic factors collectively explain 59% of the rise in Class II/III obesity (BMI≥35, also known as severe obesity), a much higher percentage than for average BMI and obesity in general. Quantile regressions confirm that the economic factors have the most explanatory power at the right tail of the BMI distribution, as they explain 51% of the rise in the 90th percentile. In sum, focusing on only BMI and obesity would lead to an understatement of the degree to which changing economic factors account for the rise in weight-related health problems.[5]

Our third contribution is to demonstrate how the results change when we run regressions for each economic factor separately as opposed to all together in a single model. The key finding is that many significant results from the one-factor-at-a-time regressions – including those for income inequality, grocery prices, general merchandise stores, gasoline prices, cigarette prices, and smoking bans – disappear or attenuate dramatically after controlling for other economic factors. Only restaurants, supercenters/warehouse clubs, and supermarkets are consistently statistically significant in the "all factors together" regressions for all outcomes. Furthermore, the standard errors are generally smaller in the regressions with all economic factors combined, suggesting that the loss of statistical significance cannot be attributed merely to multicollinearity.

[5] Of the papers from the economic causes of obesity literature cited previously, only Finkelstein et al. (2012) and Ruhm (2005) use Class II/III obesity as an outcome and only Schmeiser (2009) and Wehby and Courtemanche (2011) estimate quantile regressions.

In short, failing to account for other related economic factors can lead to an overstatement of the number of such factors that meaningfully contribute to obesity.

Finally, we also contribute to the literature by providing, to our knowledge, the first investigation of the link between economic factors and weight loss attempts. Ruhm (2012) argues that weight loss attempts can be considered an admission of past deviations from long-run utility-maximizing levels of weight. Therefore, if a certain economic factor increases both weight and weight loss attempts, this would be consistent with the effect on weight being at least partly attributable to time inconsistency rather than rational intertemporal substitution, potentially opening the door for policy intervention. We find that the supercenter/warehouse club variable is the only one that is significantly associated with more weight loss attempts.

II. Conceptual Framework and Econometric Model

We motivate our econometric strategy with a basic model of body weight. For simplicity, we follow others in the literature (e.g. Philipson and Posner 1999, Ruhm 2012) and use a static rather than dynamic model. We will later show that our empirical results are robust to the use of specifications that treat weight as a capital stock that evolves gradually over time.

Weight (W) is a function of caloric intake (I), energy expenditure (E), and metabolism (M):

$$W = w(I, E, M). \tag{1}$$

Greater caloric intake increases weight, while greater energy expenditure and a faster metabolism reduce weight. Smoking (S) can potentially affect I, E, and M: nicotine stimulates the metabolism and has appetite-suppressing properties that may reduce caloric intake, but smoking diminishes lung capacity which may reduce physical activity (Courtemanche, 2009b). We assume that caloric intake, exercise, and smoking are influenced by variables related to their monetary and time costs ($\boldsymbol{C_I}$, $\boldsymbol{C_E}$, and $\boldsymbol{C_S}$) as well as general economic ($\boldsymbol{G}$) and labor market ($\boldsymbol{L}$) characteristics.

Estimating a full model in which the choices that determine I, E, M and S are influenced by a large number of aggregate-level economic factors is not practical with available data.[6] Our empirical analysis, therefore, focuses on the estimation of a simple reduced-form model of the relationship between weight and the various economic factors in order to explain BMI and obesity trends. Following the previous literature, we assume that weight is a linear function of G, L, C_I, C_E, and C_S:

$$W_{ijt} = \beta_0 + \boldsymbol{\beta_1 G_{jt}} + \boldsymbol{\beta_2 L_{jt}} + \boldsymbol{\beta_3 C_{Ijt}} + \boldsymbol{\beta_4 C_{Ejt}} + \boldsymbol{\beta_5 C_{Sjt}} + \boldsymbol{\beta_6 X_{ijt}} + \alpha_j + \tau_t + \varepsilon_{ijt} \quad (2)$$

where i, j, and t index individuals, states, and years. W is either BMI, dummy variables for obesity (BMI≥30) or class II/III obesity (BMI≥35), or various percentiles of the BMI distribution.[7] $\boldsymbol{X}$ is a set of controls that includes individual age and age squared; dummies for gender, race/ethnicity (black, white, Hispanic, or other), marital status (single, married, divorced, or widowed), and education (less than high school degree, high school degree, some college, or college degree); as well as state population.[8] α_j and τ_t are state and year fixed effects, and ε_{ijt} is the error term.[9]

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[6] The BRFSS lacks comprehensive enough information on the mechanisms (especially eating) through which these variables influence weight, while datasets that contain sufficient information on the mechanisms (e.g. the National Health and Nutrition Examination Surveys) are too small.

[7] Our conclusions are similar if we estimate (2) as logit or probit mdoels for the binary dependent variables, rather than linear probability models. We present linear probability estimates because they are easier to interpret.

[8] We control for population because some of our economic variables are per capita, and we want to ensure that any estimated effects of these variables can be attributed to the numerator rather than the denominator.

[9] Equation (2) can be thought of as a "hybrid" model (Rosenzweig and Schultz, 1983) because it contains variables (such as race/ethnicity and education) that do not directly enter into either the underlying obesity production function or the reduced–form demand function obtained from maximizing utility subject to the production function and budget constraints. A limitation of the hybrid equations is that the coefficient estimates generally embody both the technological properties of the production technology and the demand parameters (e.g. many prices will be determined endogenously as a function of supply and demand). While this limitation does not necessarily affect our objective of explaining the BMI/obesity trends, it should be kept in mind when interpreting the specific regression coefficients.

G consists of four variables reflective of general state economic characteristics: unemployment rate, median income, and the ratios of the 90th to the 50th and the 50th to 10th percentiles of the earnings distribution. Theoretically, income could influence weight in either direction. Expanding the budget set could increase food consumption and weight, or it could lower weight by causing substitution from cheap, energy-dense foods to more expensive, healthy foods. Additional income could also reduce weight by increasing demand for health, as higher wages increase the value of healthy time (Grossman, 1972). Lakdawalla and Philipson (2002) documented an inverted U-shaped relationship between income and BMI, with additional income increasing BMI at the low end of the distribution but decreasing it at the high end. This non-linearity raises the possibility that central tendency might not be the only feature of the income distribution that influences the weight of a state's residents; variance (i.e. income inequality) might also matter. We also include unemployment rates because higher state unemployment has been linked to lower BMI, with the association *not* being explained by income (Ruhm, 2005).

L consists of five state-level variables related to labor supply: female and male labor force participation rates, average work hours among employees, proportion with a job requiring at least moderate physical activity (defined as a metabolic equivalent (MET) score of 3 or higher), and proportion of the workforce in blue collar occupations (construction, manufacturing, or extraction). The first three of these reflect the impact of market work on time constraints, perhaps leading to less exercise or substitution from home-cooked meals to less healthy prepared foods. This is particularly salient in light of the rise in female labor force participation during the 20th Century that was only partially offset by a decline in male labor force participation (Anderson et al., 2003; Ruhm, 2008; Courtemanche, 2009a). The latter two variables relate to the notion that the shift from a manufacturing-based economy to more sedentary jobs may have reduced overall levels of physical activity, as one must now exercise during leisure time (Philipson and Posner, 2003; Lakdawalla and Philipson, 2005). Proportion in active jobs captures this hypothesis directly, while the share in blue collar occupations may reflect other aspects of such jobs – e.g., their relatively rigid structure may inhibit on-the-job snacking or going out for lunch.[10]

$\boldsymbol{C_I}$ includes several variables related to the monetary or time costs of calories. These regressors test a leading theory for the rise in obesity: that food has become cheaper and more readily available, increasing caloric intake and therefore weight. The first three variables in this category are restaurant, grocery food/non-alcoholic drink, and alcohol prices. At first glance, lower prices for foods or drinks should increase weight via the law of demand; however, substitution between types of food and drink needs to also be considered. For example, if the price of grocery food falls while the price of restaurant meals stays the same, individuals might substitute away from restaurant meals toward home-cooked meals, which are presumably less caloric. Similar logic applies if the prices of certain types of grocery foods fall further than others. To that end, our fourth variable in this category is the relative price of fruits and vegetables to other grocery foods. Fifth, we include per capita food stamp spending, which effectively lowers the price of food for recipients out to a certain threshold.

Our variables related to the time cost of obtaining food are per capita numbers of restaurants, supercenters/warehouse clubs, supermarkets, convenience stores, and general

[10] It would be possible to use individual-level rather than state-level measures for a few of our general economic and labor supply variables: income, unemployment, and labor force participation. However, we prefer to use state-level measures for all economic factors to avoid giving any potential mechanisms a "head start in the horse race." Moreover, individual-level labor supply and income measures may be correlated with individual fixed effects, which cannot be included in our regressions. Finally, the BRFSS's measure of household income only gives broad categories and is top-coded at $75,000. Because of the top-coding, adjusting this variable for inflation suggests that average real income dropped by over 20% during our sample period, which is inconsistent with other data sources and might therefore misleadingly suggest that changes in real income have substantially contributed to the obesity trend. With all this said, replacing the state-level income, unemployment, and labor force participation with the individual measures has virtually no effect on the coefficient estimates for the other economic factors.

merchandisers. Greater availability of these stores reduces travel time to obtain food, presumably increasing weight; however, substitutability matters here as well. For example, the food sold in conventional supermarkets may be on average less energy-dense than food sold at the other places. A rise in supermarket density could, therefore, reduce weight by lowering the time costs of buying healthy foods. Food store availability could also influence monetary prices, either through competitive effects or, in the case of supercenters and warehouse clubs, by selling food at discounted prices (Courtemanche and Carden, 2011).

$\boldsymbol{C_E}$ includes three state-level variables: gasoline price, fitness centers per capita, and share of residents living in the central cities of MSAs. Higher gasoline prices increase the cost of driving relative to walking, bicycling, or taking public transportation, effectively reducing the opportunity cost of physical activity (Courtemanche, 2011).[11] An increase in fitness center density lowers the time cost of exercising. Share of residents living in central cities proxies for urban sprawl.[12] More sprawl (fewer residents in central cities) typically reduces the amenities accessible through walking or mass transit, increasing the opportunity cost of caloric expenditure (Zhou and Kaestner, 2010).

Finally, $\boldsymbol{C_S}$ includes state-level cigarette price and dummies for smoking bans in private workplaces, government workplaces, restaurants, and other locations. Cigarette prices capture the monetary cost of smoking, while smoking bans affect the time cost since smokers have to go outside to smoke more often (Chou et al., 2004).

III. Data

[11] Courtemanche (2011) notes that higher gasoline prices could also reduce eating at restaurants.
[12] We considered other proxies for urban sprawl, such as population-weighted population density, and share of the population living in counties with various density cutoffs. The conclusions were similar.

Our source of individual-level data is the BRFSS, a telephone survey of the health conditions and risky behaviors of randomly-selected individuals conducted by state health departments and the Centers for Disease Control. All of our estimates are weighted to account for sampling procedures and response rates.[13] The BRFSS began in 1984, but did not include all states until the 1990s. We use the years 1990-2010 to match the years in which all of our state-level economic factors are available. As already discussed, the sharp rise in obesity began around 1980, so our sample includes two-thirds of the period during which weights rapidly increased. Following Gruber and Frakes (2006), we exclude individuals older than 64 out of concerns that the true model of weight for the elderly is likely different than that for working-age adults, and that mortality is more likely endogenous to weight for seniors, which has implications for the composition of the sample. We also exclude pregnant women.

The BRFSS includes self-reported height and weight. We apply the percentile-based correction of Courtemanche et al. (forthcoming) to adjust for systematic reporting error, and use the "corrected" heights and weight to compute BMI and indicators for obesity and severe obesity. Like the more familiar approach discussed by Cawley (2004), this method uses external validation samples drawn from the NHANES to predict measured weight and height; however, percentile ranks of the self-reported variables, instead of the self-reports themselves, are used to predict the actual measures. The resulting predictions are robust to differences in misreporting between surveys.[14]

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[13] The CDC sample weights do have limitations. For example, year-to-year volatility in the estimated proportions of black or Hispanic respondents (not shown) suggests that the weights do not fully correct for the sampling of minority respondents, at least in some years. Fortunately, we do not observe the same sort of volatility in our weighted BMI variables.

[14] Courtemanche et al. (forthcoming) find that misreporting is more severe in the BRFSS than the NHANES, as one would expect given the differences in interview context. For example, NHANES respondents are interviewed in person, but BRFSS respondents are interviewed by phone. We also allow for the possibility that misreporting varies over time by matching samples from each year of the BRFSS to samples from the closest years of the NHANES.

Finally, the BRFSS contains the individual-level demographic variables discussed above, as well as questions on health behaviors that provide dependent variables for our falsification tests. These include seatbelt use and utilization of three types of preventive medical care: flu vaccinations (shot or spray), mammograms, and prostate screenings.

Our price data come from the Council for Community and Economic Research's (C2ER) Cost of Living Index (formerly known as the ACCRA Cost of Living Index). The C2ER Cost of Living Index computes prices for a wide range of grocery, energy, transportation, housing, health care, and other items in approximately 300 local markets per quarter throughout the US. Most of these local markets are single cities, but some are combinations of cities or entire counties. Following Chou et al. (2004), we average over the prices of each item in the given category (e.g. grocery foods) for each market, weighting by the C2ER shares of each item's importance in the basket of goods. We then define state prices as the population-weighted average of the prices in the state's C2ER markets. Finally, we convert prices to 2010 dollars using the Consumer Price Index for all urban consumers from the Bureau of Labor Statistics.

We use data from the Quarterly Census of Employment and Wages (QCEW) for the numbers of restaurants, supermarkets, convenience stores, and general merchandisers in each state. The data are collected by the BLS with the cooperation of the state agencies that manage the Unemployment Insurance system. In our industries, the QCEW captures the universe of establishments. The only missing values are due to BLS disclosure rules that protect confidentiality in small cells. The number of restaurants includes both fast food and full service. When we model these two categories separately, we cannot reject the hypothesis that both have the same effects.[15]

[15] Chou et al. (2004) combined fast-food and full-service restaurants for the same reason.

The QCEW information on supercenters and warehouse clubs is missing for many observations, so we construct this variable by updating the primary data collected by Courtemanche and Carden (2011).[16] The key limitation is that this variable only captures Walmart Supercenters, Sam's Clubs, Costcos, and BJ's Wholesale Clubs (and not, for instance, K-Mart or Target Supercenters). However, Walmart is by far the dominant supercenter chain, while Sam's Club, Costco, and BJ's Wholesale Club are the only three major warehouse chains operating in the U.S. We considered modeling Walmart Supercenters and warehouse clubs separately but were unable to reject the hypothesis that their effects are the same.

The other state-level variables come from various sources. Median income, unemployment rate, female and male labor force participation, proportion of the workforce in a physically active and blue collar job, average work hours, and 90/50 and 50/10 ratios come from the Current Population Study (CPS), which is conducted by the U.S. Census Bureau for the Bureau of Labor Statistics. The United States Department of Agriculture provides information on Supplemental Nutrition Assistance Program (food stamp) benefits. Population and share of residents living in MSA central cities are taken from the U.S. Census Bureau. Cigarette prices, inclusive of state and federal excise taxes, come from *The Tax Burden on Tobacco* (Orzechowski and Walker, 2010).[17] Finally, we construct dummy variables reflecting the extent of state clean indoor air laws using data from Impacteen and the classification scheme of the 1989 Surgeon General's Report (U.S. Department of Health and Human Services, 1989).

We measure economic factors at the state rather than county level because the state is the narrowest geographic level for which all determinants are available. The CPS variables are

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[16] Establishment counts for the other industries we consider are rarely missing in state-level QCEW data. The unusually large number of nondisclosed observations for supercenters and warehouse clubs is consistent with their ownership being concentrated among a few firms.

[17] *The Tax Burden on Tobacco* reports prices both including and excluding generic brands. Following Chou et al. (2004), we use the series excluding generics to allow for greater comparability across the sample period.

available at the county level but can be unreliable because the samples are frequently quite small. The C2ER price data have virtually no coverage of rural counties and only contain a subset of urban counties. We are not aware of any county-level source of cigarette prices that is available through our entire sample period, and the smoking ban variables reflect state laws. QCEW establishment counts are often suppressed in small counties due to confidentiality concerns; however, establishments in suppressed county-level cells are still included in state-level counts.[18] Additionally, the BRFSS is only designed to be representative at the state level, and county identifiers are not even available for all counties until 1998.

Combining all of these sources yields a final sample of 2,922,071 person-year observations. Some states are not included in some years due to either not being in the BRFSS in that wave or having no C2ER data; ultimately, our sample includes 1013 state-year combinations out of a possible 1071.[19] Appendix Table A2 describes the variables further, presents summary statistics, and reports means in the first and last years of the sample. From 1990 to 2010, average BMI rose from 26 to 28.5, the obesity rate rose from 18% to 34%, and severe obesity from 7% to 14%. Figures 1-10 show trends over the same period in the economic factors. The only factors steadily trending in directions that are consistent with meaningful contributions to the rise in obesity are restaurant density, supercenter/warehouse club density, proportion of the workforce in a blue collar job, cigarette price, and smoking bans.[20] The proportion in a central city,

[18] Some of the QCEW variables (restaurants, supermarkets, and convenience stores) only have a small number of missing county-year cells. Our Supercenter/warehouse club and central city share variables are available for every county and year. However, we do not want to use narrower geographic levels for some economic factors than others because this would amount to giving some variables a "head start in the horse race."

[19] Specifically, the missing state-years are as follows: Alaska 1990; Arkansas 1990 and 1992; Hawaii 1995, 1997-2001, and 2004; Kansas 1990-1991; Maine 1990-2005; Nevada 1990-1991; New Jersey 1990-1999; Rhode Island 1990-1995 and 1997-2003; Utah 2010; Vermont 2002; and Wyoming 1990-1993. Our conclusions remain similar if we restrict the sample to states with no missing years.

[20] We also decomposed the proportion of the workforce in a blue collar job variable into separate variables for manufacturing, construction, and extraction; finding that the entire decline is driven by manufacturing. All three components appear to have similar effects on weight, however, so we elect to combine them.

proportion in active jobs, female labor force participation, restaurant price, and food stamp spending exhibit trends that on net work in the direction of the trend in obesity, but are uneven throughout the sample period. Gasoline price and fitness center density exhibit trends that should theoretically work against the secular increase in weight.[21] We observe trends in income inequality during the sample period – namely, the middle of the income distribution losing ground against both the bottom and the top – that could have either increased or reduced obesity.

The remaining variables do not exhibit trends that seem consistent with a meaningful impact on the weight distribution in either direction. Of particular interest is the lack of a downward trend in grocery prices, which are widely believed to have helped cause the obesity epidemic. Ruhm (2011) observes the same phenomenon with BLS food price data; however, the C2ER and BLS both exclude or drastically undersample supercenters and warehouse clubs, which sell food at deep discounts.[22] Since the prevalence of supercenters/warehouse clubs has rapidly increased, as shown in Figure 8, it is possible that our supercenter/warehouse club variable better captures changes in food-at-home prices than our grocery price variable.

IV. Baseline Results

Estimating the impacts of such a large number of state-level covariates reduces potential omitted variable bias, but raises concerns about multicollinearity. Despite the size of our sample, including a large number of correlated economic factors in regressions that also include year and state effects could still lead to multicollinearity that reduces the precision of our coefficient

[21] Courtemanche (2011) notes that real gasoline prices fell during the 1980s and 1990s, in contrast to the pattern we observe post-2000. Changes in gasoline prices might therefore have contributed to the increase in obesity during the earlier stages of the rise, but worked against the trend in the later stages. This would imply, however, that other factors dwarf the influence of gasoline price.

[22] Specifically, the BLS excludes all supercenters and warehouse clubs, while the C2ER's sampling strategy excludes all warehouse clubs and aims to include only the supercenters at which upper income consumers regularly shop. See Hausman and Leibtag (2004) for further discussion of the BLS' exclusions and Basker and Noel (2009) and Courtemanche and Carden (2014) for further discussion of the C2ER's exclusions.

estimates.[23] We therefore estimate the models two ways: first for each economic factor separately (i.e. 27 separate regressions) and then including all economic factors together in the same regression. Comparing results from the two approaches helps to shed light on the relative importance of omitted variable bias and multicollinearity. In particular, we test for statistically significant differences in the coefficient estimates between the two models to detect omitted variable bias, and compare standard errors to understand the impact of multicollinearity.[24]

Table 2 reports the results for BMI. We standardize all economic factors to have a mean of zero and standard deviation of one. Therefore, the coefficient estimates can be interpreted as effects of one standard deviation increases, enabling the comparison of magnitudes. Running separate regressions for each economic factor suggests that a number of them are associated with BMI, sometimes in surprising ways. Income inequality, food price, supermarket density, gasoline price, fitness centers, cigarette price, and restaurant smoking bans are all statistically significant and negatively associated with BMI. Greater supercenter/warehouse club and general merchandiser densities and miscellaneous smoking bans all predict statistically significant weight gains. Coefficients on the other 16 economic factors are not statistically significant but one of these – the negative estimated effect of proportion central city – is noteworthy because its magnitude is among the largest of any factor examined.

Including all economic factors in the same regression changes the results dramatically, eliminating some effects, attenuating others, and causing new patterns to emerge. The coefficients on income inequality, grocery prices, general merchandiser density, cigarette prices,

[23] Chou et al. (2004) use this rationale to justify excluding time trends from their preferred model.

[24] We also examined variance inflation factors (VIFs), which measure the degree to which variation in an independent variable is explained by all other independent variables; however, we believe that changes in standard errors better indicate whether multicollinearity is important in practice. A VIF is unaffected by the extent to which independent variables explain variation in the dependent variable. Especially in large samples, it is possible to obtain meaningfully precise estimates even in the presence of large VIFs.

smoking bans in restaurants, and miscellaneous smoking bans all attenuate enough to become statistically insignificant, despite smaller standard errors. The magnitude of the coefficient for proportion in a central city also decreases dramatically. Those on supercenters/warehouse clubs, supermarkets, and fitness centers all shrink but remain statistically significant. New statistically significant results include positive effects of median income, alcohol price, and restaurant density on BMI, along with a negative effect of proportion blue collar. Differences between the coefficient estimates in the two columns are statistically significant (as indicated by the crosses in the last column) for twelve of 27 factors. Overall, these results suggest that omitted variable bias is an issue for many coefficient estimates in the single-economic-factor regressions.

Multicollinearity from including all economic factors at once does not appear to substantially affect the results. The standard errors for 25 of the 27 coefficient estimates actually *shrink* with the inclusion of all economic factors. In the other two cases, supercenters/warehouse clubs and smoking bans in private workplaces, the increase in standard errors is inconsequential.[25] Therefore, our preferred specifications moving forward include all economic factors together.[26]

Table 3 displays the results for obesity. As with BMI, a number of significant associations observed when running separate regressions for each economic factor disappear when the variables are included together. In the latter specification, only six factors are statistically significant: $50^{th}/10^{th}$ percentile earnings ratio and supermarket density are negatively

[25] This is not to say that there is no multicollinearity in our regressions. Variance inflation factors provide clear evidence of multicollinearity; however, the effects of that multicollinearity appear to be blunted by the size of our sample and the variation in BMI explained by covariates in the model. Furthermore, when we compare the full model and single-factor models to models that exclude state or year effects, it becomes clear that in the cases where the VIFs are high this is driven largely by the fixed effects rather than by including all the economic factors together.
[26] Note, however, that multicollinearity does appear to be a problem in models that go even further toward controlling for omitted variables, such as those including state-specific linear time trends. If we add state trends, the standard errors grow to the point where the confidence intervals for many economic factors include both zero and magnitudes that are quite large. The results are therefore uninformative.

associated with the probability of being obese, while restaurant, supercenter/warehouse club, general merchandiser densities, and miscellaneous smoking bans are positively associated with obesity. For fourteen of the 27 economic factors, the change in the coefficient estimates between the two models is statistically significant.

Table 4 presents the results for class II/III obesity. Including all economic factors together again substantially affects the results, leading to statistically significant changes in the coefficient estimates in thirteen cases. Eight economic factors are significant in the combined regression: proportion in blue collar jobs, supermarket and fitness center densities, and restaurant smoking bans reduce the probability of severe obesity; restaurant, supercenter/warehouse club, and general merchandiser densities and food stamp benefits increase it.

Table 5 uses results from the preferred all-factors-together regressions to compute the percentage of the increases in average BMI, obesity, and class II/III obesity during our sample period that can be explained by changes in the economic factors. For each factor, we multiply its coefficient estimate by the change in its (standardized) sample mean from 1990 to 2010, divide by the change in the dependent variable, and then multiply by 100%. We also compute subtotals for each category and a grand total for all factors. The last row of Table 5 shows the percentages explained collectively by changes in individual demographic and state population controls.[27] (Details are available in Appendix Table A3.)

The first column shows that changing economic factors explain 37.2% of the rise in BMI, with changes related to costs of calories accounting for almost the entire amount: 36.5%. Changes in general economic indicators, labor supply variables, and smoking-related factors

[27] Age and education are the most important demographic factors. The population aging explains over 18% of the increase in average BMI, while increased education works against the trend in BMI.

together explain less than 7.5% of the trend, while changes related to costs of physical activity actually offset 6.7% of the trend.

Turning to specific economic factors, the proliferation of supercenters/warehouse clubs alone explains 17.2% of the increase in BMI, and restaurant expansion another 12.2%. The next largest contributors are the rise in cigarette prices (3.9%), the declining proportion of blue collar workers (3.3%), higher food stamp benefits (2.7%), and the drop in fast food restaurant price (2.3%). Higher gasoline prices and fitness center expansion are the strongest forces working against the secular rise in BMI (-3.3% and -4.1% respectively).

The second column shows that changing economic factors explain 42.8% of the rise in obesity. As with BMI, this is almost entirely driven by changes in the variables related to the costs of calories, which combine to account for 39.1%. General economic indicators, labor supply, and smoking variables each contribute slightly to the trend, while variables related to physical activity work marginally against it. Supercenters/warehouse clubs and restaurants are the single largest contributors at 16.3% and 13.8%, respectively.[28] Other economic factors explaining at least 2% of the trend are higher cigarette prices (4.4%), the rise in food stamp benefits (3.9%), cheaper fast food (3.4%), and the declining earnings of the middle class relative to the poorest (2.1%). Fitness center expansion is the only factor meaningfully working against the trend (-2.7%).

The third column reports that changing economic factors explain 59.3% of the increase in class II/III obesity – a much greater portion of the trend than for BMI and overall obesity. This is an important result since excess weight does not begin to substantially increase mortality until

[28] Courtemanche and Carden (2011) found that the rise in Walmart Supercenters accounts for 10.5% of the rise in obesity. Note that our results and theirs are not directly comparable since our supercenter/warehouse club variable includes not just Walmart Supercenters but also other types of supercenters as well as warehouse clubs. This means the increase in stores over time is larger in our paper and, therefore, the percentage of the rise in obesity accounted for by this increase would be larger even if the coefficient estimates were identical.

the class II obesity threshold (Flegal et al., 2013). On the other hand, increases in BMI could actually reflect an *improvement* in health among previously underweight individuals. Therefore, the class II/III obesity is most relevant from a public health standpoint.

Changes in factors related to the costs of calories explain 59.6% of the rise in class II/III obesity, while the labor supply variables contribute another 7.8%. General economic indicators, physical-activity-related variables, and smoking-related factors each work slightly against the trend. Among the variables related to the costs of calories, supercenters/warehouse clubs and restaurants are again the most important, explaining 24.1% and 22.9% of increase. Other factors contributing meaningfully are the rise in food stamp benefits (8.3%) and the decline in blue collar jobs (6.2%).[29] Fitness center expansion offsets 3.6% and higher gasoline prices 2.8% of the trend.

Our finding that changing economic factors explain a substantial portion of the trend in weight stands in stark contrast to the results of Finkelstein et al. (2012) and Baum and Chou (forthcoming), the other recent efforts to develop comprehensive empirical models of obesity. Like us, Finkelstein et al. (2012) use individual-level BRFSS data matched with state-level covariates and estimate models with state and year fixed effects. Therefore, we can safely attribute the difference in results to our inclusion of a larger number of economic factors.

Comparing our results to those of Baum and Chou (forthcoming) is less straightforward, as their data and methods differ from ours in several ways beyond their use of a smaller set of

[29] It is interesting that proportion of blue collar workers influences severe obesity (and to a lesser extent average BMI) while proportion in a physically active job does not. This suggests the effect of blue collar employment is due to some other aspect of these jobs besides their presumably higher levels of activity. One possibility is that they tend to have relatively rigidly structured work days, with fewer opportunities for on-the-job snacking or going out to lunch. In unreported regressions (available upon request), we found some preliminary support for these hypotheses. Using data from the American Time Use Survey, we find a negative association between having a blue collar job and time spent in secondary eating. Using data from the DDB Needham Life Style Surveys, we estimate a negative association between blue collar employment and frequency of eating lunch at restaurants, but no effect on frequency of eating out for other meals. These patterns deserve further research.

economic factors. Most notably, their NLSY sample consists only of young adults and they use a Blinder-Oaxaca decomposition approach. Therefore, in order to verify that our ability to account for a larger share of the trend in weight is due to our inclusion of more economic factors rather than other differences, we re-estimated our models replacing our variables of interest with theirs (or the closest analogs to theirs that are possible with our data). The results, shown in Appendix Table A4, show that if we use their explanatory variables we reach the same conclusion as them: that very little of the trend in weight is accounted for. Much of the difference can be linked to their omission of supercenters/warehouse clubs and the fact that the estimated effect of restaurants is much weaker when we do not control for the full set of other economic factors.

V. Quantile Regressions

Our finding that changing economic factors explain a particularly large portion of the rise in class II/III obesity suggests that economic variables affect BMI most strongly at the right extreme of the distribution. This is important for two reasons. First, as mentioned, weight gain appears to only have strong negative consequences for those who are severely obese (Flegal et al., 2013). Stronger effects of economic factors at higher BMI levels imply that the health consequences of changing economic factors are more harmful than suggested by mean BMI regressions. Second, the BMI distribution did not symmetrically shift to the right over the past two decades, but instead became more right-skewed. The 10th percentile increased by about 1 BMI point (~5%) between 1990 and 2010, whereas the 90th percentile rose by over 4 points (~13%).[30] If economic factors have the strongest effects on those who already have high BMIs, they could help to explain the right-skewed growth in the BMI distribution. We use quantile regression to investigate this possibility more formally.

[30] For comparison, the 25th, 50th, and 75th BMI percentiles rose by 1.6, 2.4, and 3.4 points, respectively.

We estimate determinants of BMI at the 0.1, 0.25, 0.5, 0.75, and 0.9 quantiles using unconditional quantile regressions (UQR), which were developed by Firpo et al. (2009). UQR allow us to estimate the marginal effects of right-hand-side variables on the quantiles of the unconditional distribution of BMI, $F(BMI)$. In contrast, standard conditional quantile regressions (CQR, Koenker and Basett, 1978) would estimate effects on the quantiles of the BMI distribution conditional on the right-hand-side variables, $F(BMI|X, \boldsymbol{G}, \boldsymbol{L}, \boldsymbol{C_I}, \boldsymbol{C_E}, \boldsymbol{C_S})$**.** This conditional distribution and its quantiles change as the right-hand-side variables change, and marginal effects on quantiles of the conditional distribution are not generally the same as marginal effects of quantiles of the unconditional distribution.[31] Therefore, UQR provides estimates that are more consistent with our goal of evaluating changes in the BMI distribution over time.[32]

Table 6 reports the estimated marginal effects of the economic factors on each of the five BMI quantiles. The effects of the key variables related to costs of caloric intake vary across quantiles and are usually larger at higher quantiles. This is most apparent for supercenters/warehouse clubs and restaurants, which have effects that are roughly ten times larger at the 0.9 quantile than at the 0.1 quantile. This result is consistent with the prominent effects of these two variables on class II/III obesity. Additionally, general merchandisers have sizeable positive effects at the 0.75 and 0.9 quantiles but negative (and significant) coefficients at the 0.1 and 0.25 quantiles, while the food stamp coefficient is largest at the 0.9 quantile and small and insignificant at lower quantiles. The density of supermarkets appears to lower BMI,

[31] By contrast, in OLS, the marginal effects on the mean of the outcome conditional on the right-hand-side variables are the same as the effects on the unconditional mean. See detailed discussion in Firpo et al. (2009).

[32] Another practical reason for avoiding CQR in this work is that estimating the variance-covariance matrix for that model using bootstrap is extremely time-consuming given the large dataset we employ. Following Firpo et al. (2009), the UQR is estimated using an OLS regression of the re-centered influence function of the unconditional BMI quantiles on all of the explanatory and control variables described above, including state and year fixed effects. The regressions are weighted using BRFSS weights and standard errors are obtained using 500 bootstrap replications.

but only at the 0.75 and 0.9 quantiles. Some variables in other categories – such as female labor participation and fitness centers – exhibit heterogeneity in effects across quantiles but without clear patterns. Collectively, these results indicate that the main economic factors associated with BMI are most relevant for weight changes at the right tail of the distribution.

Table 7 shows the percentage changes in the five BMI quantiles accounted for by changes in the economic factors, computed in a similar way to those reported in Table 5. The results are consistent with the differences in effects across quantiles discussed above. The economic factors collectively explain 51% of the 4-point rise in BMI at the 0.9 quantile between 1990 and 2010, but explain less than 15% of the ~1 point rises in the 0.1 and 0.25 BMI quantiles. This pattern is again most pronounced for supercenters/warehouse clubs and restaurants, which together explain about 45% in the rise of the 0.9 quantile. In contrast, supercenters/warehouse clubs explain around 13% of the 0.1 quantile change, and restaurants have no statistically significant effect. Other changes that contribute to the rise in the 0.9 quantile are the drop in blue collar jobs (~5.3% explained) and increase in food stamp benefits (6.3%).

Interestingly, changes in the control variables explain a larger portion of the trend at lower quantiles than higher quantiles, and actually have greater explanatory power than changes in economic factors at the 0.1 and 0.25 quantiles. As in the case of mean regressions, age accounts for most of the effect of the control variables.

Overall, the results from quantile regressions are consistent with those for class II/III obesity, indicating that costs of caloric intake are important contributors to the clinically-relevant portion of the rise in BMI and the shift in the BMI distribution to the right. Costs of caloric intake – and economic factors in general – play a far smaller role in the "non-obese" weight range. These findings imply important heterogeneity in the effects across the BMI distribution.

VI. Additional Robustness Checks

We estimated a number of additional models to evaluate the sensitivity of the results from our preferred specification. Our first two robustness checks further evaluate the role of multicollinearity. First, we drop any economic factors that were not statistically significant in either the regressions for each factor separately or for all of them together. The goal is to develop a model that strikes a balance between the two extremes by including some, but not all, economic factors. Dropping irrelevant variables may help reduce the standard errors for the remaining coefficients. This approach leaves 15 of the 27 economic factors in the BMI regression, 14 in the obesity regression, and 15 in the class II/III obesity regression. Our second robustness check returns to including all 27 economic factors but replaces the year fixed effects with a quadratic time trend, thereby allowing some time-series variation to help with identifying so many separate effects at once.

Next, we aggregate all variables to the state level, using the BRFSS sampling weights and weighting the states by population in the regressions. Since all independent variables of interest are state-level, it is useful to check whether we reach the same conclusions regardless of whether or not we leave the dependent and control variables at the individual level.

Our fourth robustness check returns to individual-level data and drops the seventeen states where over a third of the population lives in rural areas.[33] We do this because, while many of our variables (e.g. the store density measures) reflect the entire state, the C2ER price data come almost exclusively from urban areas. Greater measurement error for the price than the built environment variables could then perhaps explain why the latter have better explanatory power. If so, dropping rural areas would be expected to influence the results. Since we are unable to

[33] We use 2000 Census populations, since that is the midpoint of our sample. The seventeen states are Alabama, Alaska, Arkansas, Idaho, Kentucky, Maine, Mississippi, Montana, New Hampshire, North Carolina, North Dakota, South Carolina, South Dakota, Tennessee, Vermont, West Virginia, and Wyoming.

exclude all rural counties (due to the high frequency of missing county identifiers in the first half of our sample period), we instead omit states with a sizeable share of rural residents.

The next robustness check addresses the possibility that, since weight is a capital stock accumulated over time, the short- and long-run effects of changing economic incentives could differ. It is not clear which of these our fixed effects estimates with contemporaneous economic factors more closely reflect. One approach to modeling dynamics would be to include lags of the economic factors. However, the strong correlations between contemporaneous and lagged values of the economic factors create an additional multicollinearity concern. Instead, we adopt an approach previously used in the obesity literature (Anderson et al., 2003; Courtemanche, 2009a; Wehby and Courtemanche, 2012) and model the economic factors as moving averages of their values over the past several years. We reached similar conclusions using three-, five-, and seven-year averages; and present results for the seven-year averages. The regressions therefore estimate the impacts of changes in the economic factors that are sustained for seven years (i.e. long-run effects). Seven-year averages reflect values over the current and six preceding years, so the first six years of our sample (1990-1995) are dropped.[34]

Next, we address the issue of whether our results can be interpreted as causal effects as opposed to merely associations. Our regressions already account for unobservable state and year characteristics, individual demographic characteristics, and a wide range of state-level economic factors; however, potential concerns still remain. For instance, if a state becomes more health-conscious over time relative to other states, this may affect some economic factors (e.g. types of foods stores) as well as obesity, leading to omitted variable bias. We aim to at least partially

[34] As another approach to modeling dynamics, we aggregated the data to the state level and estimated dynamic panel models that included the lag of the dependent variable as a regressor. When we implement Arrelano-Bond estimation methods, the coefficient on the lagged dependent variable is imprecisely estimated, making the results uninformative.

address these concerns with an instrumental variables approach. While it is impractical to simultaneously instrument for 27 different endogenous variables, it is feasible to instrument for the two economic factors that emerged as the leading drivers of our baseline results: supercenters/warehouse clubs and restaurants.

Prior research provides guidance on how to do this. Courtemanche and Carden (2011) estimate the impact of Walmart Supercenters on BMI by exploiting plausibly exogenous variation from Walmart's strategy of expanding in concentric circles outwards from its headquarters in Bentonville, AR. Dunn (2010) and Anderson and Matsa (2011) identified the effects of restaurants on BMI by utilizing the tendency for restaurants to locate near major highway exits.

Motivated by these approaches, we instrument for supercenter/warehouse club density and restaurant density using: 1) interactions of the natural log of distance from Bentonville (measured from the centroid of each state) with each year fixed effect, and 2) the number of interstate exits per 10,000 residents in the state interacted with year fixed-effects. Interstate exit information as of May 2014 comes from http://m.roadnow.com/ and we treat exits as being fixed over time, which is likely almost the case since the original interstate highway plan was completed by 1992.[35] Interactions with year fixed effects prevent these time-invariant variables from being dropped by the inclusion of state fixed effects. Identification comes from *changes over time* in the relationships between these variables and the endogenous regressors. We recognize that the validity of the exclusion restrictions could be questioned on various grounds and, for this reason, we include the IV estimates only as a robustness check.

[35] Roadnow.com only has data on major interstates, so we are unable to include miles and exits from auxiliary routes, e.g. the bypass around a city. In some sense this may be preferable, as auxiliary routes are more likely to have been built or expanded during our sample period, which would be problematic for our assumption that miles and exits are fixed over time. The date of completion of the interstate highway system (aside from a few parts that remain unfinished) is from http://logistics.about.com/od/legalandgovernment/a/Interstate-Highway-System.htm.

Our final robustness check addresses the issues of dynamics and endogeneity in a different way: by controlling for average state BMI (or obesity or class II/III obesity) in the preceding year.[36] If the coefficient on the lagged weight variable is large, this would suggest that the short-run and long-run effects of the economic factors could be substantially different, in which case our baseline estimates would likely be too small. Alternatively, if including lagged weight meaningfully affects the estimated effects of the economic factors, this could point to reverse causality, i.e. the body weights of state residents affecting the economic factors rather than the other way around. For instance, perhaps supercenter, warehouse club, and restaurant chains strategically locate in states with high obesity rates because of a perceived high demand for food. If this is the case, lagged weight would affect current values of the economic factors, and the results should therefore be sensitive to the inclusion of lagged weight as a covariate.

Table 8 reports the results for the robustness checks for BMI. To save space, we present only the percentage of the rise in BMI explained for each economic factor, along with indicators of statistical significance. Coefficient estimates and standard errors are available upon request. The overall percentage of the rise in BMI explained by the economic factors ranges from 27.1% to 44.5%. The baseline estimate from Table 5 was 37.2% with a standard error of 10.6%, so that the estimates from the robustness checks are all within a standard error of it. Additionally, the coefficient on lagged BMI in the final robustness check is a relatively modest 0.16, suggesting

[36] We include state lags because the pooled cross-sectional nature of the BRFSS precludes the inclusion of individual lags. In unreported regressions (results available upon request), we also considered specifications that aggregated all variables to the state-level, in which case it is possible to estimate a genuine lagged dependent variable model. In one of these specifications, we used an Arrellano-Bond estimator to account for endogeneity in the lagged dependent variable. In all cases, the conclusions reached were similar to those from the reported individual-level regressions.

that the long-run effects of the determinants of BMI are only slightly larger than the short-run effects.[37]

Turning to the subtotals from each category of economic factors, the percentages are very similar across specifications for the labor supply variables and variables related to calorie intake. The subtotals for variables related to general economic indicators, physical activity, and smoking are also generally similar across specifications, with the exception of the model with 7-year averages. In this regression, the general economic indicators and smoking categories contribute more to the trend than in the baseline model, while the physical activity category works against the trend more strongly. However, the caloric intake category remains by far the most substantial contributor to the rise in BMI. Regarding the individual economic factors, the key result is that supercenters/warehouse clubs and restaurants remain the two leading contributors to the trend in all specifications. Interestingly, however, rising cigarette prices explain virtually the same amount of the rise in BMI as increased restaurant density in the 7-year averages specification. Also noteworthy is that the IV estimates for restaurants and supercenters/warehouse clubs are both well within the confidence intervals from the baseline model, with the supercenters/warehouse clubs estimate being slightly larger in the IV model and the restaurants estimate being slightly smaller. Supercenters/warehouse clubs remain highly statistically significant despite the inherent inefficiency of IV estimation, whereas the estimate for restaurant density becomes insignificant due to the almost 3-fold increase in the standard error. The first stage F statistics are 34.58 for supercenters/warehouse clubs and 12.41 for restaurants, indicating

[37] Specifically, the long-run effect of a particular variable can be computed as the coefficient on that variable divided by one minus the coefficient on the lagged dependent variable (Basker, 2005). A coefficient on the lagged dependent variable of 0.16 therefore means the long-run effect is 19% larger than the short-run effect. If we multiply the estimates from our lagged weight regressions by 1.19, the estimated percentage of the rise in BMI explained by the economic factors is still well within the range of the estimates from the other models.

that our instruments are sufficiently strong to rule out the possibility that the IV and OLS estimates are only similar because of weak instrument bias.

Tables 9 and 10 present the results from the robustness checks for obesity and class II/III obesity. Since the conclusions about robustness are similar to those for BMI, we provide only a brief discussion. The overall percentage of the rise in obesity explained by all the economic factors together ranges from 35.0% to 49.4%, in the vicinity of the baseline estimate of 42.8%. The overall percentage of the increase in class II/III obesity varies from 49.5% to 67.0%, again similar to the baseline estimate of 59.3%. The coefficients on the lagged obesity and severe obesity variables are 0.19 and 0.13, respectively. Variables related to the costs of calorie intake – particularly restaurants and supercenters/warehouse clubs – remain the most important in all models. Interestingly, the rise in cigarette prices explains a sizeable 21.4% of the rise in obesity in the 7-year averages model, but has virtually no effect on class II/III obesity using the same specification.

VII. Falsification Tests

An important question is the extent to which the previously estimated effects of the economic factors on BMI, obesity, and class II/III obesity can be considered causal. At issue is whether movements over time in unobservable state-level characteristics are correlated with changes over time in the state-level economic variables. We believe that including more economic factors reduces this possibility, at least relative to the less comprehensive approaches typically used in the literature. The robustness of our most striking results – those for restaurants and supercenters/warehouse clubs – to the use of 2SLS is also reassuring. This section attempts to further mitigate concerns about potential omitted variables bias through a series of falsification tests.

Ideal dependent variables for falsification tests, in our context, satisfy two criteria: 1) there should not be any reason for them to be causally affected by the economic factors, and 2) they should be influenced by the same unobservable characteristics as body weight. Natural candidates to satisfy the second condition are other health behaviors, as presumably they are also affected by potentially unobserved confounders such as state residents' demand for health, health knowledge, and individual time and risk preferences. However, other health behaviors might not perfectly satisfy the first condition, especially given the wide scope of the economic factors included in our analysis. The best candidates in the BRFSS are dummies for whether the respondent always uses a seatbelt, had a flu vaccine in the past year, and had a mammogram (for women) or digital rectal prostate exam (for men 40 and older) in the past two years.[38] Nonetheless, it remains possible that even these outcomes are affected by some of our economic factors, which could result in our falsification tests indicating endogeneity when none exists.

Table 11 reports the results from linear probability models regressing each of these four falsification test outcomes on the economic factors as well as demographic controls and state and year fixed effects. The table presents a total of 108 coefficient estimates, so we expect some statistically significant "effects" even for well-specified models. We obtain slightly more falsification test failures than expected: 15 (13.9%) coefficients are significant at the 10% level, and 10 (9.3%) at the 5% level. However, we see no relationship between the coefficients that are statistically significant in these falsification tests and those that are significant in our main results. Specifically, none of the estimates for supercenters/warehouse clubs are significant, while the only significant result for restaurants is an association with *higher* levels of prostate screening. This suggests that, if anything, restaurants enter areas with *improving* health

[38] The BRFSS specifically imposed the age restriction for men's prostate exams, but not for women's mammogram's, so we follow their lead and include women of all ages. The results are similar if we impose various age cutoffs for women.

behaviors. In sum, we view the results from Table 11 as ruling out several of the threats to a causal interpretation of our estimated effects on weight – particularly for the economic factors that emerged as the most important contributors to the trend.

A possible concern is that the dependent variables are not available for the full sample, meaning that the falsification tests have somewhat less statistical power than our main analyses for the weight outcomes. The seatbelt variable is missing in 1999-2001, 2003-2005, 2007, and 2009. The flu shot variable is not available in 1990-1992. In addition to the age and sex restrictions for mammograms and prostate exams, the prostate exam variable is only available in 1994, 1996, 1998, 2000, and 2003. To address this concern, we re-estimated our main models for BMI, obesity, and severe obesity restricting the sample to those used for each falsification test (results available upon request). The only case in which the number of statistically significant results for the weight outcomes is meaningfully different from our main specification is for the substantially restricted prostate exam sample. Even in that case, we continue to obtain more significant results than would be expected due to chance, and more than when using prostate exams as the dependent variable.

VIII. Weight Loss Attempts

A lingering question with the results presented thus far is whether or not individual responses to economic factors are rational. In the standard neoclassical model with rational consumers, the utility lost from the additional weight is less than the utility gained from, for instance, greater enjoyment of tasty foods. Conversely, if preferences are time-inconsistent or individuals are otherwise irrational, the effects of changing economic incentives may be exacerbated and increases in weight may be inefficient, even in absence of externalities. Ruhm (2012) documents the prevalence of weight loss attempts and characterizes these as an admission of past deviations from one's lifetime utility maximizing plans, suggesting "internalities" due to time inconsistency or other sources of not fully rational decision-making. Building on this idea, we evaluate whether the economic factors identified as major contributors to the rise in BMI, obesity, or severe obesity are associated with the probability of reporting current weight loss attempts. Significant effects would be consistent with at least some of the weight gained from changes in these factors being welfare-decreasing.

Table 12 reports the results. The weight loss attempt variable is only available in 1994, 1996, 1998, 2000, and 2003, so our sample size is smaller than for the main regressions. The first column includes all 27 economic factors in the same regression. We observe only two significant effects, both at the 10% level: a higher proportion of the workforce in an active job is associated with fewer weight loss attempts, while greater supercenter/warehouse club density is associated with more weight loss attempts.

Since our sample only contains five years (compared to 21 for the main regressions), multicollearity among the economic factors might help explain the lack of significant results. We therefore estimate two additional models. The first includes only the "important" economic factors, which we define as those explaining more than 5% of the rise in BMI, obesity, or class II/III obesity in the baseline regressions (or working against the trend by the same amount). Variables meeting this criterion are proportion blue collar, restaurants, supercenters/warehouse clubs, food stamp benefits, gas prices, and fitness centers. Next, we include only restaurants and supercenters/warehouse clubs, which repeatedly emerged as the two most important factors. These additional specifications do not cause any new results to emerge. Supercenter/warehouse club density is the only significant economic factor, and its level of significance rises as the number of other included economic factors shrinks. Discount big box grocers may trigger impulses that lead to "mistakes," i.e. deviations from long-run utility maximization. This result is consistent with Courtemanche et al.'s (2015) finding that present-biased individuals are the most responsive to falling food prices. It is interesting, however, that we do not observe a similar effect for restaurants.

IX. Discussion

The main contribution of this paper to the literature on the economic causes of obesity is to consider the big-picture question of how well "the economic explanation" of individuals responding to changing incentives can explain the rise in obesity. We develop a model of weight that includes numerous factors reflecting the economic incentives alleged to have contributed to the upward trend in weight in the U.S. We find that changes in these economic factors collectively explain 37% of the rise in body mass index and 43% of the increase in obesity. Variables related to the costs of eating – particularly supercenter/warehouse club expansion and increasing numbers of restaurants – are the leading drivers of the results.

Our work also makes other important contributions. We show that the impacts of economic factors on BMI are generally largest in the right tail of the distribution, where the health consequences of weight gain are most severe. Changes in the economic factors collectively explain 59% of the growth in class II/III obesity and 51% of the change at the 90th BMI percentile. Another contribution is to demonstrate that the "effects" of several variables previously linked to BMI – such as prices of groceries, gasoline and cigarette prices, as well as smoking bans – disappear after controlling for the other economic factors. Finally, we document a connection between supercenters/warehouse clubs and weight loss attempts, providing suggestive (though not conclusive) evidence that some of the effect of these stores' on weight could be driven by time inconsistency or other sources of nonrational behavior.

Several limitations of our study provide opportunities for future research. Most obviously, while we identify the factors associated with a meaningful portion of the trend in weight, much of the secular increase remains unexplained. Measurement error in some economic variables could lead us to underestimate their contributions. Additionally, we are not able to evaluate some potentially important changes in incentives due to technological innovations for which it is difficult to measure cross-state over-time variation. For instance, Cutler et al. (2003) argue that the rise in obesity is the result of technological progress in food preparation and preservation that reduces the time cost of consuming snack foods. However, the specific innovations mentioned (e.g. microwaving and vacuum packing) occurred well before 1990, so they are not likely to explain the rise in obesity during our sample period. Another possible explanation is that electronic innovations – video games, computers, more television channels, cell phones, etc. – have improved sedentary leisure time options, increasing the opportunity cost of physical activity. We are skeptical, though, that this explains a large portion of the trend because Cutler et al. (2003) documented that the rise in obesity is driven by additional caloric intake rather than reduced energy expenditure.

Future research should push further to establish causality. While the inclusion of state and year fixed effects, robustness of the results for the two leading factors to an instrumental variable specification, and favorable falsification tests support a causal interpretation, it is obviously impossible to make strong claims in the absence of randomization or quasi-randomization. Further analyses, both using the "one factor at a time" approach common in the literature and comprehensive models such as the one considered here, are necessary before a consensus can emerge about the causal effects of the various economic factors.

Finally, future research should continue to evaluate the appropriate role of policy in light of an economic explanation for the rise in obesity. Economic trends such as increased prevalence of restaurants, supercenters, and warehouse clubs presumably bring substantial benefits to consumers through added convenience and greater purchasing power and it would be naïve to assume that reversing these trends would improve social welfare. Nevertheless, there are several possible economic rationales for intervention. First, if current agricultural or commercial policies subsidize unhealthy foods (e.g. energy-dense food products), changes in policies to remove these price advantages is likely to be desirable. Second, beyond "leveling the playing field" in this way, further interventions might be considered to the extent our results are consistent with an important role for time-inconsistent preferences, imperfect information about the caloric content of different foods, and negative externalities from pooled health care costs.

Researchers and policymakers should explore ways to target current distortions or market failures. In addition to removing welfare-decreasing subsidies, Pigouvean taxation might be considered as a means of targeting externalities from pooled health care costs and internalities from time-inconsistent preferences. For example, taxation of "junk food" might lessen the impact of discount big box grocers on obesity and the Affordable Care Act's mandate for chain restaurants to post calorie information might reduce information problems that lead to suboptimal food consumption decisions. That said, future research is needed for examining both the role of market failures in determining weight outcomes and the costs and benefits of possible policy options to mitigate them.

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Figure 1 – Trends in BMI, Obesity, and Class II/III (Severe) Obesity

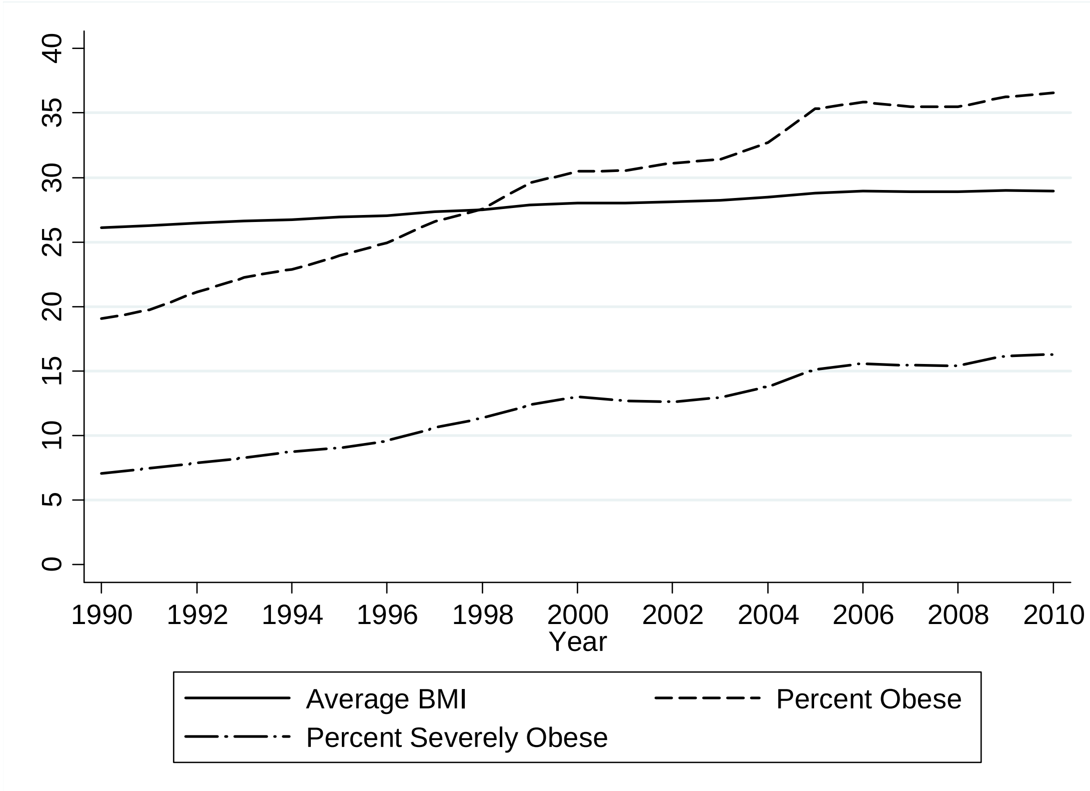

Figure 2 – Trends in Economic Factors Measured as Proportions

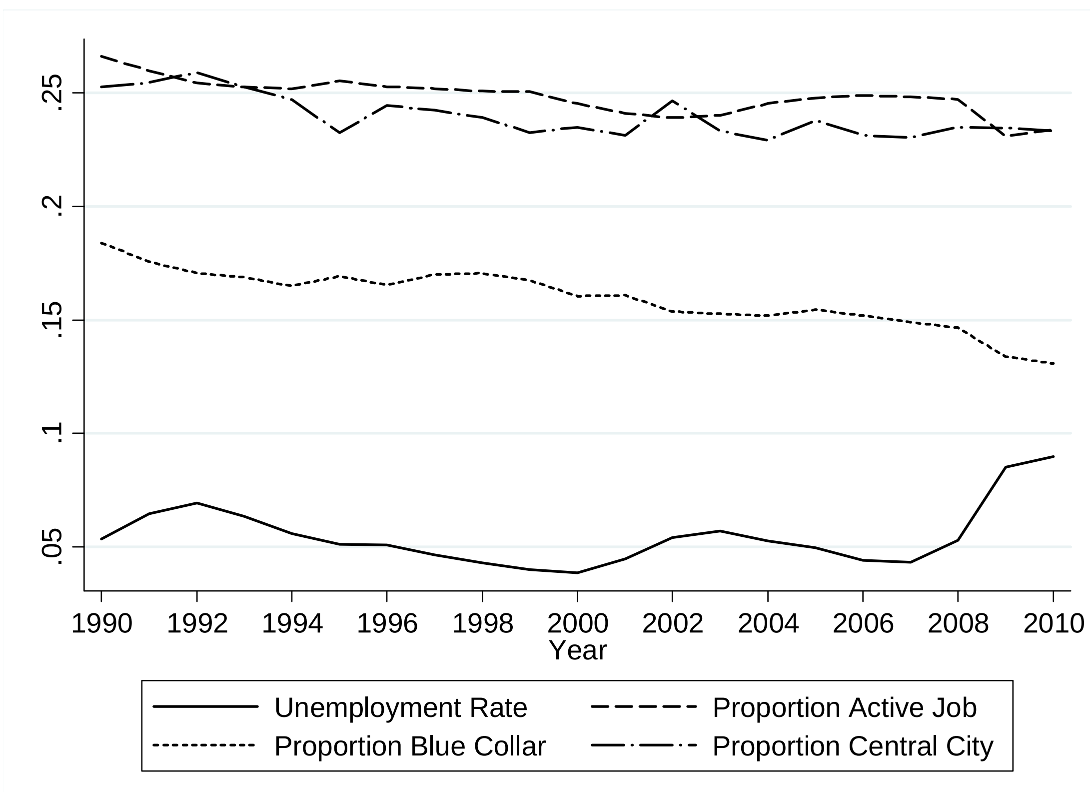

Figure 3 – Trends in Labor Force Participation Rates

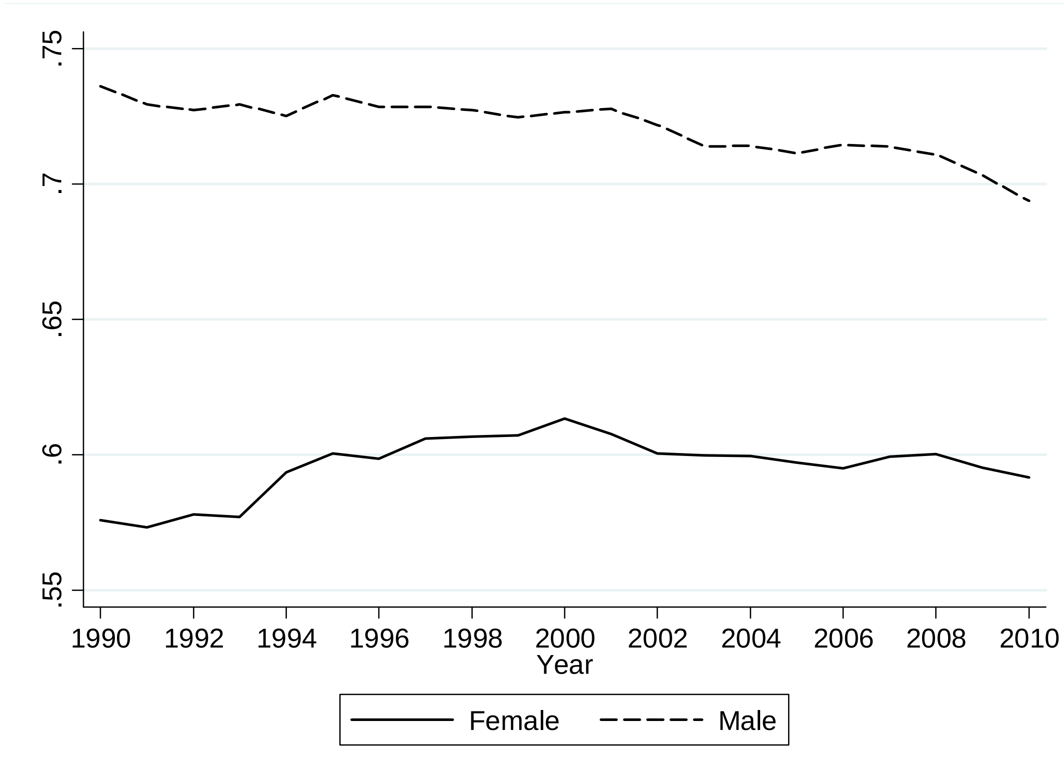

Figure 4 – Trends in Income Inequality Ratios

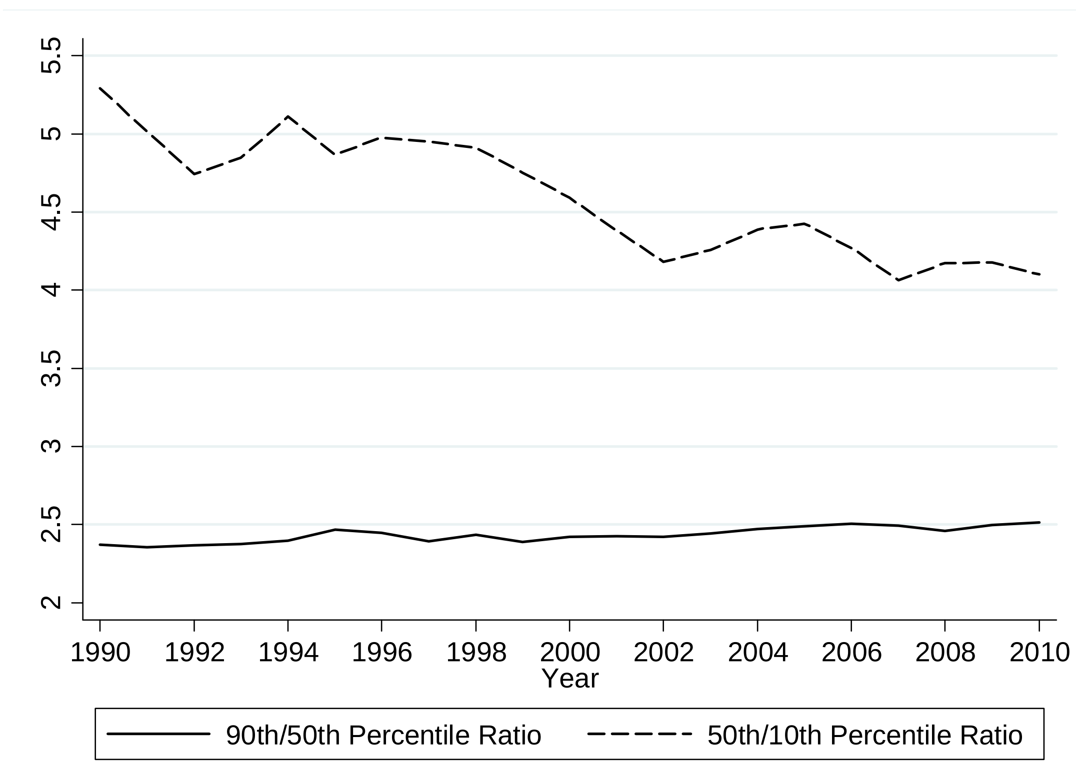

Figure 5 – Trend in Work Hours

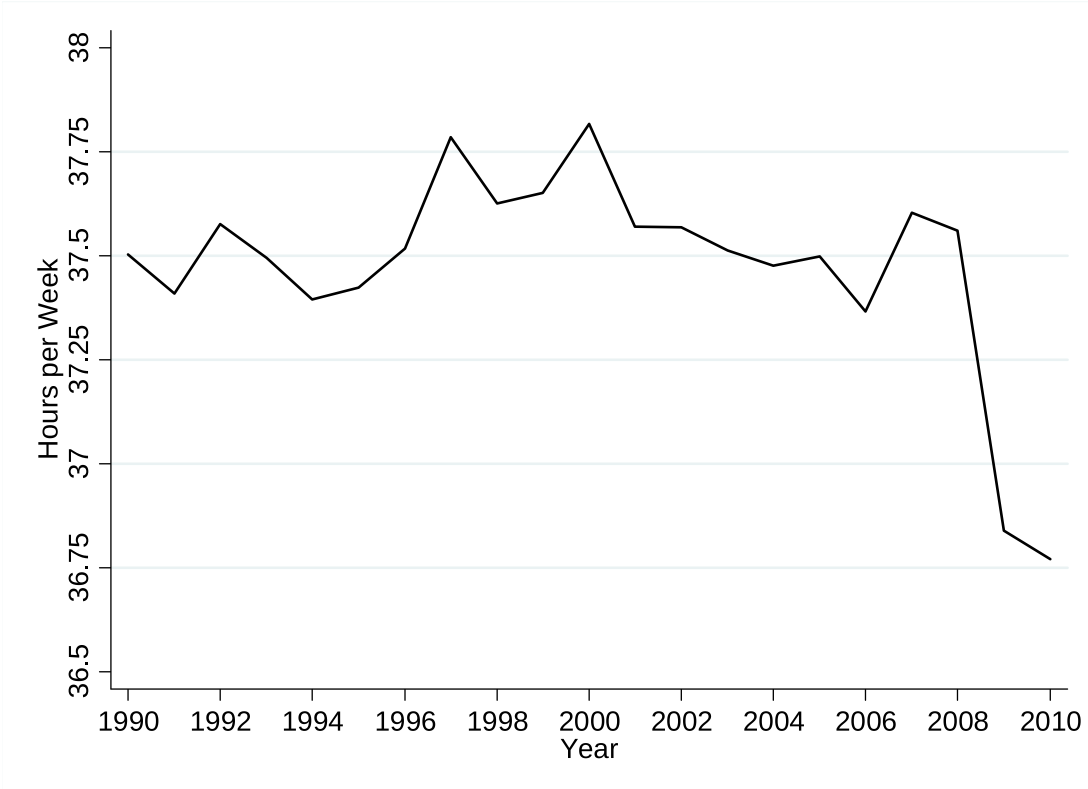

Figure 6 – Trends in Price Variables

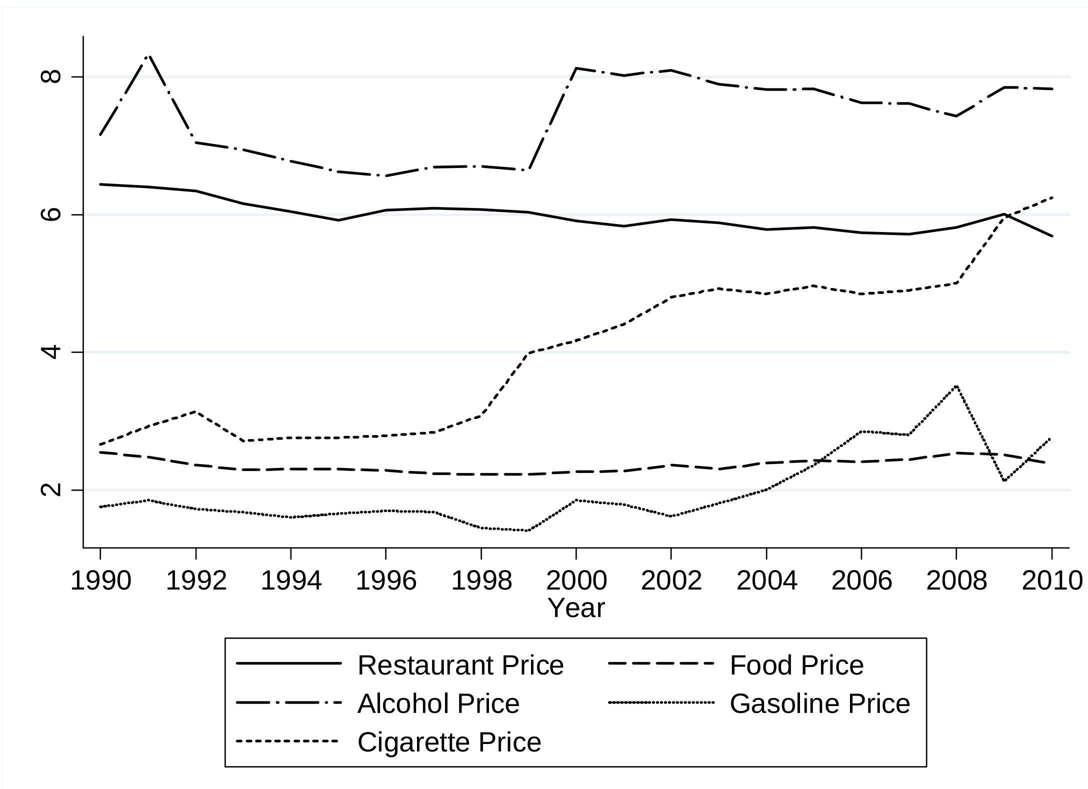

Figure 7 – Trend in Relative Price of Fruits and Vegatables

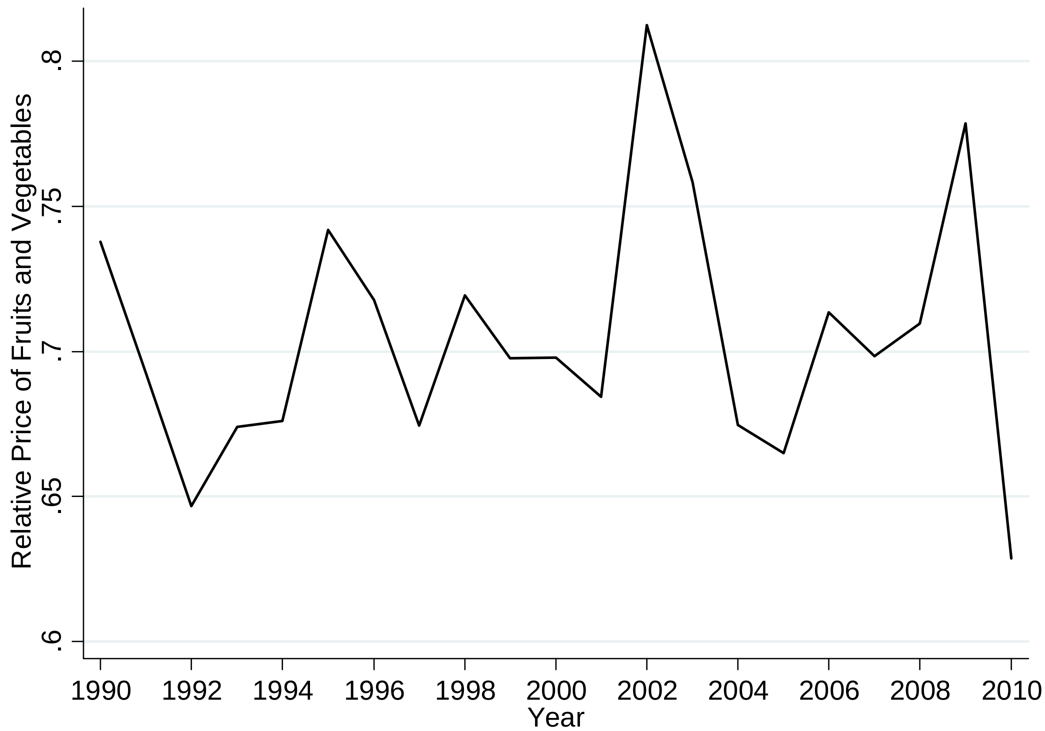

Figure 8 – Trends in Store Variables

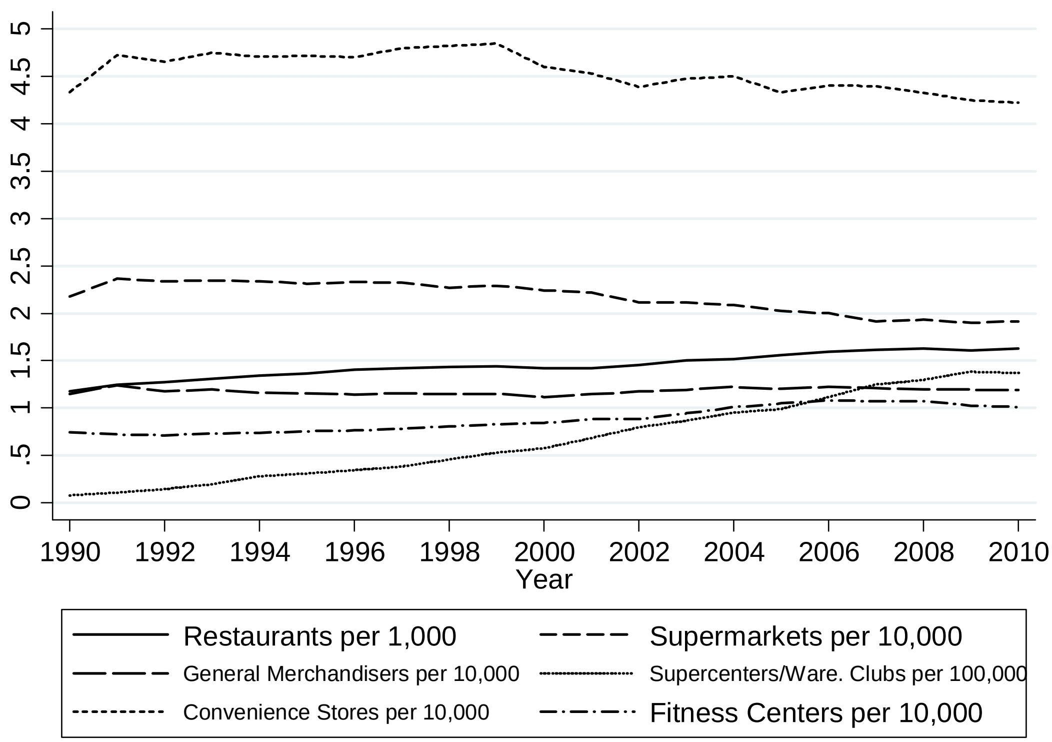

Figure 9 – Trend in Food Stamp Spending

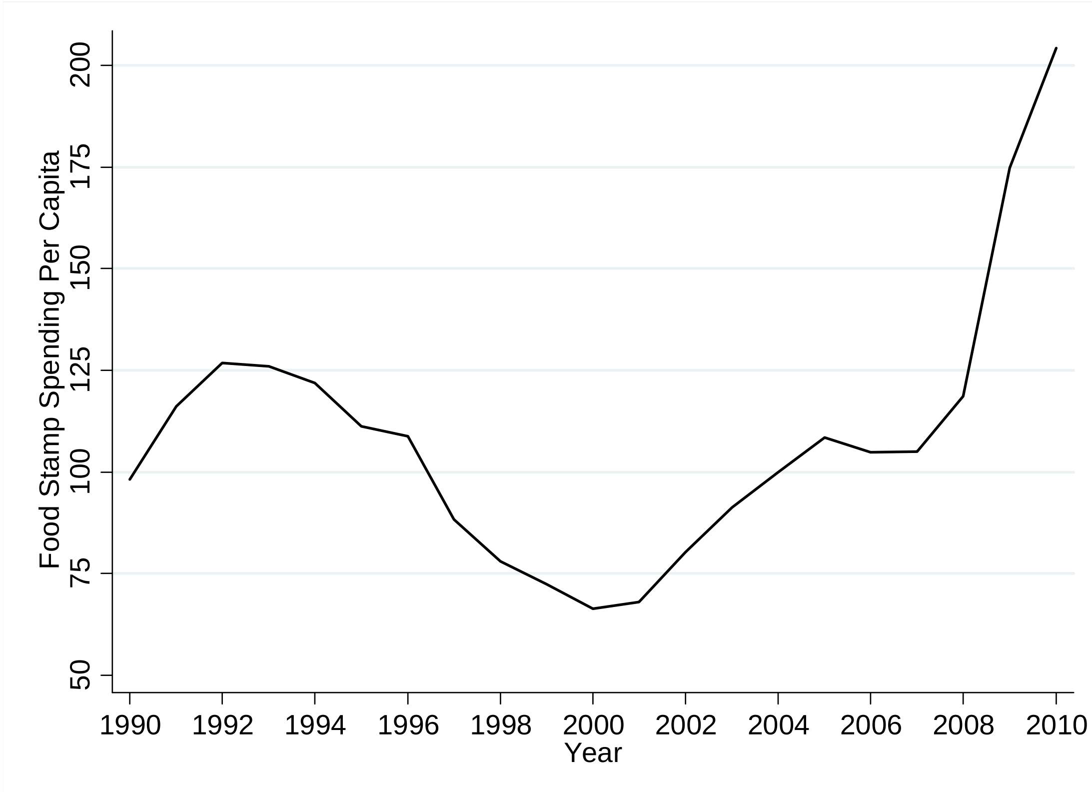

Figure 10 – Trends in Smoking Ban Variables

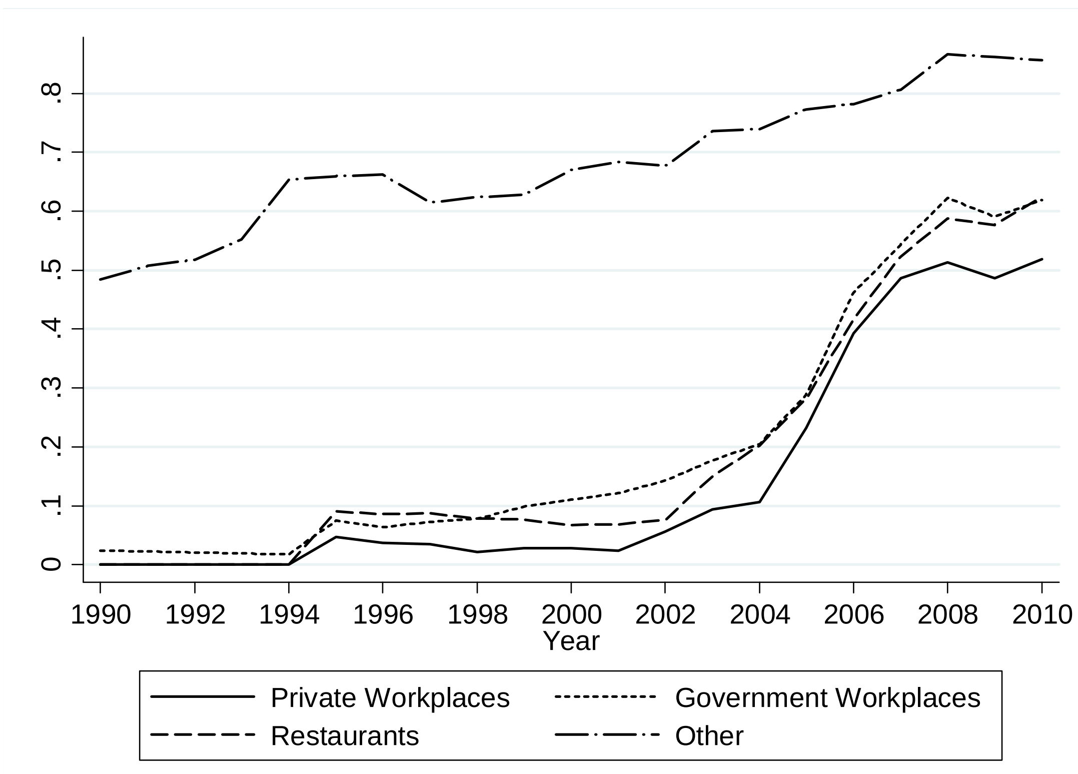

Table 1 – Percentage of Rise in BMI Explained by Prior Studies

Variable	Study	Data	Years	Percentage of Rise in BMI Explained
Fast-food price	Chou et al. (2004)	BRFSS	1984-1999	3.6%+
Grocery food price	Lakdawalla and Philipson (2002)	NHIS	1976-1994	40.0%
Alcohol price	Chou et al. (2004)	BRFSS	1984-1999	0.7%+
Restaurants	Chou et al. (2004)	BRFSS	1984-1999	64.4%+
Walmart Supercenters	Courtemanche and Carden (2011)	BRFSS	1994-2005	10.5%
Food stamps	Baum (2011)	NLSY	1985-2000	0.6%+
Work hours	Courtemanche (2009b)	NLSY	1985-2004	1.4%
Urban sprawl	Zhou and Kaestner (2010)	NHIS	1976-2001	8.6%+
On-the-job exercise	Lakdawalla and Philipson (2002)	NHIS	1976-1994	9.8%+
Gasoline prices	Courtemanche (2009b)	BRFSS	1984-2004	8.0%
Cigarette price	Chou et al. (2004)	BRFSS	1984-1999	24.9%+
Clean indoor air laws	Chou et al. (2004)	BRFSS	1984-1999	4.2%+
			Total	**176.7%**

Notes: BRFSS is Behavioral Risk Factor Surveillance System, NHIS is National Health Interview Survey, and NLSY is National Longitudinal Survey of Youth. + denotes estimate is our calculation based on summary statistics and coefficient estimates from the paper, as opposed to being directly presented by the paper's authors.

Table 2 – Impacts of One Standard Deviation Increases in Economic Factors on BMI

	Separate Regressions	All Factors Together
General Economic Indicators		
Unemployment rate	0.034 (0.033)	0.008 (0.019)
Median household income	-0.015 (0.034)	0.066 (0.027)**++
90/50 ratio	-0.050 (0.013)***	-0.014 (0.009)+++
50/10 ratio	-0.033 (0.018)*	-0.014 (0.013)
Labor Supply Variables		
Female labor force participation rate	-0.040 (0.031)	-0.035 (0.022)
Male labor force participation rate	-0.024 (0.026)	-0.007 (0.021)+
Average work hours	0.009 (0.017)	0.004 (0.014)
Proportion active job	-0.045 (0.030)	0.018 (0.019)+++
Proportion blue collar	-0.051 (0.036)	-0.048 (0.021)**
Variables Related to Monetary or Time Costs of Calorie Intake		
Fast-food restaurant price	-0.013 (0.031)	-0.031 (0.026)
Grocery food price	-0.121 (0.033)***	-0.002 (0.031)+++
Relative price of fruits/vegetables	-0.015 (0.028)	-0.002 (0.013)
Alcohol price	0.019 (0.024)	0.028 (0.014)*
Restaurants	0.045 (0.077)	0.167 (0.047)***++
Supercenters/warehouse clubs	0.280 (0.032)***	0.218 (0.039)***++
Supermarkets	-0.156 (0.051)***	-0.087 (0.031)***
Convenience stores	-0.066 (0.081)	-0.064 (0.052)
General merchandisers	0.206 (0.055)***	0.058 (0.045)+++
Food stamp benefits	0.071 (0.044)	0.033 (0.025)
Variables Related to Monetary or Time Costs of Physical Activity		
Gasoline price	-0.245 (0.107)**	-0.047 (0.065)++
Fitness centers	-0.237 (0.044)***	-0.113 (0.035)***+++
Proportion central city	-0.266 (0.197)	-0.087 (0.099)
Variables Related to Monetary or Time Costs of Smoking		
Cigarette price	-0.108 (0.049)**	0.036 (0.031)+++
Smoking ban: private	-0.020 (0.026)	0.027 (0.027)
Smoking ban: government	-0.011 (0.028)	-0.013 (0.025)
Smoking ban: restaurant	-0.052 (0.026)*	-0.011 (0.016)
Smoking ban: other	0.057 (0.023)**	0.005 (0.014) +++

Notes: Standard errors, heteroskedasticity-robust and clustered by state, are in parentheses. *** statistically significant at 1% level; ** 5% level; * 10% level. +++ difference between two regressions is statistically significant at 1% level; ++ 5% level; +++ 10% level. All regressions include the control variables and state and year fixed effects. BRFSS sampling weights are used. N=2,922,071.

Table 3 – Impacts of One Standard Deviation Increases in Economic Factors on P(Obese)

	Separate Regressions	All Factors Together
General Economic Indicators		
Unemployment rate	0.002 (0.002)	-0.001 (0.001)
Median household income	-0.001 (0.002)	0.003 (0.002)$^{+++}$
90/50 ratio	-0.003 (0.001)***	-0.0004 (0.001)$^{+++}$
50/10 ratio	-0.004 (0.001)***	-0.002 (0.001)**$^{+}$
Labor Supply Variables		
Female labor force participation rate	-0.002 (0.002)	-0.002 (0.001)
Male labor force participation rate	-0.001 (0.002)	0.001 (0.002)$^{+}$
Average work hours	0.0004 (0.001)	-0.001 (0.001)$^{++}$
Proportion active job	-0.004 (0.002)*	-0.002 (0.002)$^{++}$
Proportion blue collar	-0.003 (0.002)	-0.001 (0.001)
Variables Related to Monetary or Time Costs of Calorie Intake		
Fast-food restaurant price	-0.001 (0.002)	-0.003 (0.002)
Grocery food price	-0.006 (0.002)***	0.002 (0.002)$^{+++}$
Relative price of fruits/vegetables	-0.001 (0.002)	-0.0001 (0.001)
Alcohol price	0.001 (0.002)	0.001 (0.001)
Restaurants	0.004 (0.005)	0.012 (0.004)***$^{++}$
Supercenters/warehouse clubs	0.017 (0.002)***	0.013 (0.003)***$^{++}$
Supermarkets	-0.008 (0.003)**	-0.005 (0.003)*
Convenience stores	-0.003 (0.005)	-0.005 (0.004)
General merchandisers	0.015 (0.004)***	0.007 (0.003)**$^{+++}$
Food stamp benefits	0.003 (0.003)*	0.003 (0.002)
Variables Related to Monetary or Time Costs of Physical Activity		
Gasoline price	-0.013 (0.006)**	-0.001 (0.005)$^{+++}$
Fitness centers	-0.012 (0.003)***	-0.005 (0.004)$^{++}$
Proportion central city	-0.018 (0.011)	-0.005 (0.007)
Variables Related to Monetary or Time Costs of Smoking		
Cigarette price	-0.007 (0.003)*	0.003 (0.003)$^{+++}$
Smoking ban: private	-0.001 (0.002)	0.001 (0.001)
Smoking ban: government	-0.001 (0.002)	-0.001 (0.002)
Smoking ban: restaurant	-0.003 (0.002)**	-0.001 (0.001)
Smoking ban: other	0.005 (0.002)**	0.002 (0.001)*$^{+}$

See notes for Table 2.

Table 4 – Impacts of One Std. Dev. Increases in Economic Factors on P(Class II/III Obese)

	Separate Regressions	Surviving Factors Only
General Economic Indicators		
Unemployment rate	0.002 (0.001)	-0.001 (0.001)$^{++}$
Median household income	-0.003 (0.002)	0.001 (0.001)$^{+++}$
90/50 ratio	-0.002 (0.001)***	-0.0002 (0.001)$^{+++}$
50/10 ratio	-0.001 (0.001)	-0.0004 (0.001)
Labor Supply Variables		
Female labor force participation rate	-0.001 (0.001)	0.001 (0.001)
Male labor force participation rate	-0.003 (0.001)*	-0.002 (0.001)
Average work hours	0.0004 (0.0008)	-0.0002 (0.001)
Proportion active job	-0.002 (0.001)	0.001 (0.001)$^{+++}$
Proportion blue collar	-0.003 (0.002)**	-0.003 (0.001)***
Variables Related to Monetary or Time Costs of Calorie Intake		
Fast-food restaurant price	-0.0005 (0.001)	-0.001 (0.001)
Grocery food price	-0.006 (0.001)***	-0.0004 (0.001)$^{+++}$
Relative price of fruits/vegetables	-0.001 (0.001)	-0.0004 (0.001)
Alcohol price	-0.0001 (0.001)	0.0002 (0.001)
Restaurants	0.004 (0.003)	0.009 (0.003)***$^{++}$
Supercenters/warehouse clubs	0.013 (0.002)***	0.009 (0.002)***$^{++}$
Supermarkets	-0.007 (0.002)***	-0.004 (0.001)***
Convenience stores	-0.001 (0.003)	-0.003 (0.003)
General merchandisers	0.011 (0.002)***	0.003 (0.002)*$^{+++}$
Food stamp benefits	0.005 (0.002)**	0.003 (0.001)**
Variables Related to Monetary or Time Costs of Physical Activity		
Gasoline price	-0.010 (0.005)**	-0.001 (0.003)$^{++}$
Fitness centers	-0.010 (0.002)***	-0.003 (0.002)*$^{+++}$
Proportion central city	-0.013 (0.008)*	-0.005 (0.003)
Variables Related to Monetary or Time Costs of Smoking		
Cigarette price	-0.006 (0.002)***	0.0002 (0.001)$^{+++}$
Smoking ban: private	-0.002 (0.001)	0.001 (0.001)$^{++}$
Smoking ban: government	-0.002 (0.001)	-0.001 (0.001)
Smoking ban: restaurant	-0.003 (0.001)**	-0.001 (0.001)**
Smoking ban: other	0.003 (0.001)**	0.001 (0.001)$^{++}$

See notes for Table 2.

Table 5 – Percentage of Rises in BMI, Obesity, and Severe Obesity Explained by Changes in Economic Factors

	BMI	Obesity	Class II/III Obesity
General Economic Indicators			
Unemployment rate	0.7% (1.5%)	-1.1% (1.9%)	-2.6% (2.7%)
Median household income	0.5% (0.2%)**	0.4% (0.3%)	0.3% (0.4%)
90/50 ratio	-0.7% (0.5%)	-0.3% (0.6%)	-0.4% (0.8%)
50/10 ratio	0.8% (0.7%)	2.1%** (0.9%)**	0.8% (1.1%)
Subtotal	**1.3% (1.7%)**	**1.1% (2.1%)**	**-1.9% (2.8%)**
Labor Supply Variables			
Female labor force participation rate	-0.5% (0.3%)*	-0.4% (0.3%)	0.3% (0.4%)
Male labor force participation rate	-0.3% (0.3%)	-1.0% (1.2%)	2.1% (1.5%)
Average work hours	0.2% (0.5%)	0.5% (0.7%)	0.2% (0.8%)
Proportion active job	-0.5% (0.6%)	0.8% (0.7%)	-1.1% (0.9%)
Proportion blue collar	3.3% (1.4%)**	1.0% (1.6%)	6.2% (2.2%)***
Subtotal	**2.1% (1.8%)**	**0.9% (2.0%)**	**7.8% (2.1%)*** **
Variables Related to Monetary or Time Costs of Calorie Intake			
Fast-food restaurant price	2.3% (2.0%)	3.4% (2.1%)	1.6% (2.2%)
Grocery food price	0.06% (0.8%)	-0.6% (0.9%)	0.3% (1.1%)
Relative price of fruits/vegetables	0.1% (0.6%)	0.04% (0.8%)	0.6% (1.0%)
Alcohol price	1.1% (0.6%)*	0.8% (0.8%)	0.3% (0.9%)
Restaurants	12.2% (3.4%)***	13.8% (4.5%)***	22.9% (6.2%)***
Supercenters/warehouse clubs	17.2% (3.1%)***	16.3% (3.4%)***	24.1% (4.7%)***
Supermarkets	-0.1% (0.03%)***	-0.08% (0.04%)*	-0.1% (0.04%)***
Convenience stores	-0.1% (0.1%)	-0.2 (0.1%)	-0.2% (0.2%)
General merchandisers	0.9% (0.7%)	1.7% (0.8%)**	1.8% (0.9%)*
Food stamp benefits	2.7% (2.1%)	3.9% (2.9%)	8.3% (3.6%)**
Subtotal	**36.5% (5.7%)*** **	**39.1% (7.1%)*** **	**59.6% (9.7%)*** **
Variables Related to Monetary or Time Costs of Physical Activity			
Gasoline price	-3.3% (4.6%)	-0.7% (5.4%)	-2.8% (7.6%)
Fitness centers	-4.1% (1.3%)***	-2.7% (2.1%)	-3.6% (2.2%)*
Proportion central city	0.7% (0.8%)	0.7% (0.9%)	1.2% (0.9%)
Subtotal	**-6.7% (4.5%)**	**-2.6% (5.9%)**	**-5.2% (7.8%)**
Variables Related to Monetary or Time Costs of Smoking			
Cigarette price	3.9% (3.9%)	4.4% (4.6%)	0.6% (3.8%)
Smoking ban: private	1.2% (1.2%)	0.9% (1.0%)	1.8% (1.8%)
Smoking ban: government	-0.6% (1.1%)	-0.5% (1.1%)	-1.9% (1.7%)
Smoking ban: restaurant	-0.6% (0.9%)	-1.3% (0.9%)	-2.2% (1.0%)**
Smoking ban: other	0.1% (0.4%)	0.8% (0.5%)*	0.7% (0.9%)
Subtotal	**4.0% (3.4%)**	**4.3% (4.3%)**	**-1.0% (4.2%)**
Total from Economic Factors	**37.2% (10.6%)*** **	**42.8% (12.9%)*** **	**59.3% (16.9%)*** **
Total from Controls	**10.4% (1.1%)*** **	**6.1% (1.3%)*** **	**2.7% (1.8%)**

Notes: Standard errors, heteroskedasticity-robust and clustered by state, are in parentheses. *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. BRFSS sampling weights are used.

Table 6 – Impacts of One Standard Dev. Increases in Economic Factors on BMI Quantiles

	0.1	0.25	0.5	0.75	0.9
General Economic Indicators					
Unemployment rate	0.022 (0.021)	0.042 (0.019)**	0.016 (0.022)	0.004 (0.032)	-0.038 (0.053)
Median household income	0.030 (0.024)	0.034 (0.023)	0.082 (0.025)***	0.058 (0.036)	0.061 (0.063)
90/50 ratio	-0.007 (0.010)	-0.011 (0.008)	-0.001 (0.009)	-0.012 (0.014)	-0.030 (0.026)
50/10 ratio	-0.018 (0.013)	-0.000 (0.011)	-0.024 (0.013)*	-0.039 (0.018)**	-0.011 (0.031)
Labor Supply Variables					
Female labor force participation rate	-0.054 (0.019)***	-0.051 (0.018)***	-0.079 (0.020)***	-0.024 (0.026)	0.049 (0.046)
Male labor force participation rate	0.024 (0.016)	0.017 (0.016)	0.040 (0.017)**	0.018 (0.023)	-0.02 (0.041)**
Average work hours	0.005 (0.012)	0.024 (0.011)**	0.012 (0.012)	-0.022 (0.018)	0.003 (0.032)
Proportion active job	0.020 (0.016)	0.025 (0.016)	-0.007 (0.017)	-0.029 (0.025)	0.067 (0.044)
Proportion blue collar	-0.028 (0.018)	-0.019 (0.018)	-0.053 (0.019)***	-0.020 (0.025)	-0.014 (0.049)***
Variables Related to Monetary or Time Costs of Calorie Intake					
Fast-food rest. price	-0.020 (0.019)	-0.017 (0.018)	-0.035 (0.019)*	-0.046 (0.028)	-0.031 (0.048)
Grocery food price	0.016 (0.021)	0.019 (0.019)	-0.016 (0.020)	0.003 (0.030)	-0.022 (0.055)
Relative price of fruits/vegetables	0.012 (0.014)	0.007 (0.013)	0.001 (0.014)	-0.004 (0.022)	-0.019 (0.037)
Alcohol price	0.040 (0.015)***	0.035 (0.016)**	0.032 (0.017)**	0.026 (0.023)	0.001 (0.043)
Restaurants	0.046 (0.039)	0.016 (0.035)	0.062 (0.038)	0.274 (0.055)***	0.526 (0.097)***
Supercenters/warehouse clubs	0.068 (0.025)***	0.100 (0.024)***	0.186 (0.027)***	0.283 (0.039)***	0.492 (0.067)***
Supermarkets	0.023 (0.030)	-0.007 (0.029)	-0.034 (0.031)	-0.126 (0.046)***	-0.251 (0.073)***
Convenience stores	0.007 (0.041)	-0.050 (0.038)	-0.031 (0.043)	-0.131 (0.059)**	-0.143 (0.096)
General merchandisers	-0.066 (0.029)**	-0.056 (0.028)**	-0.014 (0.031)	0.164 (0.043)***	0.159 (0.076)**
Food stamp benefits	0.010 (0.026)	0.025 (0.025)	-0.015 (0.028)	0.043 (0.038)	0.134 (0.069)*

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Table 6 – Impacts of One Standard Dev. Increases in Economic Factors on BMI Quantiles (continued)

	0.1	0.25	0.5	0.75	0.9
Variables Related to Monetary or Time Costs of Physical Activity					
Gasoline price	-0.095 (0.074)	-0.103 (0.062)*	-0.064 (0.069)	-0.019 (0.097)	-0.056 (0.165)
Fitness centers	-0.100 (0.028)***	-0.095 (0.028)***	-0.060 (0.031)*	-0.110 (0.043)**	-0.162 (0.078)**
Proportion central city	-0.051 (0.047)	-0.041 (0.045)	-0.060 (0.046)	-0.142 (0.064)**	-0.181 (0.118)
Variables Related to Monetary or Time Costs of Smoking					
Cigarette price	0.017 (0.025)	0.033 (0.023)	0.064 (0.028)**	0.047 (0.040)	-0.034 (0.069)
Smoking ban: private	-0.019 (0.019)	0.016 (0.017)	0.013 (0.019)	0.050 (0.028)*	0.068 (0.052)
Smoking ban: government	0.025 (0.017)	0.011 (0.016)	0.013 (0.017)	-0.037 (0.026)	-0.070 (0.045)
Smoking ban: rest.	0.026 (0.019)	0.008 (0.018)	-0.005 (0.019)	-0.025 (0.028)	-0.047 (0.053)
Smoking ban: other	-0.025 (0.013)*	-0.021 (0.013)*	0.002 (0.014)	0.028 (0.021)	0.027 (0.037)

Notes: Standard errors are in parentheses; the variance-covariance matrix of the unconditional quantile regression model is estimated using 500 bootstrap replications. *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. All regressions include the control variables and state and year fixed effects. BRFSS sampling weights are used. N=2,922,071.

Table 7 – Percentage of Rise in BMI Quantiles Explained

	0.1	0.25	0.5	0.75	0.9
General Economic Indicators					
Unemployment rate	4.3%	5.4%**	1.4%	0.2%	-1.8%
Median household income	0.4%	0.4%	0.7%***	0.3%	0.3%
90/50 ratio	-0.9%	-0.9%	-0.1%	-0.5%	-0.9%
50/10 ratio	2.4%	0.03%	1.4%*	1.6%**	0.4%
Subtotal	**6.4%**	**5.0%***	**3.4%**	**1.8%**	**-2.1%**
Labor Supply Variables					
Female labor force participation rate	-1.7%***	-1.1%***	-1.1%***	-0.2%	0.4%
Male labor force participation rate	-2.4%	-1.1%	-1.8%**	-0.6%	2.3%**
Average work hours	0.5%	-1.4%**	-0.4%	0.6%	-0.1%
Proportion active job	-1.4%	-1.1%	0.2%	0.6%	-1.1%
Proportion blue collar	4.6%	2.1%	3.8%***	1.0%	5.3%***
Subtotal	**-1.3%**	**-2.7%**	**0.7%**	**1.4%**	**6.8%*** **
Variables Related to Monetary or Time Costs of Calorie Intake					
Fast-food restaurant price	3.6%	2.0%	2.7%*	2.5%	1.3%
Grocery food price	-1.0%	-0.8%	0.4%	-0.1%	0.3%
Relative price of fruits/vegetables	-1.4%	-0.5%	-0.03%	0.1%	0.5%
Alcohol price	3.8%***	2.2%**	1.8%**	0.8%	0.03%
Restaurants	8.1%	1.9%	4.8%	14.8%***	22.4%***
Supercenters/warehouse clubs	12.9%***	12.4%****	15.3%***	16.4%***	22.6%***
Supermarkets	0.05%	-0.01%	-0.03%	-0.1%***	-0.1%***
Convenience stores	0.03%	-0.2%	-0.1%	-0.2%**	-0.2%
General merchandisers	-2.5%**	-1.4%**	-0.2%	1.9%***	1.5%**
Food stamp benefits	1.9%	3.2%	-1.2%	2.6%	6.3%*
Subtotal	**25.6%*** **	**18.8%*** **	**23.4%*** **	**38.7%*** **	**54.7%*** **
Variables Related to Monetary or Time Costs of Physical Activity					
Gasoline price	-15.8	-11.3%*	-4.6%	-1.0%	-2.3%
Fitness centers	-8.8%***	-5.5%***	-2.3%*	-3.0%**	-3.5%**
Proportion central city	1.0%	0.5%	0.5%	0.8%**	0.8%
Subtotal	**-23.6%***	**-16.3%*** **	**-6.4%**	**-3.1%**	**-4.9%**
Variables Related to Monetary or Time Costs of Smoking					
Cigarette price	4.3	5.6%	7.1%**	3.7%	-2.1%
Smoking ban: private	-2.1	1.1%	0.6%	1.6%*	1.8%
Smoking ban: government	2.7	0.8%	0.6%	-1.2%	-1.8%
Smoking ban: restaurant	3.4	0.7%	-0.3%	-1.0%	-1.5%
Smoking ban: other	-1.7%*	-0.9%*	0.1%	0.6%	0.4%
Subtotal	**6.7%**	**7.3%**	**8.1%*** **	**3.7%**	**-3.2%**
Total from Econ. Factors	**13.8%**	**12.1%**	**29.1%*** **	**42.5%*** **	**51.3%*** **
Total from Controls	**32.4%*** **	**23.9%*** **	**13.8%*** **	**5.3%*** **	**1.7%**

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level, based on variance-covariance matrix of the unconditional quantile regression model estimated using 500 bootstrap replications. BRFSS sampling weights are used.

Table 8 – Robustness Checks: Percentage of Rise in BMI Explained

	Surviving Factors	Quadratic Trend	Aggregate Data	Drop Heavily Rural	7-Year Averages	Instrum-ental Variables	Add Lag of State BMI
<u>*General Economic Indicators*</u>							
Unemployment rate	--	-2.0%	0.9%	-0.7%	0.05%	1.3%	0.09%
Median income	0.3%	0.6%	0.4%	0.4%	5.0%*	0.6%	0.6%
90/50 ratio	-0.4%	-0.8%	-0.6%	-0.9%	-0.3%	-0.6%	-0.9%
50/10 ratio	0.9%	0.3%	0.5%	1.5%	5.5%	0.8%	0.8%
Subtotal	**0.8%**	**-1.9%**	**1.3%**	**0.3%**	**10.3%**	**2.1%**	**0.6%**
<u>*Labor Supply Variables*</u>							
Female labor force	--	-0.7%	-0.4%	-0.6%*	-1.0%	-0.3%	-0.5%
Male labor force	--	-0.3%	-0.03%	-0.3%	-2.7%	-0.2%	-0.2%
Average work hours	--	0.3%	0.1%	0.6%	1.0%	0.1%	0.3%
Proportion active job	--	-0.6%	-0.5%	-0.6%	-1.0%	-0.5%	-0.5%
Proportion blue collar	2.9%**	3.8%**	3.1%**	3.1%*	-0.1%	3.5%**	2.9%**
Subtotal	**2.9%****	**2.4%**	**2.3%**	**2.2%**	**-3.8%**	**2.4%**	**2.2%**
<u>*Variables Related to Monetary or Time Costs of Calorie Intake*</u>							
Fast-food price	--	1.6%	2.8%	2.1%	0.7%	2.2%	2.4%
Grocery food price	0.2%	0.1%	0.1%	0.4%	-1.6%	-0.1%	0.02%
Relative price	--	1.3%**	0.02%	-0.1%	0.4%	-0.7%	-0.5%
Alcohol price	1.0%	1.7%***	0.9%	0.9%	-0.5%	0.9%	0.4%
Restaurants	10.2%***	10.8%***	9.7%***	12.3%***	13.2%**	8.2%	8.2%**
Supercenters/ware.	18.3%***	18.9%***	15.3%***	16.9%***	18.6%***	20.9%***	14.5%***
Supermarkets	-0.1%***	-0.1%***	-0.1%	-0.1%	-0.2%	-0.1%**	-0.1%**
Convenience stores	--	-0.2%*	-0.1%	-0.1%	1.1%	-0.04%	-0.1%
General merch.	1.0%	1.5%**	1.7%***	-0.2%	-0.5%	0.9%	0.6%
Food stamp benefits	--	-1.1%	0.1%	3.0%	3.3%***	2.5%	3.3%
Subtotal	**30.5%*****	**34.5%*****	**30.4%*****	**35.0%*****	**34.4%*****	**35.4%*****	**28.8%*****
<u>*Variables Related to Monetary or Time Costs of Physical Activity*</u>							
Gasoline price	-3.5%	1.3%	0.4%	-1.2%	-14.3%	-2.2%	-4.3%
Fitness centers	-4.0%***	-1.3%	-3.0%**	-4.5%***	-13.2%***	-3.4%**	-3.4%**
Prop. central city	--	0.7%	0.6%	1.2%	1.7%	0.5%	0.2%
Subtotal	**-7.5%**	**0.7%**	**-2.0%**	**-4.6%**	**-25.8%**	**-5.1%**	**-7.4%**
<u>*Variables Related to Monetary or Time Costs of Smoking*</u>							
Cigarette price	4.3%	8.3%**	3.0%	3.3%	13.1%*	6.0%	2.8%
Smoking ban: private	--	1.4%	0.7%	1.9%	-1.1%	1.1%	1.0%
Smoking ban: gov't	--	-0.7%	-0.03%	-1.5%	-2.2%	-0.6%	-0.2%
Smoking ban: rest.	0.1%	-1.5%*	-1.0%	0.02%	2.4%	-0.3%	-0.6%
Smoking ban: other	-0.01%	0.3%	0.3%	0.1%	-0.7%	0.03%	-0.01%
Subtotal	**4.3%**	**7.8%****	**3.1%**	**3.8%**	**11.5%***	**6.3%***	**2.9%**
Total from Economic Factors	**31.0%*****	**44.5%*****	**35.1%*****	**36.6%****	**27.7%**	**41.0%*****	**27.1%****
Sample Size	2,922,071	2,922,071	1,013	2,112,308	2,430,831	2,857,581	2,836,583

Notes: *** statistically significant at 1% level; ** 5% level; * 10% level, based on heteroskedasticity-robust standard errors that are clustered by state. All regressions include the control variables and state fixed effects; all except the "quadratic trend" regression also include year fixed effects.

Table 9 – Robustness Checks: Percentage of Rise in Obesity Explained

	Surviving Factors	Quadratic Trend	Aggregate Data	Drop Heavily Rural	7-Year Averages	Instrum-ental Variables	Add Lag of State BMI
General Economic Indicators							
Unemployment rate	--	-4.6%**	-0.9%	-1.6%	0.2%	-0.8%	-1.0%
Median income	--	0.7%**	0.3%	0.3%	9.8%**	0.5%	0.5%*
90/50 ratio	0.03%	-0.3%	-0.2%	-0.3%	-1.7%	-0.1%	-0.4%
50/10 ratio	2.2%**	1.2%	1.8%	2.8%***	8.6%*	2.1%**	2.1%**
Subtotal	**2.3%****	**-3.0%**	**1.0%**	**1.1%**	**16.9%***	**1.6%**	**1.2%**
Labor Supply Variables							
Female labor force	--	-0.5%	-0.4%	-0.6%	-1.8%	-0.4%	-0.4%
Male labor force	--	-0.9%	-0.6%	-1.3%	-3.5%	-1.1%	-0.6%
Average work hours	--	0.7%	0.5%	0.6%	1.0%	0.6%	0.7%
Proportion active job	1.0%	0.8%	0.7%	1.2%	-0.2%	0.9%	0.7%
Proportion blue collar	--	1.3%	1.4%	0.6%	-2.7%	1.0%	0.9%
Subtotal	**1.0%**	**1.4%**	**1.6%**	**0.5%**	**-7.2%**	**0.9%**	**1.3%**
Variables Related to Monetary or Time Costs of Calorie Intake							
Fast-food price	--	2.1%	4.0%*	3.7%	-0.4%	3.3%	3.4%*
Grocery food price	-0.6%	-0.2%	-0.5%	-0.3%	-0.4%	-0.8%	-0.8%
Relative price	--	1.5%**	-0.1%	-0.2%	0.2%	-0.2%	-0.6%
Alcohol price	--	1.1%	0.8%	0.7%	0.9%	0.5%	-0.1%
Restaurants	10.3%**	12.8%***	10.6%***	14.9%***	15.4%*	13.0%	9.8%**
Supercenters/ware.	17.3%***	16.2%***	13.7%***	16.5%***	17.4%**	19.0%***	14.3%***
Supermarkets	-0.1%**	-0.07%*	-0.1%**	-0.1%	-0.3%	-0.1%*	-0.1%
Convenience stores	--	-0.2%**	-0.2%**	-0.2%	2.0%	-0.1%	-0.1%
General merch.	1.6%**	1.8%**	2.7%***	0.5%	0.6%	1.8%*	1.4%*
Food stamp benefits	3.4%	2.8%	0.2%	2.7%	3.8%***	3.7%	5.3%*
Subtotal	**31.9%*****	**37.7%*****	**31.0%**	**38.2%*****	**39.3%*****	**40.1%*****	**32.5%*****
Variables Related to Monetary or Time Costs of Physical Activity							
Gasoline price	-2.1%	-1.0%	4.3%	2.6%	-13.0%	0.9%	-1.1%
Fitness centers	-2.2%	-1.5%	-1.7%	-2.7%	-10.5%*	-2.1%	-2.0%
Prop. central city	--	0.9%	0.5%	1.1%	0.9%	0.6%	-0.02%
Subtotal	**-4.3%**	**-1.6%**	**3.1%**	**0.9%**	**-22.6%**	**-0.6%**	**-3.1%**
Variables Related to Monetary or Time Costs of Smoking							
Cigarette price	4.6%	5.8%	3.1%	4.7%	21.4%*	5.7%	3.1%
Smoking ban: private	--	0.5%	0.4%	0.7%	1.7%	0.9%	0.7%
Smoking ban: gov't	--	-0.3%	0.2%	-1.0%	-3.1%	-0.6%	0.01%
Smoking ban: rest.	-0.6%	-1.7%*	-1.9%	-0.3%	-1.1%	-1.1%	-1.2%
Smoking ban: other	0.7%	0.9%*	1.0%**	0.8%	-0.3%	0.8%	0.5%
Subtotal	**4.6%**	**5.1%**	**2.9%**	**4.9%**	**19.2%***	**5.8%**	**3.1%**
Total from Economic Factors	**35.5%*****	**39.6%*****	**39.6%*****	**45.7%*****	**45.2%**	**47.8%*****	**35.0%****
Sample Size	2,922,071	2,922,071	1,013	2,112,308	2,430,831	2,857,581	2,836,583

See notes for Table 8.

Table 10 – Robustness Checks: Percentage of Rise in Class II/III Obesity Explained

	All Factors Together	Quadratic Trend	Aggregate Data	Drop Heavily Rural	7-Year Averages	Instrum-ental Variables	Add Lag of State BMI
General Economic Indicators							
Unemployment rate	--	-8.4%***	-2.4%	-4.9%	0.2%	-1.6%	-4.1%
Median income	--	0.8%**	0.1%	-0.03%	7.4%*	0.3%	0.2%
90/50 ratio	-0.2%	-0.5%	-0.1%	-0.7%	-2.5%	-0.1%	-0.5%
50/10 ratio	--	-0.5%	0.7%	1.4%	7.4%	0.7%	1.1%
Subtotal	**-0.2%**	**-8.5%*** **	**-1.7%**	**-4.2%**	**12.6%**	**-0.7%**	**-3.3%**
Labor Supply Variables							
Female labor force	--	0.3%	0.5%	0.4%	0.5%	0.4%	0.3%
Male labor force	1.5%	2.5%	2.3%	2.0%	-0.5%	2.2%	2.2%
Average work hours	--	0.4%	0.2%	0.8%	2.5%**	0.2%	0.7%
Proportion active job	--	-0.8%	-1.3%	-1.3%	-1.6%	-1.2%	-1.2%
Proportion blue collar	5.1%***	6.4%**	6.8%***	4.5%*	2.0%	6.6%***	5.9%***
Subtotal	**6.5%*** **	**8.7%*** **	**8.5%*** **	**6.4%** **	**2.9%**	**8.2%*** **	**8.0%*** **
Variables Related to Monetary or Time Costs of Calorie Intake							
Fast-food price	--	-1.2%	2.2%	0.8%	2.0%	1.0%	1.8%
Grocery food price	0.2%	1.0%	0.5%	0.8%	-0.2%	0.3%	0.3%
Relative price	--	2.5%***	0.5%	0.5%	-0.1%	0.5%	0.01%
Alcohol price	--	1.7%**	0.5%	-0.3%	-10.2%**	0.1%	-0.6%
Restaurants	18.8%***	22.9%***	18.1%***	24.2%***	28.8%***	16.5%	17.8%***
Supercenters/ware.	24.7%	24.1%***	22.0%***	24.8%***	23.4%**	30.3%***	21.1%***
Supermarkets	-0.2%***	-0.1%**	-0.2%***	-0.1%	0.5%	-0.1%***	-0.1%***
Convenience stores	--	-0.3%	-0.2%	-0.2%	2.8%	-0.1%	-0.1%
General merch.	1.6%*	1.6%*	2.5%***	0.4%	-2.0%	1.7%**	1.2%
Food stamp benefits	7.2%**	2.0%	6.1%*	7.7%*	3.0%*	7.8%**	8.2%***
Subtotal	**52.4%*** **	**54.2%*** **	**52.1%*** **	**58.4%*** **	**48.9%*** **	**58.1%*** **	**49.5%*** **
Variables Related to Monetary or Time Costs of Physical Activity							
Gasoline price	-3.3%	-3.4%**	2.1%	6.1%	1.7%	2.7%	-1.4%
Fitness centers	-3.1%	-3.3%*	-2.9%	-3.2%	-22.1***	-2.4%	-3.0%
Prop. central city	1.2%	1.7%*	0.9%	1.8%	2.7%**	1.0%	1.0%
Subtotal	**-5.5%**	**-4.9%**	**0.1%**	**4.6%**	**-17.7%**	**1.2%**	**-3.3%**
Variables Related to Monetary or Time Costs of Smoking							
Cigarette price	3.1%	4.0%	-2.1%	-0.7%	-0.4%	4.1%	0.2%
Smoking ban: private	--	0.7%	1.5%	3.9%	-2.3%	1.8%	1.8%
Smoking ban: gov't	--	-1.4%	-1.5%	-4.1%	-0.1%	-1.9%	-1.2%
Smoking ban: rest.	-1.7%	-2.6%**	-2.7%*	-1.8%	1.7%	-1.9%	-2.4%*
Smoking ban: other	0.6%	0.6%	0.8%	0.4%	-1.0%	0.6%	0.3%
Subtotal	**2.1%**	**1.3%**	**-4.0%**	**-2.3%**	**-2.1%**	**2.6%**	**-1.3%**
Total from Economic Factors	**55.3%*** **	**50.7%*** **	**55.0%*** **	**62.9%*** **	**53.1%***	**69.4%*** **	**49.5%*** **
Sample Size	2,922,071	2,922,071	1,013	2,112,308	2,430,831	2,857,581	2,836,583

See notes for Table 8.

Table 11 – Falsification Tests

	Seatbelt	Flu Vaccine	Mammogram	Prostate Exam
General Economic Indicators				
Unemployment rate	-0.003 (0.008)	-0.007 (0.004)*	-0.002 (0.003)	-0.006 (0.005)
Median household income	-0.007 (0.006)	-0.003 (0.003)	-0.004 (0.004)	-0.007 (0.010)
90/50 ratio	0.002 (0.003)	0.002 (0.001)*	-0.001 (0.001)	0.002 (0.002)
50/10 ratio	0.003 (0.005)	0.001 (0.002)	0.0002 (0.002)	0.006 (0.006)
Labor Supply Variables				
Female labor force p. rate	0.004 (0.007)	0.003 (0.002)	-0.003 (0.003)	-0.003 (0.006)
Male labor force p. rate	-0.004 (0.006)	-0.001 (0.002)	0.001 (0.003)	0.003 (0.005)
Average work hours	0.007 (0.004)*	-0.002 (0.001)	-0.00003 (0.001)	-0.004 (0.004)
Proportion active job	0.0001 (0.005)	-0.002 (0.002)	-0.002 (0.003)	0.00001 (0.007)
Proportion blue collar	0.002 (0.006)	0.0001 (0.003)	-0.001 (0.003)	0.003 (0.008)
Variables Related to Monetary or Time Costs of Calorie Intake				
Fast-food restaurant price	-0.005 (0.006)	0.001 (0.003)	-0.004 (0.003)	0.0001 (0.005)
Grocery food price	0.004 (0.005)	-0.001 (0.006)	-0.001 (0.003)	-0.0002 (0.005)
Rel. price of fruits/vege.	-0.013 (0.006)**	-0.001 (0.003)	0.001 (0.003)	-0.001 (0.003)
Alcohol price	-0.016 (0.004)***	0.001 (0.003)	-0.001 (0.002)	-0.010 (0.005)**
Restaurants	0.005 (0.013)	0.013 (0.010)	-0.004 (0.005)	0.029 (0.012)**
Supercenters/ware. clubs	0.010 (0.009)	0.003 (0.005)	0.002 (0.004)	0.003 (0.008)
Supermarkets	-0.011 (0.008)	-0.007 (0.006)	0.007 (0.005)	-0.014 (0.010)
Convenience stores	-0.005 (0.012)	-0.004 (0.013)	-0.004 (0.007)	-0.024 (0.020)
General merchandisers	0.015 (0.014)	0.004 (0.007)	0.011 (0.005)**	-0.015 (0.010)
Food stamp benefits	-0.009 (0.009)	-0.001 (0.006)	-0.011 (0.005)**	-0.007 (0.008)
Variables Related to Monetary or Time Costs of Physical Activity				
Gasoline price	0.028 (0.016)*	-0.003 (0.011)	0.007 (0.005)	0.018 (0.012)
Fitness centers	0.035 (0.010)***	0.004 (0.008)	0.015 (0.005)***	-0.008 (0.008)
Proportion central city	-0.039 (0.013)***	0.009 (0.012)	0.011 (0.009)	0.059 (0.044)
Variables Related to Monetary or Time Costs of Smoking				
Cigarette price	0.002 (0.006)	0.005 (0.003)	0.001 (0.003)	0.008 (0.005)*
Smoking ban: private	-0.011 (0.008)	0.0003 (0.003)	0.001 (0.004)	-0.005 (0.005)
Smoking ban: government	0.008 (0.010)	-0.004 (0.004)	0.005 (0.004)	0.001 (0.006)
Smoking ban: restaurant	0.004 (0.005)	0.002 (0.002)	-0.009 (0.002)***	0.006 (0.005)
Smoking ban: other	-0.005 (0.006)	-0.004 (0.003)	-0.001 (0.002)	0.001 (0.005)
Sample Size	1,275,291	2,454,524	1,167,870	281,820

Notes: Standard errors, heteroskedasticity-robust and clustered by state, are in parentheses. *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. BRFSS sampling weights are used.

Table 12 – Impacts of One Standard Deviation Increases in Economic Factors on P(Trying to Lose Weight)

	All Factors	"Important" Factors Only	Top Two Factors Only
General Economic Indicators			
Unemployment rate	0.0004 (0.007)	--	--
Median household income	0.002 (0.011)	--	--
90/50 ratio	0.001 (0.003)	--	--
50/10 ratio	-0.003 (0.004)	--	--
Labor Supply Variables			
Female labor force participation rate	-0.004 (0.005)	--	--
Male labor force participation rate	0.006 (0.005)	--	--
Average work hours	-0.006 (0.004)	--	--
Proportion active job	-0.008 (0.005)*	-0.006 (0.005)	--
Proportion blue collar	-0.001 (0.005)	--	--
Variables Related to Monetary or Time Costs of Calorie Intake			
Fast-food restaurant price	0.001 (0.006)	--	--
Grocery food price	-0.004 (0.008)	--	--
Relative price of fruits/vegetables	-0.006 (0.004)	--	--
Alcohol price	0.005 (0.008)	--	--
Restaurants	0.009 (0.017)	-0.002 (0.013)	0.0004 (0.010)
Supercenters/warehouse clubs	0.019 (0.011)*	0.020 (0.008)**	0.023 (0.007)***
Supermarkets	-0.012 (0.009)	--	--
Convenience stores	-0.017 (0.019)	--	--
General merchandisers	0.008 (0.011)	--	--
Food stamp benefits	-0.007 (0.015)	0.0003 (0.012)	--
Variables Related to Monetary or Time Costs of Physical Activity			
Gasoline price	-0.014 (0.022)	-0.020 (0.023)	--
Fitness centers	0.011 (0.015)	0.004 (0.013)	--
Proportion central city	-0.005 (0.013)	--	--
Variables Related to Monetary or Time Costs of Smoking			
Cigarette price	0.007 (0.020)	--	--
Smoking ban: private	-0.001 (0.005)	--	--
Smoking ban: government	0.0003 (0.004)	--	--
Smoking ban: restaurant	0.001 (0.004)	--	--
Smoking ban: other	-0.006 (0.005)	--	--
Sample Size	515,116	515,116	515,116

Notes: Standard errors, heteroskedasticity-robust and clustered by state, are in parentheses. *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. BRFSS sampling weights are used.

Appendix Table A1 – Replications of Chou et al.'s (2004) Model for BMI

	Chou et al's results (BRFSS 1984-1999)	Chou et al's model and our data (BRFSS 1990-1999)	Add year dummies
Restaurants	0.631 (0.067)***	0.469 (0.060)***	0.122 (0.047)***
Restaurants^2	-0.011 (0.002)***	-0.007 (0.002)***	-0.004 (0.001)***
Marginal effect at mean	0.339	0.291	0.002
Fast-food restaurant price	-1.216 (0.728)*	-2.854 (1.011)***	-0.928 (0.786)
Fast-food restaurant price^2	0.135 (0.119)	0.434 (0.174)***	0.142 (0.131)
Marginal effect at mean	-0.432	-0.416	-0.135
Food at home price	-6.462 (1.918)***	-6.047 (2.322)***	-0.311 (1.535)
Food at home price^2	2.244 (0.719)***	2.644 (1.049)***	0.172 (0.707)
Marginal effect at mean	-0.816	-0.729	0.034
Cigarette price	0.486 (0.355)	1.670 (0.367)***	0.591 (0.340)*
Cigarette price^2	0.009 (0.113)	-0.293 (0.114)***	-0.194 (0.101)*
Marginal effect at mean	0.509	0.865	0.056
Alcohol price	1.140 (0.884)	-1.654 (0.457)***	-0.971 (0.340)***
Alcohol price^2	-0.734 (0.380)*	0.199 (0.067)***	0.133 (0.051)***
Marginal effect at mean	-0.423	-0.401	-0.144
Smoking ban: private	0.015 (0.039)	0.124 (0.128)	0.082 (0.095)
Smoking ban: government	0.115 (0.071)	-0.099 (0.088)	-0.155 (0.055)***
Smoking ban: restaurant	-0.020 (0.056)	-0.092 (0.071)	-0.199 (0.037)***
Smoking ban: other	0.054 (0.056)	0.253 (0.060)***	0.020 (0.037)
Observations	1,111,074	912,454	912,454

Notes: Standard errors, heteroskedasticity-robust and clustered at the state*year level, are in parentheses. *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Regressions include state fixed effects and individual-level control variables for age, age squared, real income, real income squared, and dummies for male, race/ethnicity (black, white, Hispanic, or other), marital status (single, married, divorced, or widowed), and education (less than high school degree, high school degree, some college, or college degree). Chou et al. also included full-service restaurant price and its square, but the variable was only available every five years and was imputed for the other years. Perhaps for this reason, its effect was one of the weakest Chou et al. estimated. We have not been able to find an annual measure and therefore do not include full-service restaurant prices in our dataset.

Appendix Table A2 – Variable Descriptions and Summary Statistics

Variable	Source	Description	Mean (Standard Deviation)	1990 Mean	2010 Mean
BMI	BRFSS	Body mass index	26.618 (6.141)	26.027	28.507
Obese	BRFSS	Dummy for BMI≥30	0.279 (0.449)	0.184	0.339
Class II/III Obese	BRFSS	Dummy for BMI≥35	0.111 (0.314)	0.066	0.141
Black	BRFSS	Dummy for race/ethnicity is non-Hispanic black	0.100 (0.300)	0.100	0.104
Hispanic	BRFSS	Dummy for race/ethnicity is Hispanic	0.120 (0.325)	0.083	0.142
Other	BRFSS	Dummy for race/ethnicity is not white, black, or Hispanic	0.056 (0.229)	0.030	0.076
Male	BRFSS	Dummy for sex is male	0.519 (0.500)	0.509	0.520
Some high school	BRFSS	Dummy for some high school but no degree	0.071 (0.257)	0.093	0.058
High school graduate	BRFSS	Dummy for high school degree but no college	0.301 (0.459)	0.347	0.260
Some college	BRFSS	Dummy for some college but no four-year degree	0.282 (0.450)	0.275	0.268
College graduate	BRFSS	Dummy for college graduate or further	0.315 (0.464)	0.250	0.387
Married	BRFSS	Dummy for married	0.611 (0.487)	0.618	0.639
Divorced	BRFSS	Dummy for divorced	0.122 (0.328)	0.111	0.112
Widowed	BRFSS	Dummy for widowed	0.019 (0.138)	0.022	0.017
Age	BRFSS	Age in years	39.634 (12.506)	37.623	41.983
Population	Census	State population (in 10,000s)	12.694 (10.117)	11.557	13.941
Seatbelt	BRFSS	Dummy for always wears seatbelt[a]	0.746 (0.435)	0.581	0.861
Flu shot	BRFSS	Dummy for got a flu shot within past year[b]	0.300 (0.458)	0.138	0.347
Mammogram	BRFSS	Dummy for mammogram in past two years (women only)	0.509 (0.500)	0.365	0.432
Prostate	BRFSS	Dummy for digital rectal exam in past two years (men 40+)[c]	0.432 (0.495)	0.469	0.376
Lose weight	BRFSS	Dummy for currently trying to lose weight[d]	0.397 (0.489)	0.379	0.419

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Appendix Table A2 – Variable Descriptions and Summary Statistics (continued)

Variable	Source	Description	Mean (Standard Deviation)	1990 Mean	2010 Mean
Unemployment rate	BLS	Proportion of labor force unemployed	0.059 (0.019)	0.056	0.097
Median household income	BLS	Median household income in $10,000s (2010$)	5.087 (0.678)	4.836	4.986
90/50 ratio	Census	Ratio of $90^{th}/50^{th}$ percentiles of earnings distribution	2.479 (0.166)	2.375	2.579
50/10 ratio	Census	Ratio of $50^{th}/10^{th}$ percentiles of earnings distribution	4.398 (0.699)	5.137	4.005
Female labor force p. rate	Census	Proportion of females 16+ in labor force	0.582 (0.038)	0.564	0.579
Male labor force p. rate	Census	Proportion of males 16+ in labor force	0.718 (0.033)	0.735	0.694
Average work hours	Census	Average work hours/week among those employed	37.564 (0.834)	37.660	36.791
Proportion active job	Census	Proportion of workforce in job with MET score ≥ 3	0.243 (0.028)	0.256	0.233
Proportion blue collar	Census	Proportion of workforce in blue collar job	0.159 (0.032)	0.184	0.130
Fast-food restaurant price	C2ER	Weighted average price of McDonald’s Quarter-Pounder with cheese, 11”-12” Pizza Hut or Pizza Inn thin crust cheese pizza, and Kentucky Fried Chicken or Church’s thigh and drumstick	5.967 (0.406)	6.502	5.681
Grocery food price	C2ER	Weighted average price of white bread, Kellog’s or Post corn flakes, iceberg lettuce, bananas, potatoes, Del Monte or Green Giant canned peas, Hunts, Del Monte, or Libby’s canned peaches, frozen corn, t-bone steak, ground beef, whole chicken, Jimmy Dean or Owen sausage, grade A or AA eggs, Starkist or Chicken of the Sea light tuna, Coca Cola, whole milk, cane or beat sugar, Crisco shortening, Kraft parmesan cheese, and Blue Bonnet or Parkay margarine	2.398 (0.237)	2.547	2.383
Relative price of fruits and vegetables	C2ER	Ratio of weighted average prices of the above fruit and vegetable items to the other grocery food items	0.697 (0.071)	0.727	0.632

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Appendix Table A2 – Variable Descriptions and Summary Statistics (continued)

Variable	Source	Description	Mean (Standard Deviation)	1990 Mean	2010 Mean
Alcohol price	C2ER	Weighted average price of Heineken 6-pack and Chablis or Chenin Blanc white	7.401 (0.825)	7.023	7.784
Restaurants	QCEW	Restaurants per 10,000 residents	13.851 (2.172)	10.813	15.551
Supercenters/ warehouse clubs	Primary	Walmart Supercenters, Sam's Clubs, Costcos, and BJ's Wholesale Clubs per 10,000 residents	0.065 (0.051)	0.009	0.127
Supermarkets	QCEW	Supermarkets/grocery stores per 10,000 residents	2.098 (0.656)	1.928	1.950
Convenience stores	QCEW	Convenience stores per 10,000 residents	4.029 (1.325)	3.705	3.768
General merchandisers	QCEW	General merchandise stores (minus supercenters/warehouse clubs) per 10,000 residents	1.056 (0.404)	0.946	1.135
Food stamp benefits	USDA	Per capita food stamp benefits (2010$)	112.01 (48.751)	99.162	208.437
Gasoline price	C2ER	Price of one gallon of regular unleaded gasoline (including taxes) (2010$)	2.056 (0.587)	1.723	2.796
Fitness centers	QCEW	Fitness centers/sports clubs per 10,000 residents	0.838 (0.215)	0.706	0.941
Proportion central city	Census	Proportion of residents in central city of an MSA	0.254 (0.106)	0.273	0.246
Cigarette price	*Tax Burden on Tobacco*	Weighted average price of pack of cigarettes (2010$)	4.159 (1.318)	2.756	6.265
Smoking ban: private	ImpacTeen	Dummy for state law prohibiting smoking in private workplaces	0.143 (0.351)	0	0.471
Smoking ban: government	ImpacTeen	Dummy for state law prohibiting smoking in government workplaces	0.170 (0.376)	0.007	0.521
Smoking ban: restaurant	ImpacTeen	Dummy for state law prohibiting smoking in restaurants	0.243 (0.429)	0	0.621
Smoking ban: other	ImpacTeen	Dummy for other state smoking bans	0.717 (0.450)	0.547	0.851

Notes: n=2,922,071 in all years, 55,922 in 1990, and 239,215 in 2010. BRFSS sampling weights are used. [a] indicates variable not available in 1999-2001, 2003-2005, 2007, and 2009; [b] not available 1990-1992, [c] not available 1990-2000, [d] only available in 1994, 1996, 1998, 2000, and 2003. If variables are not available in 1990 their values in the first year they are available are reported in the "1990 mean" column.

Appendix Table A3 – Percentage of Rises in BMI, Obesity, and Severe Obesity Explained by Changes in Controls

	BMI	Obesity	Class II/III Obesity
Age	61.2% (1.0%)***	48.0% (1.3%)***	54.6% (1.7%)***
Age squared	-42.8% (0.9%)***	-32.1% (1.2%)***	-39.4% (1.5%)***
Subtotal from Age	**18.4% (0.3%)*** **	**15.9% (0.3%)*** **	**15.3% (0.4%)*** **
Some high school	-0.2% (0.1%)	-0.2% (0.1%)**	-0.4% (0.3%)
High school graduate	0.6% (0.3%)	0.8% (0.3%)***	1.2% (0.9%)
Some college	0.1% (0.03%)	0.1% (0.03%)***	0.2% (0.1%)**
College graduate	-8.1% (0.4%)***	-9.2% (0.4%)***	-11.0% (1.3%)***
Subtotal from Education	**-7.7% (0.2%)*** **	**-8.4% (0.2%)*** **	**-10.0% (0.2%)*** **
Black	0.3% (0.01%)***	0.3% (0.01)***	0.4% (0.01%)***
Hispanic	1.8% (0.2%)***	1.4% (0.3%)***	0.4% (0.2%)
Other	-1.4% (0.4%)***	-1.3% (0.3%)***	-0.9% (0.4%)**
Male	0.1% (0.02%)***	-0.2% (0.02%)***	-0.7% (0.02%)***
Married	-0.04% (0.03%)	-0.03% (0.03%)	-0.6% (0.04%)***
Divorced	-0.01% (0.001%)***	-0.01% (0.001%)***	-0.02% (0.002%)***
Widowed	-0.1% (0.02%)***	-0.1% (0.02%)***	-0.1% (0.02%)***
State population	-0.9% (1.0%)	-1.3% (1.3%)	-1.0% (1.7%)
Subtotal from Other Controls	**-0.3% (1.0%)**	**-1.3% (1.3%)**	**-2.6% (1.6%)**
Total from Controls	**10.4% (1.1%)*** **	**6.1% (1.3%)*** **	**2.6% (1.8%)**

Notes: Standard errors, heteroskedasticity-robust and clustered by state, are in parentheses. *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. BRFSS sampling weights are used. + indicates age is modeled using a quadratic specification; the reported percentage of the trends explained is the sum of the percentages explained by changes in both age and age squared.

Appendix Table A4 – Percentage of Rises in BMI, Obesity, and Severe Obesity Explained by Changes in the Variables of Interest from Baum and Chou (forthcoming)

	BMI	Obesity	Class II/III Obesity
Employed (individual-level)	0.7% (0.1%)***	0.8% (0.1%)***	2/1% (0.1%)***
Proportion active job	-0.5% (0.6%)	1.4% (0.9%)	0.9% (1.0%)
Grocery food price	2.7% (0.7%)***	2.0% (0.7%)***	4.1% (1.0%)***
Restaurants	3.2% (4.0%)	5.0% (4.2%)	10.3% (5.8%)*
Food stamp benefits	5.2% (3.5%)	5.1% (3.6%)	11.9% (5.5%)**
Proportion central city	1.7% (1.2%)	2.0% (1.2%)	2.6% (1.4%)*
Cigarette price	-11.4% (4.6%)**	-10.9% (5.0%)**	-20.4% (5.9%)***
Smoker (individual-level)	2.9% (0.2%)***	2.5% (0.2%)***	3.0% (0.2%)***
Total from Economic Factors	**5.6% (8.6%)**	**7.8% (9.4%)**	**14.3% (12.1%)**

Notes: Standard errors, heteroskedasticity-robust and clustered by state, are in parentheses. *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. BRFSS sampling weights are used. Control variables are included as well as state and year fixed effects.