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Greg Colman
Dahlia K. Remler

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Vertical Equity Consequences of Very High Cigarette Tax Increases: If the Poor are the Ones Smoking, How Could Cigarette Tax Increases be Progressive?

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ABSTRACT

Traditionally, cigarette excise taxes have been seen as regressive, due to both the higher prevalence of smoking among lower income groups and the regressivity of any sales or excise tax. One challenge to this view says that "cigarette tax increases may not be regressive," because poorer individuals are more elastic, and therefore may cut back sufficiently to make the share of income spent on cigarette taxes by the rich increase by more than that spent by the poor.

We test this challenge empirically. First, we estimate how the sensitivity of cigarette consumption to price varies with income, using a two-part model and pooled cross-sections from the CPS, merging the tobacco use supplements with the February/March CPS from 1993-2002. Then, we predict the regressivity of large cigarette tax increases using the traditional tax expenditure-based definition of progressivity and traditional welfare measures. We focus on the progressivity of changes in these measures.

We find that the price elasticity of smoking participation is -.14 for the lowest income tercile, -.05 for the middle income, and -.21 for the high income. We find that the price sensitivity of conditional consumption, cigarettes smoked by smokers, shows no robust pattern with income and is frequently insignificant. Thus, our results challenge the conventional view that price sensitivity falls monotonically with income. Our predictions of the equity consequences of tax increases show that using all traditional measures of progressivity, whether based on tax expenditures or welfare, cigarette tax increases are not close to progressive.

Greg Colman
Department of Economics
Pace University
One Pace Plaza
New York, NY 10038
gcolman@pace.edu

Dahlia K. Remler
School of Public Affairs
Baruch College, CUNY
One Bernard Baruch Way, Box D-0901
and NBER
dahlia_remler@baruch.cuny.edu

I. Introduction

Traditionally, cigarette excise taxes have been considered regressive (CBO 1990; Fullerton and Rogers 1993; Lyon and Schwab 1995; Evans, Ringel and Stech 1999; CBO 2001), even more than most excise taxes, because smoking is more prevalent among lower income individuals (e.g., Evans, Ringel and Stech 1999). However, this regressivity has not been considered policy-relevant, because it is the overall progressivity of the tax system that is relevant and cigarette taxes have been a small share of total tax revenue (CBO 2001). Recent dramatic increases in cigarette taxes and proposals for further dramatic increases make their regressivity a more pressing policy issue. For example, following the recent introduction of $1.50/pack tax in New York City, combined city, state and federal taxes are over $1200/year for a pack-a-day smoker, a significant sum to a low-income person.

Moreover, the regressivity of cigarette taxes is now being challenged. In the Handbook of Health Economics chapter on tobacco, Chaloupka and Warner (2000) state that

> "Recent research on differences in the price elasticity of demand for cigarettes by various measures of socioeconomic status has produced findings that suggest that the degree of regressivity normally attributed to cigarette taxation is considerably overstated. Townsend and colleagues (1994) found that (the absolute value of) price elasticity was inversely related to social class in Great Britain… In the U.S., Chaloupka (1991) concluded that less-educated persons were more price-responsive than the more-educated, while Farrelly and his colleagues (1998) found that cigarette demand by lower income persons was more elastic that that by higher income persons… This mitigates conclusions about regressivity that derive from analyses that have failed to consider the inverse relationship between elasticity and income. The latter has characterized all studies to date."

In an article entitled "The Economics of Tobacco: Myths and Realities", Warner (2000) states that "[a tobacco] tax *increase,* however, may *not* be regressive" (italics in original).

The position that high cigarette taxes are not regressive, or at least not as regressive as commonly thought, has been picked up by some advocates of very high cigarette taxes (e.g., California Lung Association 2002, Economic Opportunity Institute 2001, American Lung Association of Texas 2003, Campaign for Tobacco Free Kids 2004). The rhetoric used by the supporters of very high cigarette taxes makes it clear that the taxes are intended to do far more

than simply correct for externalities of second-hand smoke: they are designed to get people to stop smoking for the sake of their own health. (For example, see remarks by New York City Mayor Bloomberg, quoted in Cooper 2002.) While there are many good arguments for very high cigarette taxes, the equity implications should be honestly considered, both in evaluating the merits of such taxes and in finding ways to mitigate their inequity side-effects if implemented. Calculations of the consequences and a thorough understanding of the assumptions underlying those calculations are essential to a good policy evaluation of very high cigarette taxes.

Four papers provide some evidence that the smoking behavior of low income individuals is more price sensitive than that of those with higher incomes: Farrelly and Bray (1998); Evans, Ringel and Stech (1999); Hersch (2000); Gruber and Koszegi (2004). All have significant drawbacks, including poor income data, as acknowledged by the authors. Such results lend support to the argument that cigarette taxes are not as regressive as commonly thought. However, to our knowledge, and according to Chaloupka and Warner (2000), no one has performed calculations of vertical equity that incorporate differential price sensitivity by income into traditional calculations of cigarette tax progressivity.[1] Moreover, no one has looked at the horizontal equity implications of very high cigarette taxes. The purpose of this paper is to perform empirical calculations of the vertical equity implications of very high cigarette taxes that do incorporate differential price-sensitivities by income group.

We have several results. First, our estimation of smoking participation behavior finds that price sensitivity is lower in the middle income group than the high income group, as expected, but is *higher* for the high income group than the middle income group. Strikingly, this result is robust

[1] Gruber and Koszegi (2002) perform calculations of cigarette tax regressivity that incorporate different price sensitivities by income groups, but their focus is on how incorporating the time-inconsistent, hyperbolic discounting models of behavioral economics can result in the progressivity of cigarette taxes and they do not look at the effect of cigarette tax increases on traditional progressivity measures. Their calculations of differences in price sensitivity by income group are provided as parameter inputs and are not a main focus of their paper. Gruber (2003-3) and Viscusi (2002-3) debate the applicability of behavioral economic models to cigarette taxation. Remler (2004) compares behavioral and more traditional measures of equity for cigarette taxes. In this paper, we will only use traditional economic models for measures of equity.

to a wide variety of identification strategies. Second, we find that the price sensitivity of conditional consumption, cigarettes smoked by smokers, shows no robust pattern with income. Results are frequently insignificant and when significant often show price sensitivity rising with income. Thus, our results at least challenge the existing conventional wisdom of that price sensitivity falls with income. Third, even the difference between the low and middle income groups is smaller than that found in earlier studies. Fourth, overall our estimated price elasticities have smaller magnitudes than those in the earlier literature. Since we are using a later period, 1993-2002, for estimation, it is possible that we are left with hard core smokers who are less price sensitive than smokers in earlier eras. Fifth, all traditional measures of progressivity, whether tax expenditure or welfare-based, show that even cigarette tax *increases* are not progressive. Sixth, even if price sensitivity varied to the extent found by the prior studies, tax increases would not be close to progressive.

The remainder of the paper is organized as follows: Section II looks at the theory of how to measure the tax burden of cigarette tax increases and develops several alternative measures used in the empirical section. Section III discusses the empirical methods used. Section IV gives the empirical results. Section V concludes.

II. Theory: Alternative Measures of Tax Burden for Cigarette Taxes

Public finance textbooks generally define a tax to be regressive if taxes paid as a share of income rises with income and to be progressive if the share falls (Stiglitz 2000, Rosen 2001) and this definition is commonly used in most progressivity calculations used for public policy purposes, such as Congressional Budget Office (CBO) calculations and those performed by major policy think-tanks (Pechman 1974; Pechman 1985). Unlike welfare-based measures, such a progressivity measure does not incorporate the adverse utility consequences to individuals who chose to lower consumption when faced with higher prices. To contrast this definition with more

welfare-based ones, I will refer to this as the "traditional" definition of progressivity. (See Remler 2004 for a discussion of these issues and a documentation of the history of standard practice.)

In this section, we develop various measures of tax burden that will be used to empirically measure tax progressivity. First, we develop measures for welfare using the traditional definition of tax progressivity, consumer surplus-based measures and compensating variation-based measures. Second, these measures are applied to individuals, requiring an extension for applicability to the two-part models of cigarette consumption, in which both the extensive margin of smoking at all and the intensive margin of quantity of cigarettes conditional on smoking must be modeled separately. Third, we discuss how these measures are aggregated to produce overall progressivity measures.

We assume that the supply curve is completely elastic at a constant marginal production cost, *mc*, and that the market is perfectly competitive. Consequently, the burden of the cigarette excise tax falls entirely on consumers. It is not clear that this is completely true. There is some evidence that cigarette suppliers have some market power and that prices to consumers may rise by more than 100% (Keeler *et al* 1996). However, since our interest lies in the relative burden among consumers, we will maintain this simplifying assumption. Thus, we which assume that the change in the price faced by consumers is identical to the change in the specific tax:[2]

$$p_c = p_p + t = mc + t\,, \tag{1}$$

where p_c denotes the price paid by consumers, p_p denotes the price received by producers, and t denotes the tax, measured as a specific tax in \$/cigarette.

Consider first, as depicted in Figure 1, a good consumed by an individual in continuous amounts with the relevant portion of the demand curve far from zero consumption, so that we do not need to worry about consumption of zero cigarettes. The starting tax regime is denoted 1 and the finishing tax regime is denoted 2. When the tax rises, the individual cuts back on

[2] It is possible that smuggling and border crossing vary by income group, undermining our assumption that the tax is borne fully by consumers or at least that this does not vary by income group.

consumption, by an amount |Δx|, due to the higher price, resulting in lower tax expenditures by the amount in the lower rectangle. For those cigarettes that the consumer continues to consume, tax expenditures increase by the amount shown in the upper rectangle. From a tax expenditure vantage, the tax has both positive and negative effects for the consumer, due to the upper rectangle added and lower rectangle subtracted, respectively. (Recall that Δx is negative.)

$$\Delta Exp = \Delta t[x_1 + \Delta x] + t_1 \Delta x \qquad (2)$$

When Warner suggests that tax *increases* could be progressive, he is using a tax expenditure-based definition of progressivity, as well as incorporating the effect of lower price sensitivity among lower income individuals. For the effect that he describes to occur, the upper rectangle must be small and the lower rectangle must be large among the low income.

In contrast to some earlier literature, we find at most modest differences among income groups. Therefore, we will examine the magnitude of the equity implications of more dramatic differences in price sensitivity by income. We define a representative member of income group g's share of tax expenditure in income, $s_g = \frac{\mathrm{Re}\, v_g}{Inc_g} = \frac{t\pi_g c_g}{Inc_g}$. Assuming that the price to consumers rises exactly by the amount of the tax (a horizontal supply curve), an infinitesimal increase in the specific tax results in $\frac{ds_g}{dt/t} = s_g\left(1 + \tau\varepsilon_g\right)$, where $\tau = t/p$ is the *ad valorem* measure of the tax and ε_g is the price-elasticity of demand for an individual in group g. Comparing the rich and the poor, we find that a tax increase will be considered progressive if $s_r\left(1 + \tau\varepsilon_r\right) > s_p\left(1 + \tau\varepsilon_p\right)$, where s_r and s_p are the shares of taxes in income for the rich and poor, respectively, and ε_r and ε_p are the price elasticities of demand of the rich and poor, respectively. Denoting the ratio of the budget share of the rich to that of the poor as α we find that the progressivity test becomes

$\alpha\left(1 + \tau\varepsilon_r\right) > \left(1 + \tau\varepsilon_p\right)$.

The most dramatic results for price sensitivity varying by income group were found by Hersch, who finds that low-income men have a participation elasticity of -.58 and a consumption elasticity of -.60 for a total elasticity of –1.18, while high-income men have a participation elasticity of -.25 and a consumption elasticity of -.13, for a total elasticity of -.38.[3] In Hersch's data, smoking is roughly twice as prevalent in the low income group as the high income group and income is roughly six times as large in the high income group. Thus, we will approximate α as 1/12. From our own cigarette tax and price data, the mean *ad valorem* tax rate in 1993, the year of Hersch's study, is 29%. Applying these numbers to the test equation above find that the left hand side, $\alpha(1+\tau\varepsilon_r)$, is .07415 while the right hand side, $(1+\tau\varepsilon_p)$, is .6578. Thus, the test for progressivity fails by a wide-margin, even using Hersch's results.

The notion that cigarette tax increases could be progressive is based on a tax-expenditure vantage. From a welfare vantage, using consumer surplus as the measure of welfare, the consumer is not better off at all and is worse off for two reasons. First, the added expenditures of the upper rectangle representing additional taxes on those cigarettes still consumed make the consumer worse off. Second, the consumer is also worse off because he consumes fewer cigarettes due to the higher prices, resulting in net losses represented by the triangle. The difference between the well-being implications of the two approaches depends on how much the consumer adjusts consumption and thus on the elasticity of demand.

$$\Delta CS = \Delta t[x_1 + \Delta x] + \frac{1}{2}\Delta t \Delta x \qquad (3)$$

If demand were perfectly inelastic, the tax expenditure and consumer surplus measures would be identical and would just consist of the change in tax expenditures implied by no change in consumption.

[3] Note that for the population as a whole Hersch finds that men have a participation elasticity of -.54 and a consumption elasticity of -.43, resulting in a total elasticity of -.97, larger than the results in most of the literature of -.3 to -.5 (Chaloupka and Warner 2000).

The classic Ramsey analysis implies that it is optimal to tax inelastic goods the most heavily in order to avoid distortions in consumption choices (Ramsey 1927). However, the analysis assumes that lump-sum transfers are possible. Without such lump-sum redistribution, the equity consequences of taxing inelastic goods can be severe. Moreover, it is inconsistent to advocate high cigarette taxes in order to reduce cigarette consumption and improve health and simultaneously advocate high cigarette taxes in order to take advantage of the relative inelasticity of cigarette consumption and not "distort" consumption (e.g., Manning *et al* 1989; Grossman *et al* 1993). The former view requires a substantial behavioral response and does not "respect" consumer choice. In contrast, the latter view requires a small behavioral response and takes consumer preferences both as given and as the correct standard for evaluating welfare.

For a good such as cigarettes, which is addictive and has harmful health effects, many are reluctant to use consumer surplus or other measures of welfare that "respect" consumers' choices. However, addictive goods can still be consistent with traditional consumer analysis (Becker and Murphy 1988; Becker, Grossman and Murphy 1994) and economists have traditionally been reluctant to take a paternalistic approach towards consumption decisions that affect an individuals' health when there are no externalities involved (Manning *et al* 1989; Grossman *et al* 1993).

Recently, behavioral economics, based on the experimental psychology evidence that individuals' preferences are time-inconsistent, has provided a new challenge (Gruber and Koszegi 2001, 2004; Gruber 2002-3; Viscusi 2002-3). Specifically, this view argues that everyone is looking for a commitment mechanism and that because higher taxes work for the poor more than the rich, very high cigarette taxes could be progressive (Gruber and Koszegi 2004). While this approach may have a lot of validity, it represents a very substantial departure from the traditional use of the terms progressive and regressive. In this paper, we will not consider it further.

To empirically measure the effects of the increase in taxes, we will use linear approximations to the change in demand, assuming that the slope at the starting tax regime is constant.

$$\Delta x = \left.\frac{dx}{dp}\right|_1 \Delta t \,, \tag{4}$$

where the notation $|_1$ denotes the evaluation of the slope of the Marshallian demand curve in tax regime 1. Using a linear approximation to determine the effect of a sizable increase in the tax rate is problematic, because it requires prediction far out of sample. In empirical implementations, it is possible to use the full regression model estimated to actually integrate the demand curve through to the ending tax regime. While that is somewhat preferable, it is essentially just a different functional form assumption and is still based on far out-of-sample predictions (Remler, Graff Zivin and Glied 2004).

A more rigorous form of welfare analysis would use the compensating variation (CV), which measures how much more income the consumer needs at new prices to maintain the same utility (e.g., Deaton and Muellbauer 1980, chapter 7). Such a calculation is based on the compensated demand curve, which is unknown and cannot be estimated without postulating some functional form for the utility function. An alternative approach is to use the approximation, true for infinitesimally small price changes, that providing the consumer with enough money to consume the starting regime bundle is equivalent to providing enough money to consume a bundle supplying equal utility. For larger price changes, this approach over-estimates the welfare loss, since it neglects consumers' ability to substitute other goods. Specifically,

$$\Delta CV = \Delta t[x_1 + \Delta x_{comp}] + \frac{1}{2}\Delta t \Delta x_{comp} \tag{5}$$

$$\Delta x_{comp} = [\left.\frac{\partial x}{\partial p}\right|_1 + x_1 \left.\frac{\partial x}{\partial I}\right|_1]\Delta t \tag{6}$$

where Δx_{comp} is the change along the compensated demand curve, $\left.\frac{\partial x}{\partial p}\right|_1$ is the size of the substitution effect at the starting tax regime and $\left.\frac{\partial x}{\partial I}\right|_1$ is the size of the income effect.

These formulas are also inaccurate, as are the CS and expenditure based measures, because they use the starting tax regime slopes to measure the income and substitution effects and neglect changes in the demand curve likely to occur for large discrete changes.

The above equations apply to an individual who consumes at levels far from zero. For cigarettes, many individuals are non-smokers and much of the behavioral response to higher prices comes from smokers quitting altogether. Thus, the model needs to be reformulated for a "double hurdle model" in which we estimate both the probability of smoking and the quantity smoked conditional on any smoking (Jones 1989).

The first part of a two-part model is the probability of smoking at all. Interpreting such a probability for welfare measures raises some issues of interpretation. Since we will be applying these formulas empirically to data from a sample survey, we will make the following interpretation and extension: each individual, i, in the survey represents many individuals in the population, specifically the survey weight, w_i. Each of those individuals has identical observable characteristics, X_i. Of those individuals, a share π_i smoke. Among those smokers, each smokes c_i cigarettes per day.

In the actual survey data, an individual must be either a smoker or a non-smoker. Evaluating consumption changes by comparing such dichotomous smoking status states with the fractional probabilities predicted for a new tax regime would be inconsistent. Furthermore, it would lead to strange results for the equity calculations since the number of smokers predicted by the regression to be in a sub-group in the starting tax regime would not be the same as that actually in the sub-group in the actual survey results (Remler, Graff Zivin and Glied 2004). To

be consistent, we will use the predicted results at the starting tax regime when measuring any changes.

Using the two-part model, the change in expenditure for individuals of type, i, is

$$\Delta Exp_i = \Delta t[\pi_i^1 c_i^1 + \Delta(\pi_i c_i)] + t_1 \Delta(\pi_i c_i) \tag{7}$$

The expenditures are affected by both the intensive margin of how many cigarettes are smoked and the extensive margin of how many smokers that there are. After the tax has been raised, tax expenditures are higher because of the cigarettes smoked by those who continue to smoke. However, the tax expenditures are also lower due to both the lower number of smokers and the smaller number of cigarettes smoked by those who continue to smoke. In contrast, the CS-based measures include the welfare of losses of those who decide to quit due to higher prices and due to the price-induced reduced consumption:

$$\Delta CS_i = \Delta t[\pi_i^1 c_i^1 + \Delta(\pi_i c_i)] + \frac{1}{2}\Delta t \Delta(\pi_i c_i) \tag{8}$$

For a double hurdle model of consumption, the compensating variation equations are somewhat more complicated due to the extensive margin effects. Intuitively, the money needed to compensate someone who moves across the extensive margin from c_1 cigarettes to zero cigarettes depends on the conditional consumption c_1. Specifically (Small and Rosen 1981),

$$\Delta(\pi_i c_i)_{comp} = \left[\left.\frac{\partial \pi_i}{\partial p}\right|_1 + c_i^1 \left.\frac{\partial \pi_i}{\partial I}\right|_1\right]\Delta t + \left[\left.\frac{\partial c_i}{\partial p}\right|_1 + c_i^1 \left.\frac{\partial c_i}{\partial I}\right|_1\right]\Delta t \tag{9}$$

$$\Delta CV_i = \Delta t[\pi_i^1 c_i^1 + \Delta(\pi_i c_i)_{comp}] + \frac{1}{2}\Delta t \Delta(\pi_i c_i)_{comp} \tag{10}$$

As before, we are making use of linear approximations for both the substitution price effect and the income effect at the starting tax regime. The empirical magnitude of the difference between the compensating variation measure of welfare and the consumer surplus measure of welfare depends on the magnitude of the income effect.

For normal goods, whose consumption increases with income, the compensated demand curve is steeper than the Marshallian demand curve. Because empirical estimates find cigarettes to be an inferior good whose consumption rises, the compensated demand curve will be flatter than the Marshallian demand curve. The estimated income effects may not be relevant to how an individual adjusts to reduced purchasing power of higher prices. Consider a smoker who has not quit, despite higher taxes. Would such an individual respond to compensation money by deciding to quit or reduce consumption, as implied by the estimated income effect? Possibly, at least over the long-term, but it seems more likely that the inferior good status stems from some omitted variables bias. However, because it is the standard practice of empirical consumer theory and there are no other estimates available to use for income effects, we use our estimated income effects in our CV calculations.[4]

The tax increase is deemed progressive if the change in tax expenditure or welfare, relative to income, falls with income. In this analysis, we assume that the excise tax has no impact on income, an assumption reasonable for most individuals, whose income is not derived from the cigarette industry.

III. Empirical Methods: Estimation of Effect of Tax Increases

The overall empirical method consists of three parts. First, we estimate how tobacco price sensitivity of smoking behavior varies by income group. Second, we use those estimates to predict how the different income groups respond to a cigarette tax increase. Third, we determine the implications of those behavior changes for *changes* in the progressivity of the cigarette taxes.

A. Data and Sample Selection

[4] Calculating valid income effects would require some source of exogenous income variation among the same or similar individuals. Such variation is not found in any of the standard methods for estimating price sensitivity, including state fixed effects regressions.

Few sources of data combine accurate information on income with tobacco use data. To obtain such data we merge the Current Population Survey (CPS) Tobacco Use Supplements (TUS), with the CPS March Income Supplements, which contain particularly accurate income information.[5] Half of the households interviewed for the January and May TUS, as well as three-quarters of the February and one-quarter of the June TUS, will also be interviewed for the March Income Supplement.[6] Unfortunately no variable in the CPS uniquely identifies a person across months. We follow the method of Madrian and Lefgren (1999) and use the household id (HHID), LINENO, month-in-sample and number in household (HHNUM) variables for merging. We also drop observations for which the age (plus or minus one year), race, and sex do not match. Our final data consist of four pooled cross-sections, each cross-section consisting of a merge of the TUS and March income supplements.

We use two TUS questions on smoking. The TUS asks 'Does...now smoke cigarettes every day, some days, or not at all?' We use the answer to this question as our measure of smoking participation. The TUS also asks 'On the average, how many cigarettes does … now smoke a day?' We use the answer to this question as our measure of conditional consumption of cigarettes, or the number of cigarettes smoked among those who smoke at all.

We restrict our sample to those 18 years of age and older and do not consider youth smoking. We drop those who had proxies respond for them, since proxy respondent and self-respondent results may differ for smoking behavior. We drop those for whom household income

[5] The TUS also asks about family income, but reports the responses only in categories, from less than $5,000 up to $75,000. Rather than impute to each person the midpoint of the category indicated, which is the common procedure, we use the respondent's income as shown in the March Income Supplement, perhaps the most accurate income measure of any large public data set.

[6] Each month the Census Bureau surveys approximately 50,000 households. Each household is surveyed for four months, then left alone for eight months, and finally surveyed for an additional four months and then dropped from the sampling universe. The sampling is arranged so that each month an eighth of the sample is being interviewed for the first time, an eighth for the second time, etc. The TUS were conducted in September, January, and May of 1992/1993, 1995/1996, 1998/1999, and in November, February, and June of 2001/2002.

is less than a dollar a day. This is 0.4% of our sample. Many of them have negative incomes, presumably business losses.[7]

Data on cigarette taxes and prices come from The Tax Burden on Tobacco, produced by Orzechowski and Walker. Nominal values for taxes, prices and incomes were converted to real 1997 values using the Consumer Price Index, All Urban Consumers. In the estimation stage, prices are measured in real dollars per cigarette (not pack). Consumption is measured in cigarettes per day. For consistency in the structural consumption equations, incomes are also measured per day. Although the unit of analysis will be the individual, since smoking is an individual decision, we will use household income. As noted earlier, our income data are more accurate than that used in earlier analysis of cigarette consumption. We create an index of state restrictions on smoking following Chaloupka and Saffer (1992). We allocate individuals to income quantiles, generally terciles, using household income on a year by year basis.

B. Econometric Specification

Empirically, smoking tends to be bimodal: if someone smokes, he generally smokes at least a moderate number of cigarettes. Consequently, smoking is modeled using a two-part or double hurdle model (Jones 1989). We model the first stage as a linear probability model (ordinary least squares (OLS)) and the second stage as an OLS regression of cigarette consumption among those who smoke.

Our interest is in how price-sensitivity varies by income group. In order to incorporate the effects of different price elasticities at different income levels, we include an interaction between price and income and an interaction of price and income squared. Our most-preferred specification is

[7] Dropping these individuals makes no difference to the regression estimates. However, it does affect some empirical regressivity estimates, because a very few individuals dramatically distort mean tax expenditure as a share of income measures. Without dropping those individuals, such means (but not medians or group summations) are driven by relatively few individuals.

$$\pi_i = \beta_0 + \beta_p p_i + \beta_I I_i + \beta_{I2} I_i^2 + \beta_{pI} p_i I_i + \beta_{pI2} p_i I_i^2 + \beta_X' X_i + \beta_S' S_i + \beta_T T + \varepsilon_i , \qquad (11)$$

where p_i is the cigarette price, I_i is the household income, T is the year, $\mathbf{S}_i$ is a vector of state indicator variables, and $\mathbf{X}_i$ is a vector of controls: dummies for the education levels of high school, some college, college graduate and more than college (high-school dropout is the omitted category); age and age squared; Hispanic, non-Hispanic black and non-Hispanic other race (non-Hispanic white is the omitted category); female; and an index measure of legal restrictions on indoor smoking (Chaloupka and Saffer 1992).[8] Analogously, the preferred specification for second stage of conditional consumption is:

$$c_i = \gamma_0 + \gamma_p p_i + \gamma_I I_i + \gamma_{I2} I_i^2 + \gamma_{pI} p_i I_i + \gamma_{pI2} p_i I_i^2 + \gamma_X' X_i + \gamma_S' S_i + \gamma_T T + \nu_i . \qquad (12)$$

A specification with no state effects could be subject to omitted variables bias. For example, differences across states in attitudes towards smoking could simultaneously drive state differences in both cigarette tax rates and individual smoking behavior. With state effects but no time controls, identification is based on the correlation of within-state changes in smoking behavior and within-state changes in tax rates. However, given changing attitudes towards smoking, it is likely that other factors drive the variation over time in both tax rates and smoking behavior. Therefore, we would like to control for national trends in smoking behavior. We do this with a linear time trend. We also estimate a model with year-effects and state-effects but we do not have enough within-state time variation for identification of the conditional consumption equation. We do have sufficient variation to estimate the participation equation with both year-effects and state-effects, but we preferred to use the same specification in both stages.

[8] In order to assess sensitivity to functional form, we estimated both stages of the model using income quintile dummies and price-income dummy interactions and some earlier specifications. Specifically, four dummy variables were created with the middle quintile as the omitted category and four corresponding price-income dummy interactions were created. These variables replaced the income, income-square and price-income interactions. Econometric results were similar but with less statistical significance.

All regressions are performed with weights. We calculate robust standard errors, correcting for clustering at the state level, since taxes and prices only vary at the state-level and over time. We also estimated the model using a probit for the first stage and logging the conditional consumption variable in the second stage. The predicted usage results were essentially identical. We checked that our results do not change meaningfully when tax is used directly, rather than price.[9]

Prior studies that examined differences in price sensitivity by income group (Farrelly and Bray 1998; Evans, Ringel and Stech 1999; Hersch 2000; Gruber and Koszegi 2001) estimated separate models stratified by income group. For linear models such as ours, stratification is equivalent to pooling all the income groups and interacting every covariate with the income group indicators used for stratification. In order to compare our results with those prior studies and to explore the robustness of our results, we also estimated all our models stratified by household income terciles. Those models are identical to the ones noted earlier with two differences. First, the price-income interaction and price-income-squared interaction variables are not included. Second, there is no time trend, because we do not have sufficient remaining time variation to estimate the stratified models.

C. Price-Sensitivity by Income Group

Marginal effects and elasticities are conventionally reported by evaluating them at sample means. For our most-preferred and unstratified model, the participation and conditional consumption elasticities are, respectively,

$$\varepsilon^p = (\hat{\beta}_p + \hat{\beta}_{pI}\bar{I} + \hat{\beta}_{pI2}\bar{I}^2)\bar{p}/\bar{\pi} \tag{13}$$

$$\varepsilon^c = (\hat{\gamma}_p + \hat{\gamma}_{pI}\bar{I} + \hat{\gamma}_{pI2}\bar{I}^2)\bar{p}/\bar{c} \tag{14}$$

[9] In fact, these checks were performed with an earlier, slightly different specification.

where the bars indicate (weighted) sample averages. Note that for any given level of price sensitivity, as indicated by a marginal effect, a very low baseline participation rate will result in a particularly high elasticity. Thus, differences measures of price sensitivity could result in different group differences, particularly when baseline consumption differs markedly, as for smoking participation. We also calculate income elasticities with analogous formulas. We calculate the standard error of the marginal effect using stata's NLCOM and MFX commands, which use the delta method (Stata 2003).

For the preferred, unstratified model's total population elasticity calculations and for the elasticities by income tercile from the stratified models, we use the sample average formulas above. For the preferred, unstratified model's elasticities by income tercile, we first compute the participation and conditional consumption elasticities for each individual, using the regression coefficient and that individual's state's price, predicted smoking status and predicted conditional consumption: $\varepsilon_i^p = (\hat{\beta}_p + \hat{\beta}_{pI} I_i) p_i / \hat{\pi}_i$ and $\varepsilon_i^c = (\hat{\gamma}_p + \hat{\gamma}_{pI} I_i) p_i / \hat{c}_i$. We then present the median of the individual elasticities within each income tercile.

D. Predicted Effects of Tax Increase

In order to assess the consequences of much higher cigarette taxes, we simulate the effect of a dollar per pack (5 cents per cigarette) increase in the cigarette tax. This should be compared with the average cigarette tax in our data of 68 cents/pack and an average cigarette price of $2.61/pack. The baseline starting point of the increase is the entire sample and thus includes individuals in periods with quite low cigarette taxes, as well as individuals in the later tax periods.

The estimated coefficients of the preferred specification are used to predict new smoking behavior and those predictions used to calculate changes in tax-expenditure and welfare based burden measures. As discussed in section II, when predicting changes in participation and conditional consumption, the issue arises about whether to use the actual or predicted starting

values. By construction, the predicted participation probabilities and quantities and the actual participations and quantities, averaged over the entire population, will not differ in the starting regime. However, they will differ by income group and other covariates by which we will break up the sample to look at issues of equity. Since we have no choice but to use predicted consumption for the ending tax regime, consistency suggests using predicted values for both states. On the rare occasions when a prediction results in an out-of-bounds quantity, it is adjusted accordingly. Specifically, a predicted probability greater than one is set to one; a predicted probability less than zero is set to zero; and a predicted conditional consumption of less than zero is set to zero. We estimate changes in consumption through the use of linear approximations separately for both the probability of smoking and the conditional consumption equations.

E. Progressivity Calculations

The traditional assessment of whether or not a tax is progressive is based on how the tax shares in income vary by income group. Some analyses use welfare measures or welfare measures relative to income or wealth. As suggested by Warner (2000), we focus on the pattern of how tax share *changes* due to a tax increase vary with income. In evaluating equity, we use the individual as the unit of analysis, just as we used the individual as the unit of analysis in our estimation of smoking behavior. However, we use household income in allocating individuals to income terciles.

We first examine the increase in the total tax paid by each income group relative to the total income received by that income group. This should give a sense of the overall burden of the tax increase for that income group. Second, we calculate for each individual, the share of income that they pay in cigarette taxes and look at the median within each income tercile. Third, we calculate the mean of the individual share by income tercile, a measure sensitive to errors and to skewness in the income distribution.

All these measures mask a good deal of within income group variation in burden. Non-smokers pay nothing while the burden of smokers is much greater than that implied by the group-wide measures reported.

To compare a welfare-based perspective with the tax expenditure-based perspective, we calculate the mean change in consumer surplus and the mean change in compensating variation by income tercile, as given by equations (8)-(10). We report these measures, as well as their values relative to income, by income tercile. We also report, by income tercile, the various triangle and rectangle components of the consumer surplus change shown in Figure 1. This provides a sense of the quantitative importance of both the reduced spending due to quitting and the "welfare loss" from those who quit but would have preferred to smoke.

IV. Results

A. Descriptive Statistics

Table 1 contains descriptive statistics for the entire sample and stratified by income tercile. Smoking prevalence falls with income, as found in prior literature. However, other data sets, such as the national health interview survey (NHIS), find that prevalence varies more by income group, primarily due to higher reported smoking rates in lower income groups. Smoking prevalence declined from 1993 to 1999 and to a lesser extent from 1999 to 2002. Other literature has documented that the declines of the 1990s were much smaller than those of the 1980s, when smoking fell dramatically, particularly among higher income and more educated individuals (e.g., Evans et al 1999).

In contrast to prevalence, the quantity of cigarettes smoked among smokers does not vary much among income terciles. It is actually slightly higher in the middle income tercile than in the lowest income tercile and is less than a cigarette/day lower among the high income tercile.

Self-reports of cigarette usage and smoking behavior tend to be systematically lower than cigarette use measures based on sales. For example, CBO tabulations from the consumer

expenditure survey imply that 1991 tobacco expenditures were $27.4 billion while the national income and product accounts (NIPA) show them to be $49.6 billion (http://www.nber.org/ces_cbo/varlist.txt). Our own estimates imply that total cigarette expenditures in 1996 were $23 billion in $1997. In contrast, the 1997 benchmark input-output table gives the figure of $47.9 billion for personal consumption expenditures (PCE) on cigarettes in 1997. The comparison is not exact, since unlike the CPE, the CPS excludes non-household consumption, such as by prisoners and soldiers on active duty. Assuming the non-household consumption is a small proportion of the total, the comparison implies that all of our estimates of expenditures and welfare measures will be underestimates by approximately a factor of two. We cannot be sure how much of the under-reporting is in the prevalence and how much is in the conditional consumption. It is possible that the under-reporting of tobacco consumption varies systematically with income. If high-income individuals find smoking to be a more unacceptable behavior than low-income people and under-report to a greater extent, then cigarette taxes will be less regressive than our results imply.

Cigarette prices have risen over the time period we study, particularly from 1996 to 1999, driven by tax increases (Table 2). At any given point in time, there is substantial cross-sectional variation in cigarette prices, as shown by the standard deviation. However, as illustrated by the relatively constant coefficient of variation, variability did not rise until 2002. The extent and form of both cross-sectional and time-series price variation is critical to our estimation. There may simply be too little variation in price left to estimate the conditional demand equations when time effects or trends are included.

B. Econometric Estimation Results

The results for the first stage of participation are robust to many specifications. The results for the second stage of conditional consumption are highly sensitive to the specification

and frequently not statistically significant. Because the participation results are very robust and more important for equity, we will discuss them first.

The 1st column of Table 3a illustrates the participation results for our prime specification, providing estimates of the coefficients, marginal effects, and price-elasticities. The price coefficient is negative, as expected, and significant. The price-income interaction is positive and significant, suggesting that higher income individuals are less price-sensitive, as hypothesized. However, the price-income-squared term is negative, showing a dampening effect of income on price-sensitivity that eventually reverses direction. The estimates imply a price elasticity of participation of -.133. This compares with participation elasticities of -.24 and -.26 for adults cited by Chaloupka and Warner.

Participation declines monotonically with income.[10] The income elasticity of participation implied is -.30. Thus, cigarette consumption is an inferior good. We do not know if this is an omitted variable bias, with higher income people less likely to smoke due to differences by income group in social stigma or long-term orientation. Alternatively, it could be that smoking participation rates would really decline if individuals' income were exogenously increased. Although this may seem unlikely, it is possible that income really does help people quit smoking by providing the financial means for cigarette substitutes and aids to quitting.

The demographic coefficients are all statistically significant and have signs and magnitudes as expected. Blacks, Hispanics, smokers of other races, and women all smoke less than white men. Participation first rises and then falls with age, which may reflect older smokers quitting as well as dying. The clean air index is insignificant. Surprisingly, there is no time trend in participation, once all other covariates, partcularly price, are controlled for.

[10] In order to assess sensitivity to functional form in the income variable, we re-estimated some earlier specifications using income quintile dummy variables and interactions of price with the income dummy variables. We found that basic results did not vary meaningfully, although none of the price-income interactions were statistically significant.

Column 3 of Table 3a and columns 1 and 3 of Table 3b shows the estimates from the participation models with both state-effects and year-effects, state-effects only, and year-effects only, respectively. Despite the substantially different identification strategies, the results are remarkably robust. Column 1 of Table 4 shows the participation elasticities from the different specifications. They are all somewhat lower than the participation elasticities of around -.25 cited by Chaloupka and Warner. Our estimates are from a later period, 1993-2002, than that used in earlier literature. It is possible that many individuals have quit and we are left with the more resistant, or "hard core" smokers, who are less price sensitive.

In contrast to the very robust participation results, the conditional consumption results are not robust and frequently not statistically significant. Column 2 of Table 3a shows the estimates for the conditional consumption model with both state-effects and time trend. The price coefficient is positive, indicating that consumption rises with price, but is not statistically significant. For the model with state-effects and year-effects, the coefficient is still positive and not statistically significant but larger in magnitude (column 4 of Table 3a). The price coefficients for the models with state-effects only and year-effects only are negative but still not statistically significant (columns 2 and 4 of Table 3b).

The price-income interaction is also not significant in any of the conditional consumption specifications, consistent with conditional consumption's lack of variation with income in the descriptive statistics. Income and its square are not significant in our preferred conditional consumption model. As in the participation models, the demographics are as expected and robust to different specifications. The clean air index is not significant.

In contrast to the lack of secular time trend for the participation results, column 4 of Table 3a suggests a strong downward secular trend in the number of cigarettes smoked among smokers. Because of these strong trends, in our preferred specification we include state-effects

and a linear time trend.[11] In effect, we find that for participation, price matters but there is no secular time trend after controlling for price, while for conditional consumption, price does not seem to be significant, at least not in any robust way, while there is a striking downward secular time trend.

Columns 2 and 3 of Table 4 show the conditional consumption and total elasticities, respectively, predicted by the various specifications. The estimations with only state-effects or only year-effects provide the conditional consumption elasticities more in line with the literature, resulting in total participation elasticities of -.304, on the lower magnitude end of the -.3 to -.5 consensus for the total elasticity (Chaloupka and Warner).

Given the lack of statistical significance of the conditional consumption price and price-income interaction coefficients, their use in simulation predictions is problematic. We use the state-effects and time trend model for our simulations because we feel that it combines a valid identification strategy with at least plausible conditional consumption behavior.

C. Price Sensitivity by Income Group

Our interest in equity led us to an interest in how price-sensitivity varies by income group. Another way to examine this question is through the models estimated stratified by income group. Unfortunately, we do not have sufficient within-state time variation to estimate these models with any controls for national time trends. However, that may not be critical, since the time trend was not significant in the participation model and the conditional consumption results are not robust or very important for equity calculations.

The estimates of coefficients and elasticities for the stratified models are shown in Table 5. As expected, the price sensitivity of participation falls when moving from the lowest income

[11] There may simply be too little variation in price left to estimate the conditional consumption equations if time effects or trends are included. As an illustration, regressing price on just state dummies gives an R^2 of 0.18; adding year dummies raises the R^2 to 0.93.

group to the middle income group, but surprisingly it falls when moving from the middle income group to the highest. This pattern is mirrored in the participation elasticities.[12] The difference in price elasticities of participation between the lowest and middle income groups is significant at the .01 level, while the elasticities of the lowest and highest income groups are not significant (P=.16). The price sensitivity of conditional consumption *rises* with income in the stratified models, the opposite of what we hypothesize, and is statistically significant throughout.

The surprising non-monotonic result for the relationship between price sensitivity and income is mirrored in our preferred, unstratified results also. We calculate individual income elasticities and then take the median within each income tercile. The results are shown in table 6. Once again, the elasticity magnitude falls from the lowest to the middle income group but then rises when moving from the middle to the highest group. Thus, the smoking participation decisions of the high income are more price sensitive than those of the middle income and this result is robust. Once again, the conditional consumption elasticities actually rise with income throughout the income distribution, although given the lack of statistical significance of the conditional consumption price and price-income interaction coefficients, these results should be taken with a grain of salt.

So, contrary to the prior literature, which tends to find a negative relationship between price sensitivity and income throughout the income distribution, we find no clear relation. The most dramatic variation in price sensitivity by income group was found by Hersch, who found a total elasticity of -1.18 for the bottom income quartile, -.38 for the top income quartile and a total elasticity for the entire population of -.97. [13] Farrelly and Bray used pooled cross-sections from the NHIS from 1976-1993 (incomplete), included year-effects but no state-effects and performed

[12] If the pattern was observed simply in the elasticities and not in the price coefficients, it could be due to the effect of a low prevalence on elasticity. However, the U-shaped pattern is observed for the price coefficients also.

[13] Like us, Hersch (1999) used the CPS TUS. We were able to largely duplicate her results and found that the use of the single 1993 cross-section and the categorical self-reported income groups were the primary drivers of the difference with our results.

regressions stratified by income group. They found an elasticity for the total population of -.25, with -.29 for those in the bottom half of the income distribution and -.17 for those in the upper half. The difference with our results may be due to the different time periods and the essentially cross-sectional variation used for identification. Evans, Ringel and Stech use repeated cross-sections of the Behavioral Risk Factor Surveillance System (BRFSS) for 1985-1995.[14] They found a total elasticity of -.32 for the bottom half and -.17 for the top half. Their results are very similar to those of Farrelly and Bray and show a somewhat greater magnitude of differential price sensitivity by income group than do our own. Gruber and Koszegi used the consumer expenditure survey between 1980 and 1998 with both state-effects and year-effects but no income controls.[15] They found an elasticity of -1.1 for the bottom income quartile and -0.4 for the top income quartile. Both Gruber and Koszegi and Evans, Ringel and Stech use estimation strategies similar to our own and their findings probably differ due to their inclusion of the 1980s, when large changes in smoking behavior occurred, as well as the very different surveys and income measures.[16]

D. Effect of Tax Increase on Vertical Equity

Given the U-shaped pattern of the price-sensitivity by income group, it is not surprising that our $1/pack tax increase causes the largest declines in smoking in the lowest and highest income terciles, of 1.7 percentage points, compared to a decline of only 0.4 percentage points in the middle income tercile (first 3 rows of Table 7). We find essentially no change in the conditional consumption among any income group (rows 4 and 5)[17]. Since our conditional

[14] The income variable is missing for 20% of their sample and they perform a stratified estimation, breaking the sample into those with missing income, those in the bottom half of the income distribution and those in the top half of the income distribution.
[15] Gruber and Koszegi's estimation of price sensitivity by income group is not their main focus but primarily used for inputs to their behavioral economic welfare calculations. Estimation details are scant.
[16] The TUS started in 1993 and therefore, we cannot include earlier periods.
[17] These results differ from those in the descriptive statistics because these are calculated as predicted values among the entire sample, not actual consumption among actual smokers.

consumption price sensitivity estimates, although statistically insignificant, are essentially zero with a narrow confidence interval, the lack of change is not surprising.

Rows 6 and 7 of Table 7 illustrate the vertical equity of the cigarette taxes in the actual starting regime of real smokers in our sample years of 1993, 1996, 1999, 2001 and 2002. The total expenditure of the group relative to its total income is .26% in the lowest income tercile, .10% for the middle income and .03% for the high income. The medians, among smokers, of individual tax shares in income by income tercile are .91%, .38% and .18% for the low, middle and high income, respectively. Thus, the initial pattern is unambiguously regressive and even strongly so.

However, the magnitude of the tax burden is not strikingly large. How can this be squared with the apparently large consequences described in the introduction? First, the average tax during this period is not large, only 68 cents/pack. More importantly, each income tercile contains smokers and non-smokers. In all income terciles, the median cigarette tax share in income is zero because the majority of individuals are non-smokers. The biggest equity issue is therefore between smokers and non-smokers. Vertical equity issues arise primarily because smoking prevalence differs so much between income groups. A sense of the magnitude of the burden requires an examination of smokers (Remler 2004). Row 8 shows the mean tax expenditures among smokers by income tercile. While the numbers are still not that dramatic, a 6-fold increase in the cigarette tax, the reality in NYC relative to what is seen in the sample would result in a median of 5.4% tax share in income in the lowest income tercile smokers, a substantial burden.

In the actual data, individuals are either smokers or non-smokers. In the post-tax increase regime, each individual in the sample has only a predicted probability of smoking. There are no smokers and non-smokers in the sample. Rather, each individual in the sample represents a large number of individuals in the population, a share of whom equal to the predicted probability are

presumed to smoke. Thus, for the post-tax regime changes, we can only represent the overall burden and cannot disaggregate by smoking participation status.

The tax total tax burden relative to total income burden rises by .34, .15 and .04 percentage points in the low, middle and high income groups, respectively. Thus, we see that Warner's predictions that a *tax increase* might not be regressive are not borne out in our simulation. In fact, the tax increase is still strongly regressive, driven by the sharp differences in smoking prevalence by income group and the relatively small differences in elasticity by income group. So, the traditional view of cigarette tax increases as regressive is affirmed.

Strikingly, there is little difference between the results using the traditional tax-expenditure-based definition of tax progressivity and the welfare-based consumer surplus measure. This is due to the relatively inelastic demand for cigarettes, found both in our results and the literature as a whole. There is also essentially no difference whatsoever between the consumer surplus and compensating variation based measures.

We find little evidence of the effect anticipated by Chaoloupka and Warner due to our small estimated income-price interaction. To examine this further, we explicitly calculated, by income tercile, the components illustrated in Figure 1 that could in principle drive an increased equity effect of a tax increase. Specifically, the bottom rectangle represents the reduced tax payments from quitting and reduced consumption, while the top rectangle represents the increased tax payments on continued consumption and the triangle represents the welfare losses from reduced consumption. The results in Table 8 illustrate that the top rectangle, the change in tax expenditures for continuing smokers overwhelmingly dominates the other factors and drives the regressivity.

V. Conclusions

The notion that cigarette tax increases could be progressive was based on the idea that lower income groups are dramatically more price sensitive than higher income groups. We find a

more complex situation. Our estimation of smoking participation behavior finds that price sensitivity is lower in the middle income group than the high income group, as expected, but is *higher* for the high income group than the middle income group. Strikingly, this result is robust to a wide variety of identification strategies. We also find that the price sensitivity of conditional consumption, cigarettes smoked by smokers, shows no robust pattern with income. Results are frequently insignificant and when significant often show price sensitivity rising with income. Moreover, even the magnitude of the difference between the low-income group, with a total elasticity of -.31 and the middle income group with a total elasticity of -.22, is of smaller magnitude than the elasticity differences reported in prior studies. Thus, our results at least challenge the existing conventional wisdom of that price sensitivity falls substantially with income.

Overall, our estimated price elasticities have smaller magnitudes than those in the earlier literature. Since we are using a later period, 1993-2002, for estimation, it is possible that we are left with hard core smokers who are less price sensitive than smokers in earlier eras. Gallet and List (2003) have found that recent studies tend to find more inelastic cigarette price elasticity estimates. The later period of our data could also be responsible for the differences between our results and those of the prior studies that use similar estimation strategies (Evans, Ringel and Stech; and Gruber and Koszegi). In general, the phenomenon of elasticity variation along the demand curve is probably one that has not received sufficient attention and is likely to be particularly important when considering large cigarette tax increases.

However, whatever the pattern of price sensitivity we find it virtually impossible that tax increases could be anything but strongly regressive. Consumption taxes are generally regressive. Since the poor are much more likely to smoke, cigarette excise taxes hit them all the harder. The very dramatic differences in smoking prevalence by income group are the overwhelmingly dominant driver of the regressivity. No elasticity variation with income remotely like the patterns estimated could overwhelm the prevalence effect. The phenomenon of progressive of cigarette

tax increases would only be possible if taxes were raised by so much that present elasticity estimates were no longer valid, and poor people, pushing up against sharply binding budget constraints, were forced to cut back substantially more than our simulations predict. Such seriously out of sample calculations are even more speculative than the usual out of sample calculations we are forced to do.

Moving from the traditional tax-expenditure based definition of progressivity to a traditional (non behavioral economic) welfare-based definition, would only exacerbate the regressivity of cigarette tax increases. However, we found empirically that the magnitude of the difference between the tax expenditure based progressivity measure and the welfare-based progressivity measure is quite small. We also found that the empirical difference between the consumer surplus and using the compensating variation is essentially non-existent.

There are a variety of desirable features of very high cigarette taxes as a means to discourage smoking. Cigarette smoking has a variety of bad health effects and consumers may not fully internalize the effects on their health or the economic consequences of those health effects. Gruber and Koszegi's (2001, 2004) internalities approach may be valid, and perhaps paternalism is not such a bad thing. Nonetheless, advocates of very high cigarette taxes must face the fact that many smokers will not quit, making very high cigarette taxes quite regressive and quite burdensome to some among the poor.

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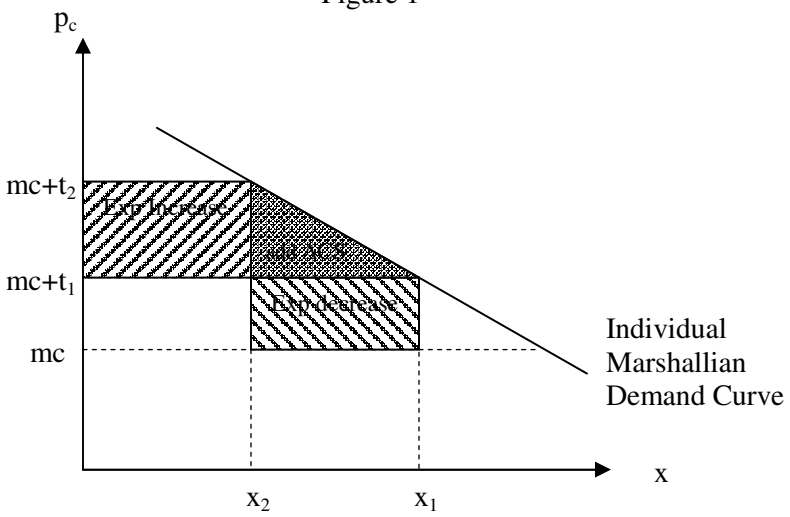
Figure 1


p_c
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t-tp decrease
Individual
Marshallian
Demand Curve
x
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Tables

Table 1: Descriptive Statistics (Standard Errors in Parentheses)				
	All Income Groups Pooled	Lowest Income Tercile	Middle Income Tercile	Highest Income Tercile
Household Income (1997$)	52,936 (124)	16,131 (31)	41,449 (35)	99,325 (253)
Smoking Prevalence 1993 (%)	24 (0.19)	27.5 (0.34)	24.9 (0.33)	19 (0.31)
Smoking Prevalence 1996 (%)	23 (0.21)	26.3 (0.38)	24.3 (0.36)	18.2 (0.34)
Smoking Prevalence 1999 (%)	21.3 (0.21)	24.6 (0.39)	23.3 (0.38)	16.7 (0.32)
Smoking Prevalence 2001 (%)	20.4 (0.45)	22.9 (0.82)	23 (0.83)	15.8 (0.68)
Smoking Prevalence 2002 (%)	20.2 (0.22)	23.8 (0.41)	22.9 (0.41)	14.9 (0.32)
Cigarettes/day Smoked Among Smokers	15.9 (0.06)	16 (0.1)	16.2 (0.1)	15.2 (0.12)
High School	32.6 (0.11)	36.1 (0.2)	37.5 (0.21)	24.6 (0.18)
Some college	27 (0.11)	21.9 (0.18)	29.4 (0.2)	29.6 (0.19)
College	16.2 (0.09)	7.3 (0.11)	14.4 (0.15)	26.6 (0.19)
College plus	6.9 (0.06)	2 (0.06)	4.8 (0.09)	13.6 (0.14)
Non-Hispanic Black	11.1 (0.08)	17 (0.17)	10.7 (0.15)	5.9 (0.11)
Non-Hispanic Other race	4 (0.05)	3.5 (0.08)	3.8 (0.09)	4.7 (0.1)
Hispanic	9.5 (0.08)	13.3 (0.16)	9.5 (0.14)	5.8 (0.11)
Female	53 (0.12)	59.5 (0.21)	51 (0.21)	48.8 (0.21)
Age (years)	45.2 (0.04)	49.7 (0.09)	43.2 (0.07)	42.7 (0.06)

Table 2: Cigarette Prices and Taxes					
Year	Mean Cigarette Price (1997 $/pack)	Standard Deviation Cigarette Price (1997 $/pack)	Coefficient of Variation of cigarette price	Mean Cigarette Tax (1997 $/pack)	Standard Deviation Cigarette Tax (1997$/pack)
1993	$1.91	$0.23	.12	$0.56	$0.13
1996	$1.94	$0.26	.13	$0.61	$0.19
1999	$2.89	$0.33	.11	$0.67	$0.35
2001	$3.18	$0.39	.12	$0.81	$0.42
2002	$3.44	$0.60	.17	$0.82	$0.42

Table 3a: Coefficients of Ordinary Least Squares Estimation of Two-part model (Standard Errors in Parentheses)				
	Probability of Any Smoking (state-effects and time trend model)	Quantity of Cigarettes conditional on any smoking (state-effects and time trend model)	Probability of Any Smoking (state- and year-effects model)	Quantity of Cigarettes conditional on any smoking (state- and year-effects model)
Price (dollars per cigarette)	-0.370**	0.631	-0.412**	13.467
	(0.094)	(5.099)	(0.118)	(7.922)
Daily Real Household Income	-7.319e-04**	4.408e-04	-7.341e-04**	8.034e-04
	(5.504e-05)	(6.940e-03)	(5.555e-05)	(7.024e-03)
Daily Real HH income squared	5.237e-07**	-5.468e-06	5.237e-07**	-5.694e-06
	(4.685e-08)	(1.012e-05)	(4.680e-08)	(1.025e-05)
Daily Real Household Income price interaction	1.236e-03*	-6.841e-02	1.250e-03*	-7.129e-02
	(4.712e-04)	(5.221e-02)	(4.749e-04)	(5.297e-02)
Daily Real Household Income squared price interaction	-8.892e-07*	9.059e-05	-8.899e-07*	9.219e-05
	(3.538e-07)	(7.372e-05)	(3.524e-07)	(7.482e-05)
high school graduate	-0.041**	-1.018**	-0.041**	-1.022**
	(0.009)	(0.151)	(0.009)	(0.151)
some college	-0.091**	-2.546**	-0.091**	-2.550**
	(0.010)	(0.225)	(0.010)	(0.225)
college graduate	-0.187**	-5.291**	-0.187**	-5.295**
	(0.012)	(0.283)	(0.012)	(0.284)
some graduate education	-0.207**	-6.088**	-0.207**	-6.090**
	(0.012)	(0.441)	(0.012)	(0.443)
Female	-0.049**	-2.952**	-0.049**	-2.948**
	(0.003)	(0.147)	(0.003)	(0.147)
Non-Hispanic Black	-0.062**	-7.036**	-0.062**	-7.034**
	(0.009)	(0.298)	(0.009)	(0.297)
Non-Hispanic Other Race	-0.051**	-4.099**	-0.051**	-4.106**
	(0.009)	(0.382)	(0.009)	(0.380)
Hispanic	-0.141**	-8.333**	-0.141**	-8.335**
	(0.007)	(0.710)	(0.007)	(0.713)
Age	1.227e-02**	7.516e-01**	1.227e-02**	7.512e-01**
	(7.654e-04)	(3.202e-02)	(7.646e-04)	(3.206e-02)
Age squared	-1.632e-04**	-7.290e-03**	-1.632e-04**	-7.286e-03**
	(8.949e-06)	(3.767e-04)	(8.936e-06)	(3.774e-04)
Clean Air Index	-0.003	0.213	-0.003	0.146
	(0.002)	(0.113)	(0.003)	(0.124)
Year 1993			-0.003	2.562**
			(0.009)	(0.411)
Year 1996			-0.003	2.351**
			(0.008)	(0.368)
Year 1999			0.002	1.054**
			(0.005)	(0.192)
Year 2001			0.001	0.685*
			(0.005)	(0.309)

Year	0.000	-0.184**		
	(0.001)	(0.031)		
Observations	231838	49888	231838	49888
R-squared	0.072	0.144	0.072	0.144
Marginal Effect	-0.226**	-5.332	-0.266**	7.194
Marginal Effect se	0.073	2.913	0.089	4.876
elasticity	-0.133**	-0.043	-0.156**	0.058
elas se	0.043	0.023	0.053	0.039
p-value	0.003	0.073	0.004	0.146
income marginal	-0.000452	-0.006762	-0.000453	-0.006770
income elasticity	-0.295923	-0.052410	-0.296100	-0.052475
Income p-value	0.000000	0.000000	0.000000	0.000000
Robust standard errors in parentheses * significant at 5%; ** significant at 1%				

Table 3b: Coefficients of Ordinary Least Squares Estimation of Two-part model (Standard Errors in Parentheses)				
	Probability of Any Smoking (state-effects model)	Quantity of Cigarettes conditional on any smoking (state-effects model)	Probability of Any Smoking (year-effects model)	Quantity of Cigarettes conditional on any smoking (year-effects model)
Price (dollars per cigarette)	-0.366**	-16.248**	-0.341**	-20.976
	(0.074)	(3.823)	(0.108)	(11.210)
Daily Real Household Income	-7.318e-04**	2.555e-05	-7.229e-04**	-6.539e-04
	(5.482e-05)	(6.844e-03)	(5.587e-05)	(6.870e-03)
Daily Real HH income squared	5.237e-07**	-5.757e-06	5.142e-07**	-5.642e-06
	(4.712e-08)	(9.965e-06)	(4.561e-08)	(9.816e-06)
Daily Real Household Income price interaction	1.235e-03*	-6.519e-02	1.180e-03*	-6.387e-02
	(4.720e-04)	(5.146e-02)	(4.746e-04)	(5.075e-02)
Daily Real Household Income squared price interaction	-8.896e-07*	9.199e-05	-8.309e-07*	9.327e-05
	(3.544e-07)	(7.255e-05)	(3.481e-07)	(7.067e-05)
high school graduate	-0.041**	-1.017**	-0.041**	-1.081**
	(0.009)	(0.152)	(0.009)	(0.151)
some college	-0.091**	-2.557**	-0.092**	-2.745**
	(0.010)	(0.225)	(0.010)	(0.223)
college graduate	-0.187**	-5.298**	-0.188**	-5.417**
	(0.012)	(0.283)	(0.012)	(0.301)
some graduate education	-0.207**	-6.095**	-0.207**	-6.135**
	(0.012)	(0.442)	(0.012)	(0.457)
Female	-0.049**	-2.946**	-0.048**	-2.931**
	(0.003)	(0.147)	(0.003)	(0.153)
Non-Hispanic Black	-0.062**	-7.042**	-0.063**	-6.958**
	(0.009)	(0.297)	(0.009)	(0.286)
Non-Hispanic Other Race	-0.051**	-4.119**	-0.054**	-4.652**
	(0.009)	(0.382)	(0.011)	(0.435)
Hispanic	-0.141**	-8.362**	-0.146**	-8.948**
	(0.007)	(0.704)	(0.008)	(0.755)
Age	1.227e-02**	7.518e-01**	1.232e-02**	7.618e-01**
	(7.650e-04)	(3.196e-02)	(7.605e-04)	(3.057e-02)
Age squared	-1.632e-04**	-7.294e-03**	-1.637e-04**	-7.402e-03**
	(8.939e-06)	(3.763e-04)	(8.839e-06)	(3.531e-04)
Clean Air Index	-0.003	0.021	-0.001	-0.223
	(0.003)	(0.130)	(0.003)	(0.159)
Year 1993			0.003	-0.125
			(0.007)	(0.816)
Year 1996			0.002	-0.123
			(0.007)	(0.838)
Year 1999			0.004	0.136
			(0.005)	(0.296)
Year 2001			0.001	0.280
			(0.005)	(0.369)
Observations	231838	49888	231838	49888
R-squared	0.072	0.143	0.071	0.135

Marginal Effect	-0.221**	-21.776**	-0.202*	-26.306*
Marginal Effect se	0.034	2.699	0.085	12.219
elasticity	-0.130**	-0.174**	-0.119*	-0.210*
elas se	0.020	0.022	0.050	0.098
p-value	0.000	0.000	0.022	0.036
income marginal	-0.000452**	-0.006795**	-0.000451**	-0.007238**
income elasticity	-0.295913	-0.052667	-0.295266	-0.056107
Income p-value	0.000000	0.000000	0.000000	0.000000
Robust standard errors in parentheses * significant at 5%; ** significant at 1%				

Table 4: Elasticities from Different Specifications (robust standard errors in parentheses)			
	Participation	Conditional consumption	Total elasticity
State-effects only	-0.130** (0.020)	-0.174** (0.022)	-0.304 (0.03)
Year-effects only	-0.119* (0.050)	-0.210* (0.098)	-0.329 (0.11)
State- and year-effects	-0.156** (0.053)	0.058 (0.039)	-0.098 (0.66)
State-effects and year trend	-0.133** (0.043)	-0.043 (0.023)	-0.176 (0.49)

Table 5: Ordinary Least Squares Estimation of Two-part model by Tercile (Standard Errors in Parentheses)						
	Participation			*Conditional Consumption*		
	Low Income	Middle Income	High Income	Low Income	Middle Income	High Income
Price (dollars per cigarette)	-0.307**	-0.092	-0.277**	-19.552**	-21.159**	-25.879**
	(0.058)	(0.048)	(0.043)	(2.455)	(3.534)	(6.097)
Daily Real Household Income	-2.057e-03**	5.943e-04	-1.875e-04**	5.311e-03	5.231e-02	-9.406e-03**
	(5.060e-04)	(8.791e-04)	(3.181e-05)	(2.451e-02)	(3.307e-02)	(3.059e-03)
Daily Real HH income squared	7.013e-06	-4.702e-06	1.154e-07**	-1.179e-04	-2.393e-04	8.139e-06*
	(5.646e-06)	(3.880e-06)	(2.730e-08)	(2.748e-04)	(1.475e-04)	(3.132e-06)
high school graduate	-3.459e-02**	-6.118e-02**	-2.668e-02*	-6.668e-01**	-1.241e+00**	-2.431e+00**
	(9.274e-03)	(9.404e-03)	(1.016e-02)	(2.220e-01)	(2.867e-01)	(4.293e-01)
some college	-0.071**	-0.114**	-0.083**	-2.228**	-2.712**	-3.962**
	(0.011)	(0.010)	(0.012)	(0.260)	(0.394)	(0.468)
college graduate	-0.168**	-0.212**	-0.171**	-4.147**	-5.705**	-6.797**
	(0.012)	(0.013)	(0.014)	(0.487)	(0.449)	(0.542)
some graduate education	-0.183**	-0.238**	-0.194**	-5.874**	-5.367**	-7.992**
	(0.013)	(0.014)	(0.014)	(1.047)	(0.722)	(0.755)
Female	-0.067**	-0.046**	-0.036**	-2.741**	-2.752**	-3.489**
	(0.004)	(0.005)	(0.003)	(0.220)	(0.167)	(0.262)
Non-Hispanic Black	-0.088**	-0.067**	-0.033**	-7.154**	-7.149**	-5.923**
	(0.009)	(0.014)	(0.011)	(0.310)	(0.401)	(0.611)
Non-Hispanic Other Race	-0.083**	-0.060**	-0.030**	-4.095**	-3.873**	-4.440**
	(0.018)	(0.011)	(0.006)	(0.558)	(0.643)	(0.552)
Hispanic	-0.190**	-0.145**	-0.071**	-8.771**	-8.267**	-7.175**
	(0.012)	(0.008)	(0.006)	(0.694)	(0.751)	(0.955)
Age	0.014**	0.013**	0.007**	0.759**	0.702**	0.741**
	(0.001)	(0.001)	(0.001)	(0.041)	(0.040)	(0.047)
Age squared	-0.000**	-0.000**	-0.000**	-0.008**	-0.007**	-0.007**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Clean Air Index	5.681e-03	-8.715e-03**	-8.741e-03**	1.651e-01	-1.755e-01	6.084e-02

	(4.080e-03)	(2.722e-03)	(2.432e-03)	(1.504e-01)	(3.078e-01)	(2.631e-01)
Observations	78184	77203	76451	19115	17910	12863
R-squared	0.098	0.061	0.045	0.151	0.142	0.145
Elasticity	-0.153162	-0.049362	-0.219781	-0.152651	-0.164557	-0.222772
elas se	0.028931	0.025994	0.034159	0.019163	0.027483	0.052486
Median elasticity	-0.14134	-0.04652	-0.21472	-0.16928	-0.17313	-0.24293
Robust standard errors in parentheses * significant at 5%; ** significant at 1% Note: Models estimated contain state effects but no time trend. Models were stratified by income group.						

Table 6: Median Individual Elasticities by Income Group (State Effects and Time Trend Model)			
	Lowest Income Tercile	Middle Income Tercile	Highest Income Tercile
Participation Price Elasticity	-0.14134	-0.04652	-0.21472
Conditional Consumption Price Elasticity	-0.16928	-0.17313	-0.24293
Total Price Elasticity	-0.31062	-0.21965	-0.45765

Table 7: Distributional Effects of a dollar/pack increase in the cigarette excise tax (State Effects and Time Trend Model)			
	Low Income	Middle Income	High Income
Simulated Smoking Behavior			
Starting Smoking Prevalence	24.8%	24.2%	17.2%
Ending Smoking Prevalence	23.1%	22.3%	15.5%
Change in smoking prevalence	-1.7%	-0.9%	-1.7%
Starting Cigarettes Smoked Among Smokers (Predicted)	14.6	14.8	13.9
Starting Cigarettes Smoked Among Smokers (Predicted)	14.6	14.9	13.9
Actual Data			
Total Tax Exp / Total Income	.26%	.10%	.03%
Median (Indiv Tax Exp/Indiv Income) Among Smokers	.91%	.38%	.18%
Mean Tax Expenditures Among Smokers	$179	$190	$185
Simulated Expected Tax Burdens			
Total Tax Exp / Total Income in starting tax regime	.26%	.10%	.03%
Median (Indiv Tax Exp/Indiv Income) Among Everyone In starting tax regime	.23%	.09%	.03%
Total Tax Exp / Total Income in ending tax regime	.64%	.25%	.07%
Median (Indiv Tax Exp/Indiv Income) Among Everyone In ending tax regime	.60%	.24%	.07%
Simulated Expected Changes in Tax Burden			
Median of the Expected Change in Indiv Tax Exp/Indiv Income	.35%	.13%	.04%
Median of Change in Tax Dollars Spent per year on cigarette taxes	$57	$60	$37
Mean of Change in Tax Dollars Spent per year on cigarette taxes	$64	$63	$44
Mean Change in Consumer Surplus ($/year)	$69	$68	$47
Mean Change in Compensating Variation ($/year)	$69	$68	$47

Table 8: Components of Accounting and Welfare Based Measures from a dollar/pack increase in the cigarette excise tax (State-Effects and Time Trend Model)			
	Lowest Income Tercile	Middle Income Tercile	Highest Income Tercile
Change in Mean Tax Exp	$64	$63	$44
Change in Mean CS	$69	$68	$47
Change in Mean CV	$69	$68	$47
Top Rectangle	$67	$66	$46
Bottom Rectangle	$3	$3	$2
Triangle	$2	$2	$1