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Journal of Health Economics 25 (2006) 389–393
JOURNAL OF HEALTH ECONOMICS
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Reply

Reply to Jonathan Gruber and Michael Frakes

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Available online 25 January 2006

Abstract

We address Gruber and Frakes's criticisms that (1) the state excise tax on a package of cigarettes is a more exogenous measure of the cost of cigarettes than the state-specific price of a package of cigarettes and (2) that it is preferable to control for the effects of unmeasured variables that vary over time with the use of time dummies instead of with a quadratic time trend. We also point out that our specification of the cost effect differs from theirs because we allow it to be nonlinear while they force it to be linear.

JEL classification: I12; I18

Keywords: Obesity; Body mass index; Cigarette price

Gruber and Frakes (2006) (GF, this issue) criticize our finding (Chou et al., 2004) that increases in the cost of a package of cigarettes lead to increases in body mass index (BMI) and in the prevalence of obesity on two grounds. First, they argue that the state excise tax on a package of cigarettes is a more exogenous measure of the cost of cigarettes than the state-specific price of a package of cigarettes used in our study. Second, they argue that it is preferable to control for the effects of unmeasured variables that vary over time with the use of time dummies instead of with the quadratic time trend used in our study.[1] These two changes produce results that differ from ours in a dramatic fashion because GF report negative relationships between the cost of cigarettes

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[1] A third difference is that GF limit their sample to persons between the ages of 18 and 65, while we include all those ages 18 and over. In Chou et al. (2002), we show that our results do not change when we exclude persons over the age of 65.

0167-6296/$ – see front matter
doi:10.1016/j.jhealeco.2005.12.004

and the two weight outcomes. In our reply, we address their two criticisms. We also point out that our specification of the cost effect differs from theirs because we allow it to be nonlinear while they force it to be linear.

Gruber has argued that the state tax is a better measure of the cost of cigarettes than the state price in his studies of the demand for cigarettes (Gruber and Köszegi, 2001; Gruber and Zinman, 2001) as well as in his study with Frakes. His argument is that a shift to the right in the demand function may cause cigarette companies to raise price. Put differently, he rejects the hypothesis that the supply function of cigarettes is infinitely elastic in favor of the hypothesis that it is upward sloping. But a model in which the cigarette industry is competitive and has an upward sloping supply function is inconsistent with the well known finding that a 1-cent increase in the excise tax on cigarettes leads to a more than 1-cent increase in the price of cigarettes (for example, Sumner, 1981).[2]

There is, however, a simple model of imperfect competition with two basic features of the market for cigarettes: the tax shifting behavior just described and a market price elasticity of demand that is smaller than one in absolute value. Moreover, that model also is consistent with a scenario in which the disturbance term in the demand function for cigarettes is not correlated with the optimal price. Suppose that the cigarette industry can be characterized by the pure version of the Cournot model of oligopoly. In that version, a firm picks its optimal output under the assumption that other firms will continue to produce their current output levels. Hence, each firm will charge the same price, and Tirole (1988) and Scherer and Ross (1990) show that the price in the jth market (jth state in our case) is given by:

$$p_{\mathrm{j}} = \left[\frac{\varepsilon_{\mathrm{j}}}{(\varepsilon_{\mathrm{j}} - h_{\mathrm{j}})}\right] c_{\mathrm{j}}. \tag{1}$$

In this equation ε_{j} is the market price elasticity of demand in the jth state (defined to be positive), h_{j} is the Herfindahl index in that state (the sum of the squared share of each seller in total output), and c_{j} is an output-share weighted average of each firm's marginal cost of producing and selling cigarettes in equilibrium.

Suppose that the market price elasticity of demand has the same constant value in every state and that each firm's marginal and average cost of selling cigarettes do not depend on the output that it produces and sells. Hence, c_{j} in Eq. (1) is an output-share weighted average of each firm's average cost of producing and selling cigarettes. Clearly, c_{j} is not the same in every state. It varies because excise taxes, transportation costs, retailing costs, and market shares vary among states. But there is no reason to expect these variables to depend on the disturbance term in the demand function. Under these assumptions, a regression of cigarette consumption on the price yields a consistent estimate of the price parameter in the demand function. Moreover, the price is a better measure of the cost of cigarettes than the tax. This is because one discards exogenous variations in the price due to differences in transportation costs, retailing costs, and the Herfindahl index among states when one employs the tax rather than the price as a regressor.[3]

[2] If the cigarette industry is competitive and has a forward falling supply function, a 1-cent increase in the tax would cause the price to rise by more than 1-cent. This assumes that the stability condition is satisfied: namely, that the supply function is more elastic in absolute value than the demand function. There is little reason, however, to expect that the technological and pecuniary external economies required to generate a forward falling supply function are important in the cigarette industry.

[3] Clearly ε must exceed h_{j}, the analogue of the condition that a monopolist must operate in the elastic portion of his or her demand function. Given that this condition is satisfied and that h_{j} does not depend on the tax, a regression of the price on the tax has a coefficient of $\varepsilon/(\varepsilon - h_{\mathrm{j}}) > 1$.

As an aside, we note that GF give an example in which a demographic shift in a state (for example, more young people) leads to more smoking and less eating and also leads cigarette companies to raise prices. This produces a spurious negative relationship between the price and BMI or obesity. Yet we find a positive relationship, and their estimated relationship becomes more negative when they replace the price with the tax. This result and the Cournot model that we outlined suggest that the price may be a better regressor than the tax.

In empirical microeconomic research, the current conventional wisdom is to control as best as one can for correlations between measured and unmeasured determinants of the outcome at issue. GF's use of time dummies reflects this approach. It results in a negative relationship between the cost of cigarettes and weight outcomes. Clearly, this is a counterintuitive finding. GF summarize studies indicating that persons who never smoked weigh more than current smokers and that smokers who quit gain weight. While some of this weight gain is temporary, quitters' long-run weight approaches that of never smokers and not that of current smokers. In theory, non-smokers could weigh less than smokers if they engage in more exercise. While GF refer to some studies showing increased physical activity following quitting, it is likely that a rather long period of time would be required for this to offset the positive effects of cigarette smoking on metabolism and its negative effects on the demand for sweet foods and carbohydrates. GF's empirical specification does not allow for such a long-run effect, and they do not cite any studies that show that ex-smokers or never smokers weigh less than smokers.

GF's counterintuitive result raises the question: Have they gone too far in trying to control for unmeasured factors? Schneider et al. (1981) illustrate this issue in a time series analysis of trends in cigarette smoking in the U.S. with an emphasis on the role of the diffusion of knowledge about the harmful effects of smoking in these trends. They fit a cigarette demand function in which per capita consumption of cigarettes depends on real income, the real price of cigarettes, the percentage of tobacco consumed as cigarettes (to account for switch from other forms of tobacco consumption to cigarette consumption over time), the market shares of filter cigarettes and low-tar cigarettes, and the average amount of tobacco consumed in each cigarette. The last three variables account for the gradual diffusion of information concerning the harmful effects of smoking.

Schneider, Klein, and Murphy compare the specification just described to one that includes trend terms and dichotomous indicators for specific health information events such as the publication of the first U.S. Surgeon General's Report on Smoking and Health in 1964. They show that the latter model is badly misspecified. Its coefficients change dramatically when the sample period is extended, and it predicts unreasonably large declines in smoking due to the broadcast advertising ban enacted in 1971. Moreover, the cigarette price elasticity, which is highly significant in the specification without the trend terms, becomes insignificant in the one with these terms. Consequently, they emphasize the former model.

An important aim of our empirical analysis was to see how much of the trend in the prevalence of the percentage of the population that is obese and in BMI could be accounted for by a variety of state-specific variables including the price of cigarettes, the per capita number of fast-food and full-service restaurants, the price of a meal in each type of restaurant, and the price of food consumed at home. If pure trend terms were included in the regressions, this aim was difficult to achieve because of multicollinearity between the state-specific variables and time. This problem was exacerbated because the restaurant measure had to be interpolated and extrapolated for years not covered by the *Census of Retail Trade*. Therefore, we fitted three models for each of the two outcomes in our National Bureau of Economic Research Working Paper (Chou et al., 2002) that served as the basis of our paper in this journal. The first included only variables measured in the behavioral risk factor surveillance system (BRFSS), time, and the square of time. The second omitted the trend terms and included the state-specific variables, while the third included all regressors. We then used these models to "explain" trends in obesity and BMI between 1984 and 1999 (the beginning and ending years of the BRFSS at the time that we began our research).

Importantly, we also used these three models to explain the trend in obesity between 1960/1961 (the mid-year of first National Health Examination Survey) and 1978 (the mid-year of second National Health and Nutrition Examination Survey). We could not perform this backcasting exercise with time dummies. Moreover, an analysis of trends between 1984 and 1999 with time dummies forced the national mean of the dependent variable to lie on the regression line in each year. Thus it "stacked the deck" in favor of the pure trend model relative to the model with state-specific variables. To be consistent with our treatment of trend effects, we employed a quadratic specification for each continuous variable. In preliminary regressions we found evidence that most of these variables had nonlinear effects.

In our 2002 paper, we reported that the specification without the trend terms did a much better job of explaining the behavior of obesity between 1960/1961 and 1978 than the specifications with these variables. In that period, BMI and obesity were very stable. The specifications with time and time squared predicted much larger increases in these outcomes than the modest ones that actually occurred. The model that replaced the trend variables with state-specific variables was much more successful. It predicted very small reductions in the outcomes compared to the very small increases that actually took place. For that reason, we did not include the models with trend variables in our paper in this journal (Chou et al., 2004).

GF fail to realize the last point and also fail to realize that we employed both the cigarette price and its square in our regressions. Therefore, the comparisons of their results to ours in Table 3 of their paper are unclear.

We conclude by addressing GF's contention that the magnitudes of both their estimated effects and our estimated effects are unreasonably large. They find that each \$1 rise in cigarette taxes in 1982–1984 dollars lowers the percentage of the population who are obese by 1.5% points. The standard deviation of the cigarette tax is, however, \$0.28. Hence, a \$1 increase in the tax amounts to an enormous change of almost four standard deviations. Effects based on such large changes need to be interpreted very cautiously. A similar comment applies to their instrumental variables estimate of the effect of smoking on obesity. Moreover, since we employ both the cigarette price and its square as regressors, both variables would have to be used to predict smoking in an IV estimate of the effect of the latter variable on obesity. Put differently, our implicit equation relating weight to smoking is overidentified and not exactly identified.

Are the magnitudes of our estimated effects reasonable? At the mean cigarette price, a 10% increase in price is associated with a 0.4% point increase in the percentage obese in the specification without time and time squared. When these variables are included, this increase falls to 0.2% points. These estimates are based on a small change in price of approximately half a standard deviation.

We consider a much larger cigarette price rise of approximately 75% when we explain the trend in obesity between 1984 and 1999. During that period, the percentage of the population obese more than doubled. The rise in the real price of cigarettes accounts for approximately 25% of this growth in the model without trend variables and for approximately 7% in the model with these variables. GF's cigarette tax effects account for none of this increase; indeed their estimates imply that the prevalence of obesity should have fallen, with other determinants held constant.

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