Rising Cigarette Prices and Rising Obesity: Coincidence or Unintended Consequence?

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Working Paper, Washington University in St. Louis

This Version: March 10, 2007

Abstract

Obesity and cigarette smoking are widely considered to be the two leading causes of preventable deaths in the U.S. However, while smoking has declined substantially in recent decades, the obesity rate has grown steadily during this period. A causal relationship between these two trends is possible since smoking is thought to curb appetite and increase metabolism, both of which would reduce weight. Health economists have recently begun to study if the recent surge in cigarette prices, driven in part by rising state cigarette excise taxes, may have contributed to the rise in obesity, reaching conclusions that are surprisingly sensitive to specification. Through the use of panel data from the National Longitudinal Survey of Youth, which allows me to track the same individuals over a twenty-year period, I am able to reconcile these differences in the literature. I find that, while increasing cigarette prices and taxes appear to cause a small short-run increase in weight, in the long run this weight gain disappears and actually becomes negative. This counterintuitive finding may be due to healthier decisions regarding eating, exercise, and alcohol consumption following smoking cessation. These results are robust to a variety of specifications, suggesting that policies designed to reduce smoking may also reduce obesity.

JEL Classification: I10

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I. Introduction

Excessive weight became a critical public health concern in the late 20th century. Studies have linked being overweight (having a body mass index[1] of 25.5-29) and being obese (having a BMI of 30 or greater) to high blood pressure, diabetes, heart disease, stroke, and a number of other adverse health conditions (Strum, 2002). The percentage of people in the US who are classified as overweight or obese has risen from 43.3% in 1960 to 66.3% in 2004, while the obesity rate has grown from 12.8% to 32.2% during this period (Flegal et al, 1998; Ogden et al 2006). Consequences of obesity include an estimated 112,000 deaths and $117 billion in medical and related costs per year (Flegal et al, 2005; U.S. Department of Health and Human Services, 2001). While exact estimates vary, experts in the medical community universally acknowledge that excessive weight imposes substantial costs on society, both in terms of early mortality and medical expenses.

An even more prominent public health concern in the past half-century has been cigarette smoking. Smoking causes an estimated 438,000 deaths per year, and annual medical costs attributed to it are $167 billion (Armour et al, 2005). However, while the prevalence of obesity has been steadily increasing, smoking has actually declined fairly steadily since the 1970s. According to the Center for Disease Control, the percentage of adults who smoke regularly has dropped from 42.4% in 1965 to 20.9% in 2004.[2] This has largely been the result of government efforts to curb smoking, such as information-spreading programs, bans on smoking in public places, and state cigarette excise taxes that contributed to a 164% rise in the real price of

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[1] Body mass index (BMI) = weight in kg / height in m^2. BMI is a commonly used measure of a person's weight relative to her medical optimum due to the fact that it takes into account one's height.

[2] The 1965 number reflects data compiled by the Centers for Disease Control and Prevention, Office on Smoking and Health from the 1965 National Health Interview Survey. The 2004 number is from Centers for Disease Control and Prevention, 2005.

cigarettes between 1980 and 2001 (Orzechowski and Walker, 2002). See Figure 1 for a graph of the trends in cigarette prices, state cigarette taxes, and obesity.

While the temporal correlation between this fall in smoking and the rise in obesity could be purely a coincidence, a causal relationship between the two is theoretically plausible. A person's weight increases if she consumes more calories than she expends. Medical evidence suggests that cigarettes can both suppress one's appetite and increase one's metabolism (calories burned); therefore, a person who quits smoking may begin to consume more calories while expending fewer, leading to weight gain (Pinkowish,1999). The larger the connection between smoking and obesity, the less cigarette taxes and other anti-smoking measures could be expected to reduce mortality and medical expenditures, thereby making these policies less effective. If the effect of smoking on weight is so large that the increase in obesity-related spending was larger in magnitude than the decrease in smoking-related spending, then increasing cigarette taxes would actually lead to a net increase in medical expenditures.

A variety of studies show that quitting smoking often leads to a modest short-term weight gain (U.S. Department of Health and Human Services, 1990). However, it is unclear whether this gain is temporary, permanent, or continues to increase as the quitter continues to not smoke, meaning that the overall effect of cigarette taxes on weight is unclear. Three recent economics papers have attempted to estimate this effect. Chou, Grossman, and Saffer (2002 and 2004) (hereafter CGS) used pooled cross-sectional data from the Behavioral Risk Factor Surveillance System (BRFSS) and found that increasing cigarette prices (and therefore taxes, since taxes are a component of price) increases weight and obesity. Strangely, Gruber and Frakes (2006) (hereafter GF), using the same data and only a slightly different estimation approach, actually found a slightly negative relationship between cigarette taxes and weight. Rashad, Chou, and

Grossman (2005) (hereafter RCG) used a hybrid of the two approaches and pooled data from the National Health and Nutrition Examination Surveys (NHANES), finding a positive but small relationship between cigarette taxes and weight.

In this paper, I attempt to reconcile the literature through the 1) the use of a variety of endogeneity-reducing techniques and 2) differentiating between the short- and long-run effects. Estimates of the impact of cigarette prices on weight may be biased as a state's level of "healthiness," which is unobservable, may be driving both prices and weight. Panel data from the National Longitudinal Survey of Youth (NLSY) allows me to utilize differences models and models including individual and state fixed effects, which remove any sources of bias that are constant over time. I also account for bias that changes over time with state-specific time trends. Finally, I attempt to eliminate any sources of bias that may remain by isolating the portion of the price/tax effect that occurs through changes in smoking behavior. Medical evidence suggests that some of the weight gained after quitting smoking may be temporary; therefore, the short-and long-run effects of quitting smoking may be different (Mizoue et al, 1998). I use the long length (20 years) of the NLSY panel to differentiate between these effects.[3] I find that a $1 increase in per-pack cigarette prices (or taxes, assuming perfect passthrough) seems to cause a small increase in obesity in the short run.[4] However, in the long run, these effects disappear and the impact of cigarette prices/taxes on weight and obesity appears to be negative. Estimates show that, in the long run, the reduction in obesity caused by a $1 increase in cigarette prices or taxes would save about 9,000 lives and $10 billion per year. I also find some evidence that people begin to make healthier eating, exercise, and alcohol consumption decisions when cigarette

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[3] I define short run to be the length of time between periods in my data set, which is 1-2 years. Long run refers to any longer period of time, and my definition of the long-run effect of a change is the cumulative effect of the change as $t \rightarrow \infty$.

prices rise, explaining the counterintuitive result. Therefore, rising cigarette prices and state cigarette excise taxes do not appear to be a major cause of the U.S.'s growing obesity rate, and could have actually limited this growth.

II. Literature Review

To date, much of the economics literature on the causes of adult obesity has centered on the role of technological progress. Philipson and Posner (1999) and Lakdawalla and Philipson (2002) claim that improved technology has lowered the real price of food and increased the percentage of jobs that are sedentary, both of which lead to weight gain. Culter, Glaeser, and Shapiro (2003) write that technological advances in food processing, packaging, and storage have reduced the time costs of food preparation, thereby increasing food consumption. In addition to examining the role of cigarette prices, CGS also show that obesity increases as the number of fast-food and full-service restaurants rise and as the price of a meal in each fall. They attribute the growth in restaurants to the increased labor market opportunities provided by technological progress, which lead to more work hours and therefore fewer meals prepared at home.

Reduced smoking has become another leading explanation for the US's rise in obesity in recent years. In order for an increase in cigarette taxes to cause a rise in obesity, cigarette taxes must negatively impact smoking and smoking must negatively impact weight. The first of these two relationships is backed by a number of studies. Most estimates place the price elasticity of demand for cigarettes between -0.3 and -0.5, meaning that a 10% increase in taxes should lead to a 3-5% drop in smoking (Chaloupka, 1999).

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[4] For the duration of this paper, cigarette prices or taxes refer to the price/tax per pack, or twenty cigarettes.

The link between smoking and weight, however, is less clear. A 1990 U.S. Surgeon General review of 15 studies found that 58-87% of people who quit smoking gained weight, with the average gain being four pounds (U.S. Department of Health and Human Services, 1990). However, the long-run effect of quitting on weight is still subject to debate. The impact of most shocks to weight is gradual, so theoretically one would expect the long-term weight gain from quitting smoking to be even larger than the short-term gain captured by the studies.[5] However, some evidence exists to the contrary. For example, Caan et al (1996) showed that the rate of weight increase after quitting slows after six months, and Mizoue et al (1998) actually found that some of the initial weight gain is ultimately lost.

Three recent economics papers have used reduced-form estimation in an attempt to determine the relation between cigarette prices and weight. CGS (2004) used pooled micro data from the Behavior Risk Factor Surveillance System (BRFSS) data matched with state-level cigarette prices from the Tax Burden on Tobacco (Orzechowski and Walker, 2002), finding that a 10% rise in the real price of cigarettes leads to a statistically significant 2.5% increase in BMI and 0.445% increase in the probability an individual is obese. They use a quadratic functional form for the controls income and age, and, while they do not explicitly control for the upward trend in BMI over time, they include state-level price variables for fast-food restaurant price, full-service restaurant price, food at home price, and alcohol price, all of which are strongly correlated with time and should therefore capture much of the effect of time. A quadratic functional form is also used for these variables. In the working paper version of this paper (2002), they also run regressions include a quadratic time trend, which does not affect the signs of their results but does reduce their magnitude.

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[5] See Section V for a more detailed explanation as to why the effect of shocks is gradual.

GF argue that CGS’ estimates could be biased due to the fact that prices are generally endogenous since they depend on a variety of demand-side characteristics. In addition, GF argue that CGS’ use of a quadratic time trend is an incomplete approach to modeling the effects of time on weight; this could affect their results because of the strong upward trend in both weight and cigarette prices. GF attempt to solve these problems by using state cigarette tax rate instead of price and dummy variables for each month-year combination instead of the quadratic time trend. Other minor alterations include a linear instead of quadratic variable of interest (price/tax), a linear instead of quadratic income effect, the use of a set of dummy variables for gender-age group combinations, and the inclusion of state unemployment rate as a regressor. Although they use the same data set as CGS, GF find a negative relationship between cigarette tax rate and weight/obesity: a $1.00 rise in taxes lowers BMI by -0.151 and the probability of being obese by 0.015%. They claim, therefore, that measures taken to curb cigarette smoking do not worsen America’s obesity problem.

In a reply to GF, CGS (2006) argue that for this particular topic using cigarette prices and a quadratic time trend are actually preferable to taxes and time dummies. While taxes are more exogenous that prices in markets where supply is upward sloping, CGS discuss evidence which suggests that this is not the case in the cigarette industry and that a model where optimal price is uncorrelated with the error term in the demand function more accurately fits the industry’s data. CGS also cite a paper (Schneider et al, 1981) which demonstrated that excessive controls can lead to misspecified models and unstable results in the case of cigarettes prices. Therefore, they argue that the large number of time dummies used by GF may actually produce less reliable results than CGS’ more simple approach.

RCG used NHANES data and an estimation approach similar to GF in that their variable of interest was cigarette tax and they accounted for the change in weight over time using year dummies.[6] However, they modeled age, gender, and income similarly to CGS. They found a positive relationship between cigarette taxes and weight: a 10% rise in cigarette taxes increased BMI by a modest 0.1%. Their results were in between those of CGS and GF, which is not surprising since their approach represented a hybrid of the approaches of CGS and GF.

In short, results in the literature vary greatly despite similar data and estimation techniques. This lack of robustness suggests that further study is necessary to determine the true causal relationship. In this paper, I attempt to improve upon these results by providing an improved identification strategy and isolating the short- and long-run effects. Regarding identification, fixed effects and differences models may lead to more reliable coefficient estimates because they remove the bias caused by individual characteristics that are constant over time. In the case of cigarette prices, an unhealthy state may have high prices due to strong demand and also a high obesity rate, possibly explaining the positive coefficient estimated by CGS. While cigarette taxes may be more exogenous than prices, they still may be correlated with the error term. For example, an unhealthy state may have high body weights and low taxes, since they would not be politically popular, possibly explaining GF's negative result. CGS, GF, and RCG both use state-level fixed effects, but the potential source of endogeneity is unlikely to affect the weight of all residents of a state in the same way since some people are more susceptible to weight gain than others. A state's level of health consciousness may not be constant over time, in which case differences and fixed effects would not completely remove the

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[6] RCG used a quadratic functional form for tax, while GF used a linear form. However, the coefficient on RCG's squared term is essentially zero, suggesting that this is not driving the different results.

bias. Therefore, I also include state-specific linear time-trends in my regressions.[7] As a final identification strategy, I attempt to isolate the impact that occurs through changes in smoking behavior, since other effects are likely to be endogenous. I do this by dividing the sample into "potential smokers," people who would be responsive to changes in cigarette prices, and "non-potential smokers," and treating the difference between the effects of prices on the two groups as the true causal impact.

An advantage to panel data is that individuals can be tracked for a long period of time, allowing me to differentiate between the short-term and long-term effects of changes in cigarette prices or taxes. As previously discussed, the relationship between the long-run effect of smoking on body weight and the short-run effect is unclear. Since the long-run effect is more relevant for policy considerations, distinguishing between the two is critical, and this is impossible with pooled cross-sectional data.

III. Data

I obtained data on the body weights and other characteristics of individuals from the 1979 cohort of the National Longitudinal Survey of Youth (NLSY79) survey. The NLSY79 includes data from 6,111 randomly-chosen U.S. youths, plus a supplemental sample of 5,295 minority and economically disadvantaged youths, and 1,280 military youths. Although the sample is therefore not random, the data includes sampling weights that I use to prevent selection bias. All respondents were first interviewed in 1979, and were between fourteen and twenty-two years of age at this time. They were subsequently interviewed each year until 1994, after which they were interviewed every two years until 2002. The respondents' reported their weight in 1981,

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[7] As a robustness check, GF also included state-specific time trends, which did not affect their results.

1982, 1985, 1986, 1988, 1989, 1990, 1992, 1993, 1994, 1996, 1998, 2000, and 2001 and their height in 1981, 1982, and 1985. I use the years starting in 1985 because each person is at least nineteen in 1985; therefore, my sample consists only of adults. I assume that the respondents' 1985 heights are their adult heights and use them in the body mass index calculations for later years. Although the retention rate of the NLSY79 was high, not all youths were followed for the duration of the sample, making my data an unbalanced panel. I match the NLSY data with state cigarette prices and excise tax rates from *The Tax Burden on Tobacco* (Orzechowski and Walker, 2005), which reports prices each year and taxes each month. Following GF, I match each individual with the tax rate in the month before his/her interview to allow for a short lag. Price, tax, and income data is then adjusted for inflation using Consumer Price Index data from the Bureau of Labor Statistics. Eliminating all observations before 1985 as well as those with missing data, I am left with a sample size of 90,839.

Table 1 reports the weighted summary statistics for adults in the final sample, including descriptions of the variables used. BMI, or body mass index, was calculated using respondents' self-reported weight and height data. Self-reported weight and height data could be problematic as people commonly underreport their weight and, to a lesser extent, overreport their height. However, researchers with access to both self-reported and actual weight and height have shown that, in regressions of body weight, correcting for errors in the self-reported values does not substantially alter coefficient estimates.[8] In other words, the extent to which one underreports weight or overreports height does not appear to be correlated with the variables commonly included in body weight regressions. This is likely especially true for the state-level variables of interest used in this paper. Consequently, my use of self-reported weight and height should not

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[8] For examples, see Cawley (1999) and Lakdawalla and Philipson (2002).

be a main driver of my results.

My average real cigarette price of $1.44 is similar to that of CGS ($1.29). My average real tax of $0.22 is smaller than that of GF ($0.44); the discrepancy is likely due to the fact that this and CGS' paper use 1982-84 dollars while GF use 2002 dollars. I find a slightly higher prevalence of smoking than GF (CGS did not report cigarette consumption statistics): 5.4 cigarettes per day smoked by the average respondent compared to 3.9. However, the numbers are not comparable because NLSY only collected data on smoking behavior in the years 1992, 1994, and 1998, compared to all years between 1984 and 1999 for the BRFSS.

I include all of the controls necessary to replicate the studies of CGS and GF except for the food and alcohol prices used by CGS. As previously discussed, additional income is expected to decrease weight. People often gain weight as they become older or get married; therefore, age and marital status are included. Ruhm (2000) found a negative relationship between unemployment rate and weight. Controlling for unemployment rate is especially important when the variable(s) of interest are state-level variables, such as prices and tax rates, that may be influenced by economic circumstances. Education may lower weight by enabling people to make wiser choices regarding food consumption. I allow for a non-linear effect of education on weight by using the same series of binary variables employed by GF. I also control for gender and race since both may influence body weight. Finally, I create a series of binary variables that represent gender-age group combinations. This is the method in which GF control for the effects of gender and age.

IV. Empirical Analysis

The goal of my empirical analysis is to show that show that both the CGS and GF methodologies lead to the same conclusion when unobservable heterogeneity and the difference between short- and long-run effects are accounted for. I concentrate only on the CGS and GF approaches since they are the extremes in the literature, both methodologically and in terms of results.[9] I begin by replicating the specifications of CGS and GF in order to show that the discrepancy between their results that exists using BRFSS data is also present when using NLSY data. In the remainder of my empirical section, I employ a number of different approaches that attempt to reduce endogeneity, in each case using both the CGS and GF methodology to see if the two produce similar results. I first attempt to determine the short-run effect of cigarette prices/taxes on weight using first differences models. Next, I analyze the long-run impact by converting the independent variables to averages over the length of the panel and applying long differences and fixed effects models. I then run the short and long-run regressions again, distinguishing between the effects on people who have and have not smoked at least 100 cigarettes in their lives, treating the difference between the two as the true causal impact. Finally, I estimate "intermediate-run" models in an attempt to determine the speed at which the full long-run effect is reached.

IVa. Replications

Both CGS and GF use descriptive models to estimate the relationship between cigarette prices/taxes and two different measures of body weight: BMI and whether or not a person is obese. Their specifications are different only in the ways discussed in section II. The NLSY and *Tax Burden on Tobacco* data allow me to replicate the GF approach identically except for minor

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[9] Results in this paper are robust to the RCG approach as well.

differences in the modeling of race, marital status, age, and unemployment rate.[10] The regression equation for my GF replication using BMI as the dependent variable, therefore, is:

$$BMI_{ist} = \beta_0 + \beta_1 TAX_{st} + \beta_2 X_{ist} + \lambda_s + \tau_t + \varepsilon_{ist} \qquad (1)$$

where i, s, and t are the indexes for individual, state, and month/year, respectively, BMI is body mass index, TAX is real cigarette tax, X is a set of individual-specific attributes chosen to reflect those in GF, and λ and τ are fixed effects for state and month/year, respectively.

I estimate the effect of these covariates on the probability an individual is obese using a linear probability model:

$$OBESE_{ist} = \beta_0 + \beta_1 TAX_{st} + \beta_2 X_{ist} + \lambda_s + \tau_t + \varepsilon_{ist} \qquad (2)$$

where OBESE is an indicator variable equal to 1 if the individual is obese and 0 otherwise. Both CGS and GF use a linear probability model instead of a logit or probit model due to their large sample size.[11]

Replicating the CGS approach is less straightforward because I do not have data on the food and alcohol prices included as regressors in their paper. In their working paper, CGS account for the effect of time using both a quadratic time trend and the quadratic food and alcohol prices. However, they include only the prices in their published paper. Since in both papers the relationship between time and weight is assumed to be quadratic, I include the quadratic time trend in my CGS replications. Other covariates are the same as those used by CGS, except for the minor differences in marital status and race discussed footnote six. Also,

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[10] My categories for race are black, white, and other, while GF's are black, white, hispanic, and other. GF classify marital status as married, divorced, widowed, or single, while I use only married or single. Due to data differences, my highest age category is 45 to 50, while GF's is 60 to 65. Finally, I use county instead of state unemployment rate.

[11] All results in this paper are robust to the use of non-linear probit models.

mimicking CGS, I include the square of cigarette price. My regression equations for the CGS replication are:

$$BMI_{ist} = \beta_0 + \beta_1 PRICE_{st} + \beta_2 PRICE_{st}^{\ 2} + \beta_3 Z_{ist} + \beta_4 T + \beta_5 T^2 + \lambda_s + \varepsilon_{ist} \qquad (3)$$

$$OBESE_{ist} = \beta_0 + \beta_1 PRICE_{st} + \beta_2 PRICE_{st}^{\ 2} + \beta_3 Z_{ist} + \beta_4 T + \beta_5 T^2 + \lambda_s + \varepsilon_{ist} \qquad (4)$$

where T is a measure of time elapsed since the beginning of the panel (it equals zero in the first month of 1985, twelve in the first month of 1986, and so on) and Z differs from X according to the aforementioned differences between the CGS and GF specifications.

Table 2 contains a summary of the differences between the CGS and GF methodologies that I use throughout the paper.

IVb. Short-Run Effects

After determining if the sensitivity to specification that is present when using BRFSS data is also present with NLSY data, I next attempt to reconcile the results produced by the CGS and GF methodologies by using a first differences approach. First differences will eliminate any bias in the estimates that is caused by omitted variables that are constant over time. For reasons discussed in section II, eliminating this bias may have a substantial impact on my estimate of the effect of cigarette prices/taxes on weight.

My first differences regressions using the CGS approach are:

$$\Delta BMI_{ist} / \Delta OBESE_{ist} = \beta_0 + \beta_1 \Delta PRICE_{st} + \beta_2 \Delta Z_{ist} + \beta_3 \Delta T + \beta_5 (\Delta T)^2 + \beta_6 \Delta T_s + \Delta\lambda_s + \varepsilon_{ist} \quad (5)$$

where Δ represents the change in the variable from one period to the next, and T_s is a state-specific time trend. Since periods are separated by either one or two years, this first differences approach depicts the short-run effect of changes in the regressors on body weight. Note that I do not include the square of the change in price since these changes can be either positive or negative but their square would always be positive, making its meaning unclear.

My GF first differences regression equations are:

$$\Delta BMI_{ist} / \Delta OBESE_{ist} = \beta_0 + \beta_1 \Delta TAX_{st} + \beta_2 \Delta X_{ist} + \Delta\tau_t + \beta_3 \Delta T_s + \Delta\lambda_s + \varepsilon_{ist} \qquad (6).$$

I also estimate the short-run effect of cigarette prices/taxes on weight using a two-step procedure. First, I determine the effect of average number of cigarettes smoked per day (PERDAY) on body weight using CGS and GF first differences models:

$$\Delta BMI_{ist} / \Delta OBESE_{ist} = \beta_0 + \beta_1 \Delta PERDAY_{ist} + \beta_2 \Delta Z_{ist} + \beta_3 \Delta T + \beta_5 (\Delta T)^2 + \Delta\lambda_s + \varepsilon_{ist} \quad (7)$$
$$\Delta BMI_{ist} / \Delta OBESE_{ist} = \beta_0 + \beta_1 \Delta PERDAY_{st} + \beta_2 \Delta X_{ist} + \Delta\tau_t + \Delta\lambda_s + \varepsilon_{ist} \qquad (8).$$[12]

Next, I combine these estimates with cigarette price elasticity estimates from the literature to determine the effect of cigarette prices/taxes on weight. This approach is advantageous because prices/taxes are only allowed to impact weight through their effect on smoking behavior. Therefore, omitted variables that affect the weight of both smokers and non-smokers should not bias this estimate. The two-step approach is limited, however, by the fact that the NLSY only records smoking behavior in 1992, 1994, and 1998, meaning that the sample size and range of years included in the sample is reduced.

As discussed in the literature review, most studies place the cigarette price elasticity between -0.3 and -0.5, so I use an elasticity of -0.4 in my calculations. A $1 increase in cigarette prices represents a 69.3% increase using the mean from my sample, which would then lead to a 27.7%, or 1.50 cigarettes per person per day, decrease in smoking. The change in BMI/P(Obese) due to a $1 increase in cigarette prices is therefore 1.50*β_1.

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[12] After differencing, I am left with only two waves of data for this analysis. Therefore, I omit the state time trends.

Since the medical literature discussed in section II shows that people who quit smoking often experience a several pound weight gain, I expect the short-run effect of cigarette price/tax increases on BMI and P(Obese) to be positive.

IVc. Long-Run Effects

There is ample reason to believe that the short-run and long-run effects of cigarette price/tax changes on weight are different. Body weight is widely known to respond gradually to changes in eating and exercise habits. Consequently, even if these habits respond immediately to economic shocks, the effect of these shocks on weight will be gradual. For example, if food prices fall, a person's calorie consumption may rise. She will then begin to gain weight, and this gain will slowly increase (as long as the new eating habits continue) until a new steady-state weight is reached, likely several years after the price change.[13] Therefore, the long-run effect of cigarette price/tax changes on weight may be even larger than the short-run effect. However, as discussed in section II, some evidence exists that people who gain weight after quitting smoking may later lose some of this weight, suggesting that the long-run impact of price/tax changes of weight may be zero. There are also reasons to suspect that the long-run impact could be negative. First, people who quit smoking may experience a renewed interest and excitement about their health, leading them to next turn their attention to making healthier choices in other areas, such as diet, exercise, and alcohol consumption. Alcohol consists largely of "empty" calories, meaning that consuming it increases weight while providing little nutritional value (Suter, 2000). Next, individuals who experience a weight gain after quitting smoking may change these habits in an effort to lose the weight. If they continue to practice these new habits

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[13] See Cutler, Glaser, and Shapiro (2003) for a model that describes this phenomenon.

after all of the new weight is lost, their net change in weight after quitting will be negative. Third, smoking may reduce one's lung capacity, suggesting that people who quit smoking could begin to exercise more. Furthermore, quitters save money, which could lead to weight loss since several papers suggest that income and weight are negatively correlated.[14] Also, increased cigarette taxes often means additional government spending or lower taxes, which could also produce an income effect, reducing weight. Finally, both smoking and purchasing cigarettes are time consuming, so quitting may leave a person with more free time. If given more free time, people may tend to substitute from fast food and pre-prepared processed food to healthier home-cooked meals, reducing their weight (Anderson, Butcher, and Levine, 2003; CGS, 2002). More spare time may also lead to more exercise, again reducing weight. (Of course, people may simply use the extra time to eat more, which would increase weight.)

I estimate the long-run effects of the independent variables by converting them to weighted (by the length of time between each interview) averages of their values over all periods in the panel in which the respondents were at least eighteen years old.[15] By using averages, a person's weight in the current period depends on the values of the independent variables in all preceding periods. Since weight is traditionally modeled as a capital stock that depends on many prior periods,[16] using averages may provide a superior approach to regressions of body weight.[17] Additionally, regression coefficients for variable averages provide complete, long-run estimates of the effect of changes in those variables. For example, people who live in states where the price of a pack of cigarettes has been $2 for the past twenty years are differentiated from people who live in states where the price only rose to $2 last year. A $1 difference in average price,

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[14] For example, see CGS or GF.

[15] Age and time variables, however, are not converted to averages.

[16] For an example, see Philipson and Posner (1999).

therefore, reflects a $1 difference in every period's price, the effect of which is the full long-run effect.

I account for time-invariant endogeneity using two methods. First, I estimate models including individual fixed effects. The regressions using the CGS and GF approaches, respectively, are:

$$\begin{aligned} BMI_{ist}/OBESE_{ist} &= \beta_0 + \beta_1 aPRICE_{st} + \beta_1 (aPRICE_{st})^2 + \beta_3 aZZ_{ist} + \beta_4 AGE + \beta_5 AGE^2 \\ &\quad + \beta_6 T + \beta_7 T^2 + \beta_8 T_S + a\lambda_s + \alpha_i + \varepsilon_{ist} \qquad (9) \end{aligned}$$

$$BMI_{ist}/OBESE_{ist} = \beta_0 + \beta_1 aTAX_{st} + \beta_2 aXX_{ist} + \beta_3 AGESEX_{ist} + \tau_t + \beta_4 T_S + a\lambda_s + \alpha_i + \varepsilon_{ist} \quad (10)$$

where α is the set of individual fixed effects. Also,

$$aPRICE_{st} = \frac{\sum_{j=1}^{t} PRICE_{sj} * WK_{isj}}{\sum_{j=1}^{t} WK_{isj}}$$, where WK = number of weeks since the individual's last interview (or 52 for the individual's first interview), and other averages (denoted by the prefix "a") are similarly defined.

Next, I employ a long differences approach used by Anderson, Butcher, and Levine (2003). I use only one difference per individual, and the difference is the difference between the variable averages in the last period in which the person is in the panel and the first period in which she is at least eighteen years old. Differencing over a 10-20 year period allows me to better capture long-term effects and account for the gradual nature of weight changes than differencing over a 1-2 year period. Furthermore, as pointed out by Anderson, Butcher, and Levine (2003), using long differences helps to reduce any bias caused by measurement error. Formally, the long differences regression equations, using the CGS methodology are:

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[17] For a more detailed argument, see Anderson, Butcher, and Levine (2003).

$$DBMI_{ist} / DOBESE_{ist} = \beta_0 + \beta_1 DaPRICE_{st} + \beta_2 DaZZ_{ist} + \beta_3 DAGE + \beta_4 (DAGE)^2 + \beta_5 DT_{ist} + \beta_6 (DT)^2 + \beta_7 DT_S + Da\lambda_s + \varepsilon_{ist} \quad (11)$$

where D represents long difference and ZZ is the set Z without age, which is listed separately due to the fact that age is not averaged. The GF long differences regressions are:

$$DBMI_{ist} = \beta_0 + \beta_1 DaTAX_{st} + \beta_2 DaXX_{ist} + \beta_3 DAGESEX_{ist} + D\tau_t + \beta_4 + DT_S + Da\lambda_s + \varepsilon_{ist} \quad (12)$$

where XX is X without the set of age-gender dummies, which have been separated and labeled AGESEX. In all long differences regressions, β_1 can be interpreted as the complete, long-run effect of a change in price/tax on BMI/P(Obese). This is because, if prices/taxes change, average price/tax will slowly change until it converges to the new price/tax in the limit. Also, when creating the long differences, I omit the years 2000, 2002, and 2004 from the panel. This is because cigarette prices and taxes rose much more sharply from 1999-present than they did during the other years. Since the vast majority of respondents were interviewed for the last time in one of those three years, long differences estimates with these years included may actually capture the short-run effect.[18] Therefore, I use 1998, a year in which cigarette price and tax growth was more similar to that of the preceding twenty years, as the end year for people whose actual end years are between 2000 and 2004.

IVd. Isolating the Effect on Potential Smokers

While the differences and fixed effects estimators discussed in the preceding sections are consistent in the absence of omitted variables that are correlated with both cigarette prices/taxes

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[18] For example, suppose a person's first year in the sample is 1985 and her last year is 2004, and that during that time real cigarette prices rose by 100%. However, suppose 2/3 of that increase occurred between 2002 and 2004. The part of the difference between her weight in 2004 and weight in 1985 that is due to changing cigarette prices would mostly be due to the change between 2002 and 2004, which is the short-run effect. Therefore, to ensure that

and body weight and that change over time, I cannot completely rule out the possibility of a such variables. For example, general health attitudes in states, which affect both cigarette taxes and weight, could change over time.

Omitted variables such as this would affect the weight of both smokers and non-smokers, and there is little reason to believe that any effect of cigarette prices/taxes on the weight of people who would never smoke regardless of price is causal.[19] Therefore, the difference between the impact of cigarette prices/taxes on the weight of people who have never smoked and the weight of people who have smoked may provide a more reliable estimate of the true causal effect, while also reducing noise. The NLSY data from 1992, 1994, and 1998 contains a variable that states whether or not the respondent has smoked at least 100 cigarettes in his/her life. I classify those respondents for whom this variable is 1 in 1998 as "potential smokers."[20] I run all regressions from sections Vb and Vc, adding the interaction term *PRICE/TAX*CIG100*, where *CIG100* is 1 if the person is a potential smoker and zero otherwise. The coefficient on the interaction term, therefore, is the difference between the effects of prices on the weight of never-smokers and potential smokers. Assuming that the true impact of prices on never-smokers is zero, the effect of price changes on the weight of the population as a whole is this number multiplied by the percentage of people who are classified as potential smokers (51%).

IVe. Speed of Convergence

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long differences capture the long-run effect, the last year in which the majority of the people were in the sample must be a fairly typical year in terms of cigarette price growth.

[19] According to my theoretical analysis in section III, the only possible causal relationship between prices/taxes and the weight of never-smokers would be the income effect from increase government spending or reduced taxes. However, the total net revenue from state cigarette taxes in 2005 was $12.25 billion (Orzechowski and Walker, 2005), or $41.39 per capita, based on a population estimate of 296 million (U.S. Census Bureau, 2006). The effect of an additional $41 per year on weight would be minimal.

[20] If the 1998 value of this variable is missing, I use the 1994 value, and if both are missing, I use the 1992 value.

The aforementioned long-run estimation approaches determine the total effect of a change in cigarette prices/taxes in the limit. However, inferences based on these results would depend heavily on the rate of convergence to this full long-term effect. Therefore, I also estimate an individual fixed effects regression that includes a number of lags for price in an effort to determine how weight changes in response to price changes over time:

$$\begin{aligned} BMI_{ist} = \gamma_0 + \sum_{j=0}^{10} \beta_j PRICE_{s,t-j} + \beta_{11} avZZ_{ist} + \beta_{12} AGE + \beta_{13} AGE^2 + \beta_{12} T + \beta_{13} T^2 \\ + \beta_{14} T_S + av\lambda_s + \alpha_i + \varepsilon_{ist} \qquad (13) \end{aligned}$$

where *av* indicates average over the current and previous ten years only. $\beta_0 + \ldots + \beta_{10}$ is the total effect of a $1 price increase on weight after eleven years. In order for each lag to represent one year, when waves are separated by two years I impute the value of price in the year between by taking the average of the year before and the year after.

V. Results

Va. Replications

Table 3 reports the coefficient estimates from my replications of the approaches of CGS and GF, while Table 4 reports the marginal effects of cigarette prices/taxes on BMI/P(Obese) and compares them to those obtained by CGS and GF. As expected, the CGS methodology yields a positive relationship between cigarette prices and body weight while the GF methodology produces a negative relationship between taxes and weight. The magnitude of the difference between the two estimates is similar to that of the actual CGS and GF results. As discussed in section IV, CGS report two types of results: 1) those from regressions including a number of state-level prices that serve as indirect time trends, and 2) those from regressions including both these prices and an explicit quadratic time trend. Since my CGS replication includes a quadratic time trend but not the additional prices, it is unclear to which of CGS's models my replication more closely resembles. Therefore, in Table 4 the left half of the CGS columns reports CGS's results without the time trend and the right half reports their results with the time trend. Not surprisingly, my estimates fall between the two. Using the fact that at the sample mean height a one unit increase in BMI is equivalent to 6.5 pounds, my CGS replications predict that a $1 increase in prices leads to a 1.7 pound increase in average weight and 1.5% increase in the obesity rate, while my GF replications predict a 3.2 pound drop in average weight and 2.3% decline in the obesity rate.

The coefficient estimates for the control variables are generally similar to those of CGS and GF. As predicted in section III, additional income reduces weight. Minorities appear to weigh more than whites, with blacks weighing more than non-black minorities. Married people weigh more than singles, which may be due to paying less attention to their eating and exercise habits, either because of time constraints caused by the presence of a spouse and children or because of the removal of the pressure to stay thin to improve dating market prospects. People with a college education seem to weigh less than those with only a high school education. Additional education may increase nutritional and fitness knowledge, causing weight to fall. However, the education effect may be endogenous if it is due to an omitted variable such as general ambition. Unemployment rate is positively correlated with weight. This suggests that obesity is countercyclical, likely because additional income reduces weight. This finding is contrary to that of Ruhm (2000), who concluded that people become thinner during recessions. I do not report the coefficients for variables controlling for age and gender. Generally, the BMI of women is slightly lower than that of men, and people tend to gain weight as they grow older.

Vb. Short-Run Effects

Table 5 displays the results from my first differences regressions. An increase in cigarette prices/taxes now leads to weight gain using both methodologies and both dependent variables. The magnitude of this gain, however, is small: a $1 increase leads to a short-run increase of 1-1.5 pounds and 1.6 to 1.7 percentage points P(Obese). Given the medical literature on short-run weight gains following smoking cessation, these magnitudes seem reasonable. The CGS estimate using *BMI* as the dependent variable is highly significant, while the estimate using *OBESE* is significant at the 5% level. Regressions with Obese as the dependent variable frequently have lower t-statistics than those with BMI since such a specification drastically limits the range of values the dependent variable can take. Both GF estimates of the tax effect are positive but insignificant. The larger standard errors are a consequence of using tax instead of price as the variable of interest. Since state cigarette tax rates account for an average of only 15% of the total price, tax is not a particularly accurate proxy for price. State A having a higher tax than state B only slightly increases the probability that state A has a higher overall price than state B, standard errors for tax will typically be larger than those for price. Due to the fact that we should not assume perfect passthrough of the excise taxes, the coefficients on price and tax are not completely comparable. Nonetheless, the similarity of the point estimates using the CGS and GF approaches suggests that, using first differences, choice of variable of interest and method of capturing the effect of time do not drive the results.

In Tables 6 and 7, I show the results of the two-step procedure in which I estimate the impact of smoking on weight and combine this result with the commonly accepted cigarette price elasticity of -0.4 to determine the effect of price on weight. Number of cigarettes smoked per day is negative and statistically significant in all models. My results imply that a person who quits smoking after smoking a pack of cigarettes per day will gain around 3-3.5 pounds and experience a 3% rise in her P(Obese). As discussed in section II, medical studies suggest that 58-87% of quitters gain weight, with the average gain being 4 pounds for those who do gain weight, so my results appear reasonable. When calibrated by the effect of prices on smoking behavior, the marginal effect of prices on weight (Table 7) is positive but very small (about 0.25 pounds and 0.3 percentage points P(Obese)).

Vc. Long-Run Effects

Tables 8 and 9 display the fixed effects averages results, with Table 9 containing the marginal effects of prices/taxes on weight. In contrast to the first differences models, the marginal effect is negative in all four regressions, with a $1 increase in prices reducing weight by 2.9 pounds and P(Obese) by 7.7 percentage points and a $1 increase in taxes reducing weight by -10.8 pounds and -14.1 percentage points P(Obese). However, all estimates are imprecise: only the GF BMI regression is statistically significant at the 10% level.

Table 10 reports the results for the long differences models using averages of the independent variables. Again, the effect of cigarette prices/taxes on weight is negative for all specifications, but the standard errors are large.[21] The point estimates are less sensitive to specification, though: 2.5 pounds/6.5 percentage points P(Obese) for prices and 3.3 pounds/4.7 percentage points P(Obese) for taxes. Note that the R^2s for the long differences regressions are substantially higher than those for the first differences regressions. This suggests that examining the determinants of weight through a long-run approach is more appropriate than through a short-

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[21] Standard errors may be somewhat inflated due to the smaller sample size caused by the fact that I am including only one observation per person.

run approach, which is not surprising given the fact that weight changes in response to shocks are gradual.

Vd. Isolating the Effect on Potential Smokers

Tables 11-16 contain the results for first differences, long differences averages, and fixed effects averages regressions that include the interaction term for cigarette price/tax conditional on the respondent having smoked at least 100 cigarettes in his/her entire life. Assuming that the true effect of cigarette prices/taxes on the weight of people who have not smoked at least 100 cigarettes in their lives is zero, the coefficient on this interaction term multiplied by the percentage of people who have smoked 100 cigarettes is the overall, society-wide effect (Tables 12, 14, and 16). This assumption may understate the true effect since some people who never smoked 100 cigarettes may have eventually started smoking if the prices were lower. Therefore, claims made on the basis of my results are conservative.

Table 11 reports the short-run results (for key variables only) obtained using the first differences models. The effect of "real cigarette price" is assumed to be simply noise since this is the effect shared by both potential smokers and never-smokers. The coefficient on "price*smoked 100 cigarettes" is the difference between the effects on potential smokers and never-smokers, which I assume to be exogenous. Table 12 shows this coefficient multiplied by 0.512, which is the proportion of people who are potential smokers. As seen in Table 12, the short-run effect of a $1 increase in prices/taxes on weight is positive but even smaller than reported in Table 5: about 0.4 pounds. The impact on obesity is less clear. However, when whether or not the person is overweight (BMI≥25) is used as the dependent variable instead of

OBESE, the positive result returns: the marginal effect of both prices and taxes is about 2 percentage points P(Overweight).

Tables 13 and 14 display the long-run effects captured by the fixed effects averages models. The relationship between cigarette prices/taxes and weight is negative in all four specifications, with magnitudes of about -3.5 pounds and -5.4 percentage points P(Obese) for price and -2.4 pounds and -2.9 percentage points P(Obese) for tax. As expected, including the interaction term improves precision: the marginal effect of price is significant in both regressions, and the point estimates using the two methodologies are closer together than they are in Table 9. The marginal effect of tax is again insignificant; again, this is probably due to tax being a poor proxy for price.[22]

Tables 15 and 16 report the long differences averages results. The long-run effect of price on weight is negative for all specifications. The magnitudes for both methodologies are about 3-4 pounds and 4-5 percentage points P(Obese). Again, estimates of the price effect are statistically significant while estimates of the tax effect are not. The small coefficients of cigarette price/tax (without the interaction term) suggest that the results from Table 9 were not significantly biased; accordingly, the marginal effects of price/tax in Table 16 are similar to those in Table 9.

Ve. Speed of Convergence

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[22] Interestingly, if the assumption that the effect of price/tax on the weight of non-potential smokers is true, the CGS estimates from Table 8 appear more consistent than the GF estimates. The marginal effect of real cigarette price (not price*potential smoker) at the mean is 0.17 units BMI and 0.003 percentage points P(Obese) using the CGS approach, while it is -1.3 units BMI and -9.7 percentage points P(Obese) using the GF approach. As discussed in section II, unhealthy states may have low taxes and high body weights, explaining the downward bias. However, with price, this downward bias may be cancelled out by an upward bias caused by unhealthy states having a strong demand for cigarettes and a higher price.

The results for the regression with lags of cigarette price are found in Table 17. The short-run effect is positive and significant, but the coefficients of all lags are negative. A sharp downward movement in weight appears to occur in years 1-6, with the change in weight slowing in years 7-10. The total effect in all periods is -0.5942, which is actually larger than the most comparable regression from earlier in the paper: the CGS BMI regression in the first column of Tables 8 and 9. Therefore, the full long-run effect of a price change appears to be reached within the first decade.

VI. Economic Significance

In Tables 18 and 19, I list all short-run and long-run estimates from the various differences and fixed effects models. 11 of the 12 short-run estimates are positive, although all are fairly small (the largest being 1.5 pounds and 1.7% P(Obese)). All 16 long-run estimates are negative, with the long-run estimates ranging from -2.4 to -10.8 pounds and -2.9% to -14.1% P(Obese). Though the varying level of statistical significance prevents the long-run results from being conclusive, the price effect is highly significant in all regressions including the interaction term.

Tables 20 through 24 attempt to express the economic significance of the long-run results. In Tables 20 and 22, I determine the short-run and long-run percentage changes in the prevalence in obesity that would result if cigarette prices rose by $1 in 2004 dollars. This is simply the effect of cigarette prices/taxes on P(Obese) divided by the 2004 obesity rate of 32.2% and multiplied by 0.53, to convert 1982-84 dollars to 2004 dollars. In Tables 21 and 23, I determine the short-run and long-run changes in mortality and medical expenditures due to obesity that would occur if cigarette prices/taxes rose by $1 in 2004 dollars, using information on the costs of obesity from the introduction. I use only the two-step results and those from regressions with the interaction term because those models attempt to reduce noise by isolating the effect that occurs through changes in smoking.

In the short run (Tables 20 and 21), a $1 increase in cigarette prices increases the prevalence of obesity by less than 0.5%, which costs less than 500 lives and approximately $600 million per year. For comparison purposes, using smoking costs data from the introduction, a cigarette price elasticity of 0.4, and the mean cigarette price from this paper, a $1 (in 2004 dollars) increase in cigarette prices would save 64,303 lives and $24.52 billion annually due to reduced smoking (assuming no impact of smoking on weight). Therefore, the positive effects of the anti-smoking campaign on public health are only slightly mitigated by considering its impact on obesity, even at the point when the adverse impact on obesity is at its highest.

In the long run, (Tables 22 and 23), increasing cigarette prices by $1 lowers the prevalence of obesity by 7-9%, saving about 9,000 lives and $10 billion per year. Given that this entire long-run effect appears to be reached within a decade, the anti-smoking campaign appears to have produced a fairly substantial unexpected public health benefit by limiting the rise in obesity that has occurred over the past several decades. Additionally, the large cigarette price increases during the period 1999-2005 may help to reduce America’s obesity rate in the coming years.

VII. Explaining the Negative Long-Run Effect

While a zero long-run effect is plausible given the scientific evidence suggesting that some of the weight gain following smoking cessation is temporary, my finding of a negative long-run relationship is surprising. In section IVc, I proposed several possible explanations.

First, the additional revenue generated by cigarette excise taxes may cause governments to lower taxes or increase spending, both of which increase people's disposable income, inducing weight loss since a variety of evidence shows that income and weight are negatively correlated. However, as shown in a previous footnote, annual per capita state cigarette tax revenue is only \$41. Even using this paper's most generous estimate of income's effect on weight, \$41 accounts for a weight loss of only 0.003 pounds. I also argued that the money saved when one quits smoking creates a similar income effect. In section IVb, I found that a \$1 increase in cigarette prices reduces cigarette consumption by 1.5 per person per day, or 548 per year. At an average price of \$1.44 per pack (7.2 cents per cigarette), annual per capita savings due to reduced smoking is \$39 per year, which again leads to a per capita weight loss of 0.003 pounds. Therefore, the majority of the negative effect of cigarette prices/taxes on weight seems to be due to a combination of the other explanations, which center around the idea that quitting smoking eventually causes people to take more of an interest in other aspects of their health, such as weight reduction and alcohol consumption, which affects weight. This could be because quitters experience renewed confidence in their ability to control their own health, inspiring them to next target eating, exercise, and drinking habits. Also, quitters who initially gain a few pounds may decide they need to lose the weight, causing them to develop improved eating and exercise habits that persist even after the new weight is lost. Furthermore, smoking may reduce lung capacity, so exercise levels may increase after quitting. Finally, the additional free time resulting from quitting may induce a person to exercise more and prepare more of her own meals instead of eating fast food and processed food.

The NLSY includes data on alcohol consumption in 1982, 1983, 1984, 1985, 1988, 1989, 1994, and 2002, allowing me to test the hypothesis that cigarette prices influence alcohol intake.

In 1982-85, the respondents were asked the number of beers, glasses of wine, and drinks containing liquor they consumed in the preceding week. In 1988, 1989, 1994, and 2002 they were asked the number of days in which they drank alcohol in the past month, and the average number of drinks on these days. These questions allow me to construct a variable for average number of drinks per week. Using the GF methodology, I estimate the impact of cigarette taxes on drinks per week in two ways.[23] First, I include individual- and state-level fixed effects. Next, I also include the interaction term tax*potential smoker. I report these results in Table 28. A $1 increase in cigarette taxes reduces drinks per day by 1.8. With the interaction term, the effect on potential smokers is -2.1 drinks per day. Assuming no effect on non-potential smokers, the effect on the entire population is -1.1 drinks per day.

In 1998 and 2000, the NLSY asked the frequency with which respondents obtained both light exercise, such as walking, and strenuous exercise, such as working out or participating in sports. For both questions, the respondents chose from the following options: never (0), less than once a month (1), one to three times a month (2), once or twice a week (3), and three or more times a week (4). The NLSY also asked the frequency with which respondents read nutritional information when purchasing food. Responses ranged from 0 for almost never to 4 for almost always. Reading food labels serves as a proxy for level of interest in one’s weight. Using ordered probit regressions, I find that increases in cigarette taxes are associated with increases in both types of exercise as well as the reading of nutritional information (Table 29).[24] A $1 rise in cigarette taxes increases the probability of being in the highest category of light exercise by 12.9

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[23] Results are robust to the use of the CGS methodology.

[24] I do not implement panel data techniques since I only have two waves of data. Results using prices and the CGS methodology are also statistically significant but slightly smaller in magnitude.

percentage points, heavy exercise by 9.3 percentage points, and label reading by 3.6 percentage points.

VIII. Discussion/Conclusion

In this paper, I attempt to reconcile differences in the literature and determine the true effect of cigarette prices/taxes on body weight. I also, through the use of NLSY panel data, attempt to distinguish between the short-run and long-run effects. I find robust evidence that increasing prices by $1 may lead to a small sort-run weight gain of less than 1.5 pounds per person. This is likely due to the fact that smoking can stimulate one's metabolism and curb one's appetite. However, in the long run, the effect of prices/taxes on weight appears to become negative, ultimately leading to an annual savings of roughly 9,000 lives and $10 billion for every $1 increase in prices. I find some evidence that people who are induced to quit smoking by price changes begin to more closely monitor their eating, exercise, and alcohol consumption decisions, explaining this counterintuitive result.

An obvious policy implication is that the existence of additional public health benefits of cigarette taxes implies that the optimal tax rate may be higher than previously believed. However, the fact that tax increases might actually lead to an immediate increase in weight before ultimately reducing weight in the long run, combined with the somewhat modest magnitude of the long-run effect, suggests that raising cigarette taxes should not become a major component of the government's obesity-reducing campaign. An avenue for future research would be to analyze how the results from this paper affect optimal cigarette taxation policies.

Future research should also utilize a data set with richer information on exercise and eating habits to determine the exact cause of the negative long-run effect. Until more evidence is gathered regarding why cigarette prices seem to ultimately reduce weight, a safer conclusion from this paper is simply that concerns about cigarette taxes having the unintended consequence of contributing to America’s rise in obesity appear to have been exaggerated. An extension of this conclusion is that smokers should not postpone quitting due to the fear of gaining weight.

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Appendix 1 – Theoretical Analysis of the Long-Run Impact of Cigarette Prices on Weight

The fact that smoking can increase one's metabolism and suppress one's appetite suggests that cigarette prices and body weight should be positively correlated, ceteris paribus. However, a more complete analysis of the ways in which cigarette prices (and therefore taxes) could influence weight reveals that the long-run effect is theoretically ambiguous.

Assume that a representative agent's weight (W) is a function of calories consumed (C) and expended (E). As calories consumed rises, weight rises, and as calories burned rises, weight falls:

$$W = w(C,E);\ \frac{\partial w}{\partial C} > 0;\ \frac{\partial w}{\partial E} < 0 \qquad (1).$$

Since smoking can act as an appetite suppressant, calories consumed is decreasing in number of cigarettes smoked (S). The aforementioned relationship between income and weight is generally considered to be due to the fact that people with money can afford healthier, more expensive food. Therefore, C is decreasing in income (I). Additionally, people with a high amount of interest in their health tend to consume fewer calories than those who are less interested. Therefore,

$$C = c(S,I,H);\ \frac{\partial c}{\partial S} < 0;\ \frac{\partial c}{\partial I} < 0;\ \frac{\partial c}{\partial H} < 0 \qquad (2)$$

where H is the level of attention the person pays to her health. Since smoking can stimulate one's metabolism, but at the same may decrease lung capacity and therefore ability to exercise, the effect of S on calories expended is ambiguous. People with a high level of interest in their health tend to exercise more, thereby increasing their metabolism, so

$$E = e(S,H);\ \frac{\partial e}{\partial S} ? 0;\ \frac{\partial e}{\partial H} > 0 \qquad (3).$$

Number of cigarettes smoked depends on the price of cigarettes (P), of which cigarette tax is a component:

$$S = s(P);\ \frac{\partial s}{\partial P} < 0 \qquad (4).$$

Smoking more cigarettes reduces a person's real disposable income, as does a rise in the price of cigarettes. An increase in the level of public goods (G) provided by the government essentially increases disposable income, as does a reduction in (non-cigarette) taxes. Assuming tax cuts act as an increase in G,

$$I = i(S,P,G);\ \frac{\partial i}{\partial S} < 0;\ \frac{\partial i}{\partial P} < 0;\ \frac{\partial i}{\partial G} > 0 \qquad (5).$$

As previously discussed, quitting smoking could lead to a renewed interest in one's health and confidence that one can make positive health-related changes. Therefore, smoking and H are inversely related:

$$H = h(S);\ \frac{\partial h}{\partial S} < 0 \qquad (6).$$

Finally, as cigarette taxes (and therefore prices) increase, government spending may rise or other taxes may be cut. Therefore,

$$G = g(P);\ \frac{\partial G}{\partial P} > 0 \qquad (7).$$

Combining (1)-(7) yields the following expression for weight:

$$W = w(c(s(P), i(s(P), P, g(P)), h(S)), e(s(P), h(S))) \qquad (8).$$

Differentiating (8) with respect to P yields:

$$\frac{dW}{dP} = \frac{\partial w}{\partial C}\frac{\partial c}{\partial S}\frac{\partial s}{\partial P} + \frac{\partial w}{\partial C}\frac{\partial c}{\partial I}\frac{\partial i}{\partial G}\frac{\partial g}{\partial P} + \frac{\partial w}{\partial C}\frac{\partial c}{\partial I}\frac{\partial i}{\partial S}\frac{\partial s}{\partial P} + \frac{\partial w}{\partial C}\frac{\partial c}{\partial I}\frac{\partial i}{\partial P} + \frac{\partial w}{\partial C}\frac{\partial c}{\partial H}\frac{\partial h}{\partial S}\frac{\partial s}{\partial P}$$
$$+ \frac{\partial w}{\partial E}\frac{\partial e}{\partial S}\frac{\partial s}{\partial P} + \frac{\partial w}{\partial E}\frac{\partial e}{\partial H}\frac{\partial h}{\partial S}\frac{\partial s}{\partial P} \qquad (9).$$

The first and fourth of these terms are positive, while the second, third, fifth, and seventh terms are negative and the sixth is uncertain. Therefore, the overall effect of cigarette price on weight is ambiguous, depending on the relative magnitude of the terms in (9).

Figure 1: Trends in Average Real State Cigarette Tax Rate, Average Real Cigarette Price, and Obesity

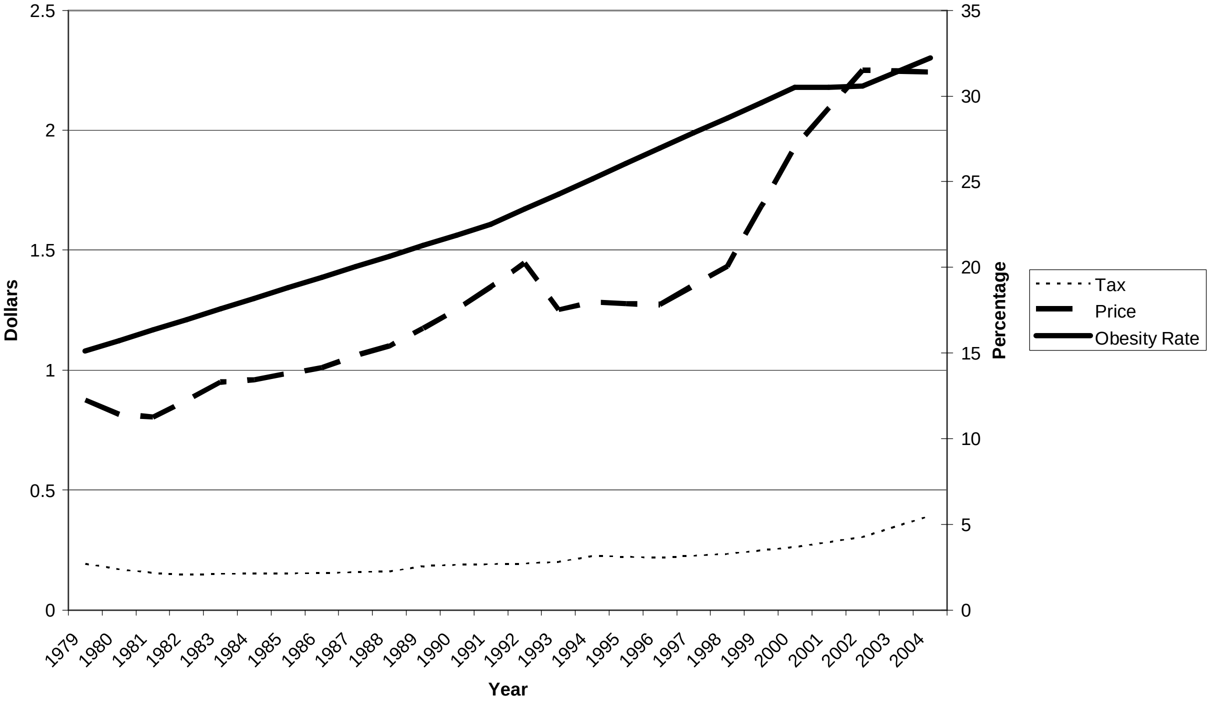

Figure 2 -- Change in BMI After a $1 Increase in Cigarette Prices

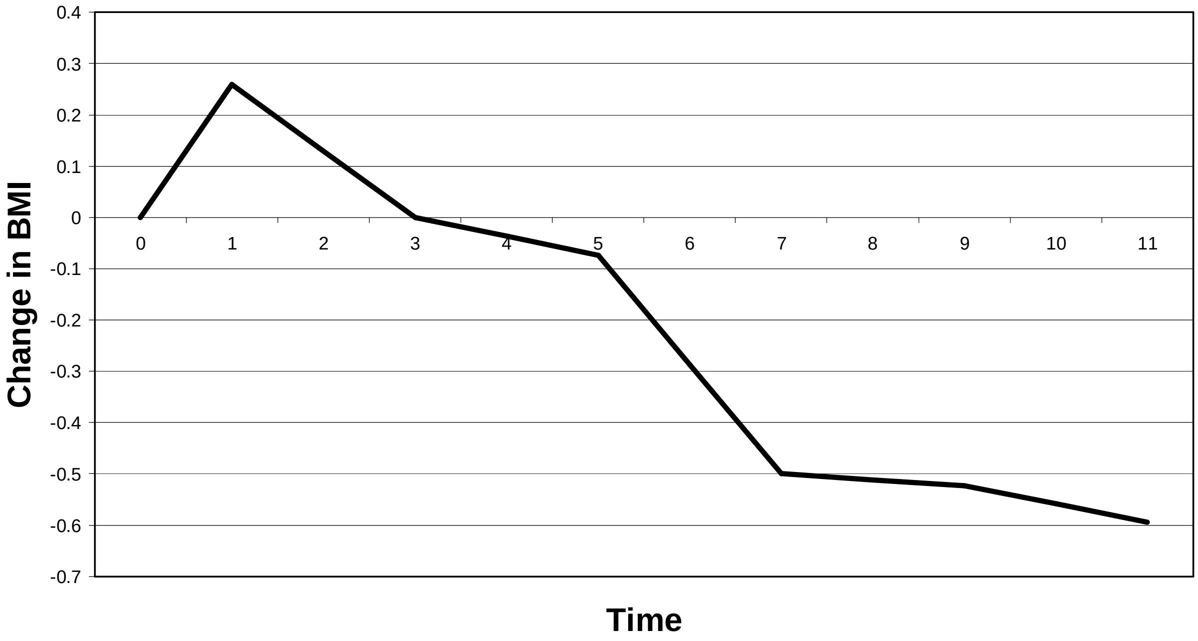

Table 1 – Summary statistics

Variable	Description	Mean and standard deviation
Weight	Weight in pounds	168.4296 (39.9712)
Height	Height in inches	67.5171 (4.0725)
BMI	Body mass index = weight in kilograms divided by height in meters squared	25.8658 (5.2703)
Obese	Binary variable that equals 1 if BMI≥30 kg/m2 and 0 otherwise	0.1768 (0.3815)
Real cigarette price	Real cigarette price (in 1982-84 dollars) in the respondent's state of residence	1.4423 (0.4633)
Real cigarette tax	Real state excise cigarette tax (in 1982-84 dollars) in the respondent's state of residence	0.2217 (0.1525)
Real income	Real household income (in 1982-84 dollars) in units of $10,000	3.5102 (6.1039)
Race: black	Binary variable that equals 1 if the respondent's race is black and 0 otherwise	0.1268 (0.3327)
Race: other	Binary variable that equals 1 if race is neither white nor black and 0 otherwise	0.0257 (0.1583)
Married	Binary variable that equals 1 if the respondent is married and 0 otherwise	0.5911 (0.4916)
Unemployment rate	Percent unemployment rate in the respondent's county of residence	6.3923 (2.6253)
Education: grades 9-11	Binary variable that equals 1 if the respondent's highest grade completed is between 9 and 11 and 0 otherwise	0.0815 (0.2737)
Education: high school grad.	Binary variable that equals 1 if highest grade completed is 12 and 0 otherwise	0.4264 (0.4945)
Education: some college	Binary variable that equals 1 if highest grade completed is between 13 and 15 and 0 otherwise	0.2312 (0.4216)
Education: college grad.	Binary variable that equals 1 if highest grade completed is greater than 16 and 0 otherwise	0.4264 (0.4945)
Age	Respondent's age	32.8406 (6.3697)
Female	Binary variable that equals 1 if the respondent is female and 0 otherwise	0.4947 (0.5000)
Female25	Binary variable that equals 1 if the respondent is	0.0667

	female with age≤25 and 0 otherwise	(0.2496)
Female30	Binary variable that equals 1 if the respondent is female with age≤30 and 0 otherwise	0.1351 (0.3418)
Female35	Binary variable that equals 1 if the respondent is female with age≤35 and 0 otherwise	0.1276 (0.3336)
Female40	Binary variable that equals 1 if the respondent is female with age≤40 and 0 otherwise	0.0955 (0.2939)
Female45	Binary variable that equals 1 if the respondent is female with age≤45 and 0 otherwise	0.0604 (0.2383)
Female50	Binary variable that equals 1 if the respondent is female with age>45 and 0 otherwise	0.0094 (0.0963)
Male30	Binary variable that equals 1 if the respondent is male with age≤30 and 0 otherwise	0.1328 (0.3393)
Male35	Binary variable that equals 1 if the respondent is male with age≤35 and 0 otherwise	0.1310 (0.3374)
Male40	Binary variable that equals 1 if the respondent is male with age≤40 and 0 otherwise	0.1017 (0.3022)
Male45	Binary variable that equals 1 if the respondent is male with age≤45 and 0 otherwise	0.0662 (0.2486)
Male50	Binary variable that equals 1 if the respondent is male with age≤50 and 0 otherwise	0.0096 (0.2496)
Cigarettes per day	Average number of cigarettes smoked per day by the respondent	5.4067 (10.1759)
Smoked 100 cigarettes	Binary variable that equals 1 if the respondent smoked at least 100 cigarettes in his/her life	0.5116 (0.4999)

Note: All summary statistics are weighted using the NLSY sampling weights.

Table 2 – Summary of CGS and GF methodologies

CGS methodology	GF methodology
Quadratic price is variable of interest	Linear tax is variable of interest
Quadratic time trend	Month/year dummy variables as time trend
Quadratic age effect; dummy for gender	Categories for gender/age combinations
Quadratic income effect	Linear income effect

Table 3 – Replications of the results of CGS and GF

	CGS BMI	GF BMI	CGS P(Obese)	GF P(Obese)
Real cigarette price/tax	0.8730	-0.4932	0.0479	-0.0234
	(0.2382)***	(0.1743)***	(0.0333)	(0.0221)
Price/tax squared	-0.2115	-	-0.0114	-
	(0.0621)***		(0.0089)	
Real income (each $10,000)	-0.1228	-0.0283	-0.0092	-0.0021
	(0.0190)***	(0.0053)***	(0.0011)***	(0.0002)***
Income squared	0.0014	-	0.0001	-
	(0.0002)***		(0.0000)***	
Race: black	1.5473	1.6312	0.0860	0.0916
	(0.1486)***	(0.1462)***	(0.0083)***	(0.0082)***
Race: other	0.6223	0.6420	0.0398	0.0419
	(0.2638)**	(0.2714)**	(0.0170)***	(0.0173)**
Married	0.4465	0.3271	0.0204	0.0112
	(0.0755)***	(0.0723)***	(0.0049)***	(0.0046)**
Unemployment rate	-	0.0701	-	0.0037
		(0.0165)***		(0.0011)***
Education: grades 9-11	-0.8544	-0.8861	-0.0418	-0.0436
	(0.4311)*	(0.4303)**	(0.0333)	(0.0330)
Education: high school grad.	-0.7655	-0.8580	-0.0526	-0.0589
	(0.4064)*	(0.4066)**	(0.0311)*	(0.0308)*
Education: some college	-1.0100	-1.1390	-0.0659	-0.0743
	(0.4313)**	(0.4362)**	(0.0320)**	(0.0318)**
Education: college grad.	-1.8334	-2.0450	-0.1179	-0.1332
	(0.4422)***	(0.4471)***	(0.0323)***	(0.0318)***
R-squared	0.1139	0.1157	0.0587	0.0606
Observations	92,415	90,839	92,415	90,839

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Standard errors in parentheses. All standard errors are heteroskedasticity-robust and clustered by state. Observations in each regression are weighted using the NLSY sampling weights. All regressions include state-level fixed effects, as well as the CGS or GF methods of controlling for the effects of time, gender, and age.

Table 4 – Marginal effects of real cigarette prices/taxes

	CGS: BMI		GF: BMI	CGS: P(Obese)		GF: P(Obese)
Their paper	0.5092	0.1511	-0.1505	0.0346	0.0142	-0.0150
	(0.4579)	(0.3679)	(0.0734)**	(0.0337)	(0.0267)	(0.0059)***
Replication	0.2629		-0.4932	0.0150		-0.0234
	(0.0917)***		(0.1743)***	(0.0096)		(0.0221)

Notes: Standard errors in parentheses. *,**,*** indicate statistical significance at the 1%, 5%, and 10% levels respectively. Marginal effects are calculated at the weighted sample means for price and tax.

Table 5 – Regression output for first differences models

	CGS BMI	GF BMI	CGS P(Obese)	GF P(Obese)
Real cigarette price/tax	0.2321	0.1638	0.0172	0.0165
	(0.0569)***	(0.1193)	(0.0070)**	(0.0222)
Real income (each $10,000)	0.0046	0.0050	0.0001	0.0002
	(0.0019)**	(0.0020)**	(0.0001)	(0.0001)
Married	0.4007	0.3930	0.0221	0.0220
	(0.0412)***	(0.0422)***	(0.0041)***	(0.0040)**
Unemployment rate	-	-0.0078	-	-0.0003
		(0.0080)		(0.0009)
Education: grades 9-11	0.2523	0.2463	-0.0462	-0.0427
	(0.5901)	(0.6012)	(0.0561)	(0.0512)
Education: high school grad.	-0.1664	-0.1394	-0.0456	-0.0430
	(0.5997)	(0.6075)	(0.0488)	(0.0512)
Education: some college	-0.2110	-0.2056	-0.0451	-0.0432
	(0.6325)	(0.6435)	(0.0484)	(0.0508)
Education: college grad.	-0.4177	-0.4528	-0.0415	-0.0396
	(0.6745)	(0.6820)	(0.0487)	(0.0511)
R-squared	0.0066	0.0127	0.0023	0.0065
Observations	58,430	57,384	58,430	57,384

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Standard errors in parentheses. All standard errors are heteroskedasticity-robust and clustered by state. Observations in each regression are weighted using the average of the current and previous period’s NLSY sampling weights. All regressions include a set of variables that reflect the difference in the state dummies, as well as the CGS or GF methods of controlling for the effects of time, gender, and age. All regressions also include linear state time trends.

Table 6 – Regressions of weight on cigarettes smoked per day

	CGS BMI	GF BMI	CGS P(Obese)	GF P(Obese)
Cigarettes per day	-0.0254 (0.0046)***	-0.0257 (0.0046)***	-0.0017 (0.0006)***	-0.0018 (0.0006)***
R-squared	0.0249	0.0341	0.0098	0.0138
Observations	10,638	10,624	10,638	10,624

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. BMI models use individual-level fixed effects; P(Obese) models use first differences. Standard errors in parentheses. All standard errors are heteroskedasticity-robust and clustered by state. Observations in each regression are weighted using the NLSY sampling weights. All regressions include state-level fixed effects, as well as the CGS or GF methods of controlling for the effects of time, gender, and age. All regressions also include linear state time trends.

Table 7 – Implied effect of real cigarette price/tax on BMI and P(Obese)

	CGS BMI	GF BMI	CGS P(Obese)	GF P(Obese)
Price/tax	0.0381	0.0386	0.0026	0.0027

Table 8 – Regression output for fixed effects averages models

	CGS BMI	GF BMI	CGS P(Obese)	GF P(Obese)
Avg. real cigarette price/tax	0.3513 (1.6750)	-1.6613 (0.8298)*	-0.1847 (0.2649)	-0.1406 (0.1028)
Avg. real price/tax squared	-0.3831 (0.6406)	-	0.0520 (0.0981)	-
Avg. income (each $10,000)	-0.0765 (0.0201)***	-0.0681 (0.0139)***	-0.0085 (0.0013)***	-0.0067 (0.0011)***
Avg. income squared	0.0006 (0.0005)	-	0.0001 (0.0000)*	-
Avg. married	0.4336 (0.1647)**	0.5638 (0.1719)***	0.0461 (0.0134)**	0.0430 (0.0127)***
Avg. unem. Rate	-	-0.0307 (0.0210)	-	0.0003 (0.0027)
Avg. grades 9-11	-0.0028 (0.8971)	0.1136 (0.9157)	0.1787 (0.1378)	0.1706 (0.1366)
Avg. high school grad.	0.4335 (0.8988)	0.7852 (0.9016)	0.1246 (0.1329)	0.1212 (0.1310)
Avg. some college	0.3697 (0.8771)	0.7603 (0.8911)	0.1112 (0.1325)	0.1169 (0.1318)
Avg. college grad.	-0.2117 (0.9325)	0.2924 (0.9379)	0.0504 (0.1338)	0.0601 (0.1340)
R-squared	0.8660	0.8677	0.6743	0.6782
Observations	84,628	83,110	84,628	83,110

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Standard errors in parentheses. All standard errors are heteroskedasticity-robust and clustered by state. Observations in each regression are weighted using the NLSY sampling weights. All regressions include a set of variables that reflect the percentage of time spent living in each state, as well as the CGS or GF methods of controlling for the effects of time, gender, and age. The time, gender, and age effects are also differenced. All regressions also include linear state time trends.

Table 9 – Long-run marginal effects of real cigarette prices/taxes

	CGS BMI	GF BMI	CGS P(Obese)	GF P(Obese)
Avg. price/tax	-0.4397 (0.4915)	-1.6613 (0.8298)*	-0.0773 (0.0736)	-0.1406 (0.1028)

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Standard errors in parentheses. Marginal effects are calculated at the weighted sample means for current and past average price and current and past average tax.

Table 10 – Regression output for long differences averages models

	CGS BMI	GF BMI	CGS P(Obese)	GF P(Obese)
Avg. cigarette price/tax	-0.3863	-0.5096	-0.0646	-0.0473
	(0.5886)	(2.7493)	(0.0568)	(0.2599)
R-squared	0.0924	0.1109	0.0419	0.0492
Observations	8,416	8,416	8,416	8,416

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Standard errors in parentheses. All standard errors are heteroskedasticity-robust and clustered by state. Observations in each regression are weighted using the average of the NLSY sampling weights from the two periods used to create the differences. All regressions include a set of variables that reflect the difference in the percentage of time spent living in each state, as well as the CGS or GF methods of controlling for the effects of time, gender, and age. All regressions also include linear state time trends.

Table 11 – Separate effects for potential smokers; Regression output for first differences models

	CGS BMI	GF BMI	CGS P(Obese)	GF P(Obese)
Real cigarette price	0.1695 (0.0753)**	0.1087 (0.1838)	0.0170 (0.0075)**	0.0255 (0.0233)
Price*smoked 100 cigarettes	0.1255 (0.0816)	0.1099 (0.2740)	0.0005 (0.0098)	-0.0179 (0.0210)
R-squared	0.0066	0.0127	0.0023	0.0065
Observations	58,430	57,384	58,430	57,384

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Standard errors in parentheses. All standard errors are heteroskedasticity-robust and clustered by state. Observations in each regression are weighted using the average of the current and previous period's NLSY sampling weights. All regressions include a set of variables that reflect the difference in the state dummies, as well as the CGS or GF methods of controlling for the effects of time, gender, and age. All regressions also include linear state time trends.

Table 12 – Short-run marginal effects of real cigarette prices (assuming no effect on people who have not smoked 100 cigarettes)

	CGS BMI	GF BMI	CGS P(Obese)	GF P(Obese)
Price/tax	0.0642 (0.0385)	0.0562 (0.0430)	0.0003 (0.0050)	-0.0092 (0.0107)

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Standard errors in parentheses.

Table 13 – Separate effects for potential smokers; Regression output for fixed effects averages models

	CGS BMI	GF BMI	CGS P(Obese)	GF P(Obese)
Avg. real cigarette price/tax	3.5744 (1.9988)*	-1.3317 (1.0687)	0.1648 (0.2598)	-0.0966 (0.1217)
Avg. price/tax squared	-1.6957 (0.7857)**	-	-0.0822 (0.1002)	-
Avg. price/tax*smoked 100 cigarettes	-5.7399 (1.8941)***	-0.7094 (1.1575)	-0.5807 (0.1708)***	-0.0569 (0.1088)
Avg. price/tax*smoked 100 cigarettes squared	2.2735 (0.8534)**	-	0.2299 (0.0756)***	-
R-squared	0.8648	0.8664	0.6721	0.6758
Observations	78,176	76,885	78,176	76,885

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Standard errors in parentheses. All standard errors are heteroskedasticity-robust and clustered by state. Observations in each regression are weighted using the NLSY sampling weights. All regressions include a set of variables that reflect the percentage of time spent living in each state, as well as the CGS or GF methods of controlling for the effects of time, gender, and age. The time, gender, and age effects are also differenced. All regressions also include linear state time trends.

Table 14 – Long-run marginal effects of real cigarette prices/taxes (assuming no effect on people who have not smoked 100 cigarettes)

	CGS BMI	GF BMI	CGS P(Obese)	GF P(Obese)
Avg. price/tax	-0.5354 (0.1488)***	-0.3629 (0.5922)	-0.0542 (0.0140)***	-0.0291 (0.0623)

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Standard errors in parentheses. Marginal effects are calculated at the weighted sample means for current and past average price and current and past average tax.

Table 15 – Separate effects for potential smokers; Regression output for long differences averages models

	CGS BMI	GF BMI	CGS P(Obese)	GF P(Obese)
Avg. cigarette price/tax	0.1492 (0.5976)	0.0300 (2.7511)	-0.0145 (0.0580)	-0.0088 (0.2516)
Price/tax*smoked 100 cigarettes	-0.9695 (0.2391)***	-1.1104 (1.7500)***	-0.0907 (0.0278)***	-0.0792 (0.2028)
R-squared	0.0953	0.1110	0.0441	0.0492
Observations	8,416	8,416	8,416	8,416

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Standard errors in parentheses. All standard errors are heteroskedasticity-robust and clustered by state. Observations in each regression are weighted using the average of the NLSY sampling weights from the two periods used to create the differences. All regressions include a set of variables that reflect the difference in the percentage of time spent living in each state, as well as the CGS or GF methods of controlling for the effects of time, gender, and age. All regressions also include linear state time trends.

Table 16 – Long-run marginal effects of real cigarette prices/taxes (assuming no effect on people who have not smoked 100 cigarettes)

	CGS BMI	GF BMI	CGS P(Obese)	GF P(Obese)
Price/tax	-0.4960 (0.1223)***	-0.5681 (0.8953)	-0.0464 (0.0142)***	-0.0405 (0.1038)

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Standard errors in parentheses. *,**,*** indicate statistical significance at the 1%, 5%, and 10% levels respectively.

Table 17 – Output for regression with lags of cigarette price

	BMI
Real cigarette price: current	0.2588 (0.0784)***
Real cigarette price: 1-2 years ago	-0.2586 (0.1023)**
Real cigarette price: 3-4 years ago	-0.0743 (0.1176)
Real cigarette price: 5-6 years ago	-0.4255 (0.2317)*
Real cigarette price: 7-8 years ago	-0.0238 (0.2440)
Real cigarette price: 9-10 years ago	-0.0708 (0.2277)
Total effect: 1-10 years ago	**-0.8530** **(0.3392)****
Total effect: All periods	**-0.5942** **(0.3420)***
R-squared	0.8945
Observations	48,981

Notes: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Standard errors in parentheses. All standard errors are heteroskedasticity-robust and clustered by state. Observations in each regression are weighted using the average of the NLSY sampling weights from the two periods used to create the differences. All regressions include a set of variables that reflect the difference in the percentage of time spent living in each state, as well as the CGS methods of controlling for the effects of time, gender, and age. All regressions also include linear state time trends.

Table 18 – Short-run marginal effects of real cigarette prices/taxes on BMI and P(Obese)

	BMI	P(Obese)
First differences; CGS	0.2321***	0.0172***
First differences; GF	0.1638	0.0165
Two-stage; CGS	0.0381***	0.0026***
Two-stage; GF	0.0386***	0.0027***
First differences with interaction term; CGS	0.0642	0.0003
First differences with interaction term; GF	0.0562	-0.0092

Table 19 – Long-run marginal effects of real cigarette prices/taxes on BMI and P(Obese)

	BMI	P(Obese)
Fixed effects; CGS	-0.4397	-0.0773
Fixed effects; GF	-1.6613*	-0.1406
Long differences; CGS	-0.3863	-0.0646
Long differences; GF	-0.5096	-0.0473
Fixed effects with interaction term; CGS	-0.5354***	-0.0542***
Fixed effects with interaction term; GF	-0.3629	-0.0291
Long differences with interaction term; CGS	-0.4960***	-0.0464**
Long differences with interaction term; GF	-0.5681	-0.0405

Notes for Tables 18 and 19: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level.

Table 20 – Short-run percentage change in obesity if cigarette prices by $1 (in 2004 dollars)

	% change in obesity
Two-step	0.43%
First differences with interaction term	0.05%

Table 21 – Short-run annual change in deaths and medical expenditures due to decreased obesity if cigarette prices/taxes rise by $1 (in 2004 dollars)

	Deaths	Billions of $
Two-step	482	0.53
First differences with interaction term	56	0.06

Table 22 – Long-run percentage change in obesity if cigarette prices rise by $1 (in 2004 dollars)

	% change in obesity
Fixed effects with interaction term	-8.92%
Long differences with interaction term	-7.64%

Table 23 – Long-run annual change in deaths and medical expenditures due to decreased obesity if cigarette prices rise by $1 (in 2004 dollars)

	Deaths	Billions of $
Fixed effects with interaction term	-9,990	-10.44
Long differences with interaction term	-8,557	-8.94

Table 24 – Effect of a $1 increase in cigarette taxes on number of alcoholic drinks per week

	Fixed Effects	Fixed Effects with Interaction Term
Cigarette Tax	-1.7678 (0.7111)**	-0.6698 (0.7578)
Cigarette Tax*Potential Smoker	-	-2.0948 (1.0489)**
R-squared	0.6408	0.6377
Obesrvations	23,564	20,978

Table 25 – Effect of a $1 increase in cigarette taxes on light exercise, strenuous exercise, and reading of nutritional information

Category	Light Exercise	Strenuous Exercise	Nutritional Information
0 (Lowest)	-0.0343 (0.0003)***	-0.1157 (0.0262)***	-0.0330 (0.0146)**
1	-0.0280 (0.0012)***	-0.0178 (0.0041)***	-0.0069 (0.0031)**
2	-0.0321 (0.0021)***	0.0034 (0.0010)***	-0.0035 (0.0016)**
3	-0.0343 (0.0047)***	0.0367 (0.0084)***	0.0077 (0.0034)**
4 (Highest)	0.1287 (0.0081)***	0.0934 (0.0211)***	0.0358 (0.0159)**
R-squared	0.0193	0.0349	0.0336
Observations	11,312	11,312	12,751

Notes for Tables 24 and 25: *** indicates statistically significant at the 1% level; ** 5% level; * 10% level. Standard errors in parentheses. All standard errors are heteroskedasticity-robust. Observations in each regression are weighted using the NLSY sampling weights. All regressions include the control variables used in other regressions and the GF methods of controlling for the effects of time, gender, and age.