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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

Cigarette smoking is concentrated among low income groups. Consequently, cigarette taxes are considered regressive. However, if poorer individuals are much more price sensitive than richer individuals, then tax increases would reduce smoking much more among the poor and their cigarette tax expenditures as a share of income would rise by much less than for the rich. Warner (2000) said this phenomenon would make cigarette tax increases progressive. We test this empirically. Among low-, middle-, and high-income, we estimate total price elasticities of -0.37, -0.35, and -0.20, respectively. We find that cigarette tax increases are not close to progressive using both tax expenditure-based and traditional welfare measures. This finding is robust to cross-border purchasing, generic cigarettes, and substantial external effects. However, we find that taxes can be progressive under some behavioral economic models (Gruber & Koszegi, 2004) but that these may only apply to a small share of smokers.

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INTRODUCTION

Raising cigarette taxes has become very popular among lawmakers and public health advocates. As the Campaign for Tobacco-Free Kids Web site notes approvingly, "Since the beginning of 2000, 43 states and the District of Columbia have passed over 78 separate state cigarette tax increases. Eight states already have cigarette tax rates of $2.00 per pack or more." More hikes are on the horizon; for example, when many in Congress wanted to maintain and extend government funding for health insurance for poorer children, they advocated higher federal cigarette taxes as a source of funds (Pear, 2007).

The lure of very high cigarette taxes is obvious. Smoking is bad for one's health and for that of others as well (U.S. Department of Health and Human Services, 2006). To the extent that high taxes get people to quit or cut back, their health has been improved. To the extent that people continue to smoke, the government has a dependable source of income for which they can't be criticized.

Very high cigarette taxes, however, have a dirty little secret: their regressivity. Overwhelmingly and increasingly, smokers are concentrated among the poor (for example, Evans, Ringel, & Stech, 1999; Farrelly & Bray, 1998). Moreover, our era of rising cigarette taxes is also an era of dramatically rising income inequality and possibly lower purchasing power for the poor (Katz & Autor, 1999; Matlack & Vigdor, 2006)

Despite the continued focus on taxes that overwhelmingly hit the poor, little is heard today about cigarette tax regressivity, not even from those who normally consider themselves advocates of the poor. In the rare instances when cigarette tax regressivity is mentioned, it is usually to challenge the notion that they are regressive. For example, the American Lung Association of Texas (2003) instructs readers to counter arguments that cigarette taxes are regressive by stating that "[l]ow-income smokers are four times more likely than high-income smokers to quit because of a tobacco tax increase, and low-income children are less likely to start.

Not only is this a health benefit, but it also frees up limited income that can be spent on other items." The position that high cigarette taxes are not regressive is put forward by many advocates of very high cigarette taxes, including for example California Lung Association (2002), Economic Opportunity Institute (2001), and Campaign for Tobacco Free Kids (2004). The advocates maintain that high cigarette taxes are not regressive, because in response to tax increases, lower income individuals are more likely to quit or cut back than the higher income.

This position, and the implicit position that it is quantitatively important, are given support in the academic literature. In the Handbook of Health Economics chapter on tobacco, Chaloupka and Warner (2000) state:

"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 than 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."

Warner (2000) goes further in an article entitled "The Economics of Tobacco: Myths and Realities," stating that "[a tobacco] tax *increase,* however, may *not* be regressive" (italics in original). This challenge to cigarette tax regressivity is novel because of its focus, not on the level of progressivity of the tax, but on the *change* in progressivity from a tax increase.

This challenge is distinct from the behavioral economic challenge to cigarette tax regressivity of Gruber and Koszegi (hereafter G&K) (2004), which also depends on the different responsiveness of different income groups to cigarette taxes. G&K (2004) use time-inconsistent models, which imply that people would like to be able to force their future selves to carry out the plans made by their current selves, plans that may include cutting back on smoking. The current self votes for higher cigarette taxes so that their future selves really do smoke less. Because the poor are more responsive to price increases, they benefit more from higher taxes as commitment mechanisms.

Remler (2004) addressed qualitatively the different underlying notions of regressivity. In this paper, we investigate thoroughly whether Warner's contention that cigarette tax increases are movements towards progressivity in a traditional framework is true empirically. While G&K have incorporated differential price sensitivities by income into behavioral economic measures of vertical equity, 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. We also examine how our new measures of price sensitivity by income groups affect behavioral economic measures of equity.

The paper has two main findings on equity. First, all nonbehavioral economic measures of progressivity, whether tax expenditure or welfare-based, show that cigarette tax increases are neither progressive nor movements towards progressivity. This conclusion is robust to controls for cross-border purchasing and for the changing relative price of generic cigarettes. Second, even if price elasticities vary with income by far more than we estimated, tax increases are still not movements towards progressivity in a traditional framework: tax increases can only be seen as progressive by using extreme elasticity estimates and assuming that those estimates remain valid for far out-of-sample predictions.

The remainder of the paper is organized into sections as follows: a look at the theory of how to measure the tax burden of cigarette tax increases, including several alternative measures used in the empirical section; a discussion of the empirical methods used; empirical results; and a conclusion containing policy implications.

THEORY: ALTERNATIVE MEASURES OF TAX BURDEN FOR CIGARETTE TAXES

A tax is generally defined to be regressive if taxes paid as a share of income fall with income and to be progressive if the share rises (Rosen, 2001; Stiglitz,, 2000). This definition is commonly used in progressivity calculations for public policy purposes, such as those by the Congressional Budget Office (CBO, 1990) and policy think-tanks (Pechman, 1985). Unlike welfare-based measures, such an expenditure-based progressivity measure does not incorporate the adverse utility consequences to individuals who choose to reduce consumption when faced with higher prices.

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.

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

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. Smuggling, border crossing, and the more recent phenomenon of online sales, may vary by income group. This would undermine our assumption that the change in price paid by consumers due to a tax increase does not vary by income group. For border crossing and smuggling, we investigate this empirically.

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 corner solutions. The starting tax regime is denoted 1 and the finishing tax regime is denoted 2. When the tax rises, the individual cuts back on consumption by an amount $|\Delta x|$ 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.

$$\Delta \mathrm{Exp} = \Delta t[x_1 + \Delta x] + t_1 \Delta x \tag{2}$$

When Warner suggests that tax *increases* could be progressive (that is,, a change towards progressivity), he is using a tax expenditure-based definition of progressivity, as well as incorporating the effect of higher 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, which in turn requires that the low income be highly elastic.

From a welfare vantage—using consumer surplus as the measure of welfare—the consumer is actually worse off, for two reasons. First, taxes rise on those cigarettes still consumed, by the amount represented by the upper rectangle. Second, the consumer smokes fewer cigarettes due to the higher prices, resulting in net losses represented by the triangle. The partial equilibrium perspective of the consumer surplus neglects the value of the income no longer spent on cigarettes due to reduced consumption, the lower rectangle, which is included in the tax expenditure-based perspective.[1]

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

The difference between the well-being implications of the consumer surplus and tax-expenditure perspectives depends on how much the consumer adjusts consumption and thus on the elasticity of demand. 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.

The classic Ramsey (1927) analysis implies that it is optimal to tax inelastic goods the most heavily in order to avoid distortions in consumption choices. However, without assuming lump-sum transfers, the equity consequences of taxing inelastic goods can be severe. Moreover, using the Ramsey analysis to support high cigarette taxes implicitly takes consumer preferences as the correct standard for welfare analysis and assumes demand for cigarettes is inelastic (e.g.,

[1] Neither perspective considers the value to society of government expenditures funded through the taxes. However, tax revenue is fungible. Assuming the revenue is not differentially spent on any particular income group, this omission will not affect the equity implications of the tax.

Manning *et al* 1989; Grossman *et al* 1993). In contrast, using the public health analysis to justifyhigh cigarette taxes implicitly does not "respect" consumer preferences and assumes that demand is elastic so that smoking behavior can be changes. Using both arguments simultaneously is thus inconsistent. . 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 goods such as cigarettes, which are addictive and unhealthy, 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 & Murphy, 1988) and economists have traditionally been reluctant to take a paternalistic approach towards consumption decisions that affect an individual's health when there are no externalities involved (Grossman, Sindelar, Mullaby, & Anderson, 1993: Manning, Keeler, Newhouse, Sloss, & Wasserman, 1989). Recently, behavioral economics, based on evidence from experimental psychology that individuals' preferences are time-inconsistent, has provided a new challenge to traditional welfare analysis (Gruber & Koszegi, 2001, 2004; Gruber, 2002–03; Viscusi, 2002–03). This view argues that many smokers are looking for a commitment mechanism to help them quit and that because higher taxes affect the poor more than the rich, very high cigarette taxes could be progressive. As G&K put it, taxes provide beneficial "internalities" for smokers trying to smoke less.

In G&K's model, the size of the benefit of cigarette taxes depends on whether the smoker is "sophisticated" time-inconsistent, "naïve" time-inconsistent, or time-consistent. Sophisticated time-inconsistent smokers take their time-inconsistency into account when planning consumption. If they believe that they can raise their lifetime utility by smoking less in the future, they try to place constraints, such as cigarette taxes or public smoking restrictions (G&K, 2004, p. 1979), on their future behavior so that they will actually do so. Naïve time-inconsistent may also believe that smoking less in the future will raise their lifetime utility, but falsely assume that if they decide now to smoke less later, their "later" selves will obey the plan set for them, without any constraints. Thus naïve smokers oppose higher taxes before they are passed, but afterwards they are grateful that they are smoking less. Time-consistent smokers, whose future selves carry out the plans made in the initial period, receive no benefit from cigarette taxes.

Thus for time-inconsistent consumers, G&K's model implies that equation (3) overstates consumer loss. For sophisticated smokers, who are the focus of G&K's papers, the overstatement can be corrected by multiplying the consumer loss as given in equation (3) by the following adjustment factor (G&K 2004, p. 1973):

$$1-(1-\beta)\frac{-H_s}{p}\left(-\frac{\partial a}{\partial p}\frac{p}{a}\right)\frac{1-(1-d)\delta}{1-(1-d)\delta\left(1+(1-\beta)\lambda^{*s}\right)}, \tag{4}$$

where 'a' is the addictive good; 'p', the price of the addictive good; 'β', the "short-run discount factor"; 'δ', the "long-run discount factor"; 'λ', the marginal effect of the stock of addictive capital on current consumption; 'Hs', the present value of lost life (and thus a negative number), in the same units as the price; and 'd', the rate of depreciation of the addictive stock. The adjustment factor, and hence the welfare burden of taxes, becomes smaller (or more negative) as the absolute value of the elasticity rises. If cigarette demand is relatively elastic among the poor, they benefit more than others from the self-commitment effect of taxes. Later in the paper we investigate whether the adjustment factor makes a practical difference in the relative tax burden.

In addition to internalities, cigarette consumption also has negative externalities, the harm caused by secondhand smoke absorbed by the smoker's family and co-workers. A recent Surgeon General report (Surgeon General, 2006) concluded that environmental smoke causes heart disease and lung cancer in adults, and raises the risks of Sudden Infant Death Syndrome (SIDS), respiratory infections, and ear illnesses in children (p. 9). The economic value of the damage caused may well be large (Sloan, Ostermann, Picone, Conover, & Taylor, 2004). However, there is a lack of consensus among economists as to whether environmental smoke within the household is "external." Presumably smokers and nonsmokers within a household take into account the damage caused by environmental smoke. In particular, the finding that approximately 40 percent of female smokers quit during pregnancy (Colman & Joyce 2003) suggests that many mothers consider their children's health when deciding whether to smoke. Equally important, externalities will only affect our equity results if they differ proportionately by income group. To see whether externalities affect our equity results, we estimate what size of external effects would be needed to make cigarette taxes moves toward progressivity.

Our empirical implementation uses linear approximations to the change in demand, assuming that the slope at the starting tax regime is constant:

$$\Delta x = \left.\frac{dx}{dp}\right|_1 \Delta t \tag{6}$$

$$\left|\Delta CS\right| = \Delta t[x_1 + \Delta x] - \frac{1}{2}\Delta t \Delta x = x_1 \Delta t + \frac{1}{2}\frac{dx}{dp}\left(\Delta t\right)^2 \tag{7}$$

$$\left|\frac{\Delta CS}{Y}\right| = s_c \frac{\Delta t}{p_0}\left(1 + \tfrac{1}{2}\varepsilon_{uncomp} \cdot \frac{\Delta t}{p_0}\right), \tag{8}$$

where the notation $|_1$ denotes the evaluation of the slope of the Marshallian demand curve in tax regime 1, s_c is the share of cigarette spending in total income and ε_{uncomp} is (the absolute value of) the uncompensated or Marshallian price elasticity. Compensating variation is calculated using equation (7) but replacing the uncompensated with the compensated change in x, estimated with the Slutsky formula:

$$\Delta x_{comp} = [\left.\frac{\partial x}{\partial p}\right|_1 + x_1 \left.\frac{\partial x}{\partial I}\right|_1]\Delta t\,, \tag{9}$$

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.

Using a linear approximation to determine the effect of a sizable increase in the tax rate is problematic, because such an increase requires prediction far out of sample.[2] However, since policy-makers are considering and implementing large tax increases, forecasting far out-of-sample is necessary to provide some idea of the consequences.

How big a difference between the elasticities of high and low income groups is necessary for tax increases to be a move towards progressivity? The change in consumer surplus as share of income (equation (8)) will be the same for high and low income groups when

$$\varepsilon_{\text{low}} = \frac{2\left(s_{\text{high}} - s_{\text{low}}\right) + s_{\text{high}}\hat{p}_0\varepsilon_{\text{high}}}{s_{\text{low}}\hat{p}_0}, \qquad (10)$$

where p-hat represents the proportional change in the price. In the results section, we use this equation to determine whether a cigarette tax increase might conceivably be progressive in light of our elasticity estimates and what elasticity differences by income are required for progressivity.

The change in external effects as a share of income is

$$\frac{\Delta Ext}{Y} = -s\hat{p}_0 h\varepsilon\,, \qquad (11)$$

where h is the harm per cigarette measured in dollars per cigarette divided by the price of cigarettes. For example, if the price of cigarettes is \$3/pack and the external effect of cigarettes is \$1.5/pack, h = .5. If we assume that external effects occur in the smoker's income group, as for maternal and spousal smoking, the change in welfare relative to income for each income group is given by the sum of equations (8) and (11). We can calculate the externality effect size needed to make a tax increase progressive by equating the welfare change relative to income for the high and low income groups. The critical value is given by:

$$h = \frac{s_{low} - s_{high}}{s_{high}\varepsilon_{high} - s_{low}\varepsilon_{low}} - \tfrac{1}{2}\,\hat{p}_0 \qquad (12)$$

[2] In empirical implementations, the estimated regression model can be used to integrate the demand curve through to the ending tax regime, but this is just a different functional form assumption and is still based on far out-of-sample predictions (Remler, Graff Zivin and Glied 2004).

In the results section, we use this equation and our empirical estimates of elasticities to determine how large externalities must be so that a cigarette tax increase would be progressive.

Many individuals are nonsmokers and much of the behavioral response to higher prices comes from smokers quitting altogether. Therefore, smoking participation and consumption conditional of smoking must be modeled separately, as in a two-part or "hurdle" model (Jones, 1989). Since we cannot know for certain which respondents will continue to smoke when the cigarette tax is raised, we assign each respondent a probability of smoking (Small & Rosen, 1981, p. 115). The product of this probability (π_i) and the number of cigarettes smoked among smokers (c_i) then gives the *expected* cigarette consumption, which is the quantity we will analyze to examine the distributional effects of tax increases. Specifically,

$$\Delta Exp_i = \Delta t[\pi_i^1 c_i^1 + \Delta(\pi_i c_i)] + t_1 \Delta(\pi_i c_i) \tag{13}$$

$$\left|\Delta CS_i\right| = \Delta t[\pi_i^1 c_i^1 + \Delta(\pi_i c_i)] - \frac{1}{2}\Delta t \Delta(\pi_i c_i) \tag{14}$$

In the above two equations we approximate the change in expected consumption with a first-order Taylor expansion, taking into account the effect of a change in price on both the propensity to smoke and on the number of cigarettes smoked by smokers:

$$\Delta(\pi_i c_i) \approx \left(\frac{\partial \pi_i}{\partial p} c_i + \frac{\partial c_i}{\partial p} \pi_i\right) \Delta t \tag{15}$$

The compensating variation equations are somewhat more complicated in a hurdle model, due to the extensive margin effects. Intuitively, the money needed to compensate someone who moves across the extensive margin from c_1, the number of cigarettes smoked among smokers ("conditional consumption"), to zero cigarettes depends on c_1. Formally (Small & Rosen, 1981), the compensated change in expected consumption can be derived in usual Slutsky fashion, to get

$$\left.\frac{\partial \pi_{comp,i}}{\partial p}\right|_1 \equiv \left.\frac{\partial \pi_i}{\partial p}\right|_1 + \left.\frac{\partial \pi_i}{\partial I_i}\right|_1 c_i \tag{16}$$

Combining equations (14), (15), and (16) yields the equation we use to calculate the compensating variation implied by a given tax increase.

The elasticity of expected consumption is

$$\frac{d\ln(\pi_i c_i)}{d\ln p} = \frac{d\ln \pi_i}{d\ln p} + \frac{d\ln c_i}{d\ln p} = \varepsilon_{\pi,i} + \varepsilon_{c,i}\,, \tag{17}$$

often called the "total elasticity." To calculate the changes in a respondent's consumer surplus and compensating variation as a share of income, we use the individual's total uncompensated and total compensated elasticities.

The empirical 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, while for inferior goods it is flatter. The few previous estimates of the income elasticity of cigarettes using individual data center around zero (Gallet and List 2003). We estimate a significant negative income elasticity, but this may be due to omitted variables bias. Would smokers who have not quit in spite of higher taxes, respond to compensation by quitting or reducing consumption? Possibly they would, at least over the long-term, but it seems unlikely. Nonetheless, we use our estimated income effects in our CV calculations, because it is the standard practice of empirical consumer theory and there are no other estimates available to use for income effects.[3]

The tax increase is deemed progressive if the change in tax expenditure or welfare, relative to income, rises 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.

[3] 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.

EMPIRICAL METHODS: ESTIMATION OF EFFECT OF TAX INCREASES

The empirical method consists of three parts. First, we estimate how cigarette 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.

Data and Sample Selection

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.[4] Our data set consists of six pooled cross-sections—1993, 1996, 1999, 2001, 2002, and 2003. The merge is based on the method of Madrian and Lefgren (1999) and we also drop observations for which the age (plus or minus one year), race, and sex do not match. Of the 634,571 respondents who may have been surveyed in both the month of a TUS and in the March Income Supplements, we match 575,426, for a match rate of 91 percent. Of these, 395,916 actually participated in a TUS and provided valid data on their cigarette use. We focus on adults and therefore exclude respondents under 18 years of age (21,013 observations). We also exclude those who had proxies respond for them (66,721), because responses on someone else's smoking may systematically differ from responses on one's own smoking. Further excluding respondents with missing values for other covariates (13,489) yields our analysis sample of 294,693 observations.

We use three TUS questions to create our measures of smoking. The TUS asks "Do you now smoke cigarettes every day, some days, or not at all?" We categorize as smokers those respondents who answer "every day" or "some days." The TUS also asks "On the average, how

[4] 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.

many cigarettes do you now smoke a day?" For respondents who smoke every day, the answer to this question gives daily consumption conditional on being a smoker. For respondents who smoke only some days, the TUS also asks, "On how many of the past 30 days did you smoke cigarettes?" For these persons, we calculate daily consumption as the number of cigarettes smoked per day on those days they smoke times the number of days they smoke, divided by 30. Other questions used are, "Are you seriously considering stopping within the next 6 months?" and "Are you planning to stop within the next 30 days?"

The income measure reported in the March CPS includes cash income received on a regular basis. We add to this the value of food stamps, but we include no other government aid because respondents are not asked about their value. We set business losses to zero, to avoid the problem of calculating tax burdens for families with negative incomes. To account for family size, we then divide this augmented family income measure by the Census Bureau poverty threshold appropriate for each respondent's family, and multiply the result by the adult threshold for 1997, producing an adult-equivalent-income in $1997. We drop those whose income is less than a dollar a day, about 0.4% of our sample.

Data on cigarette taxes and prices come from *The Tax Burden on Tobacco* (Orzechowski & Walker, 2006). We use the weighted average state price including generic cigarettes. 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. We create an index of state restrictions on smoking (*clean-air index)* following Chaloupka and Saffer (1992). We allocate individuals to income quantiles, specifically terciles, using adult-equivalent family income on a year by year basis.

Primary Econometric Specification

Empirically, smoking tends to be bimodal: if someone smokes, he or she generally smokes at least a moderate number of cigarettes. Therefore, participation and the number of cigarettes smoked among smokers must be modeled separately and we use a two-part 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. A more common specification for the two-part model is a probit or logit for the first part and a least squares regression with the log of quantity as the dependent variable for the second part. For comparison with our primary results, we also estimate such a specification. But we prefer to use linear models because, compared with nonlinear models, they are more robust to heteroskedasticity, which according to diagnostic tests pervades our models, and they allow much easier interpretation of interactions (Ai & Norton, 2003), which are essential to our analysis. Further, our models predict almost no negative quantities and few probabilities outside the zero-one bounds, and these few pertain to the respondents whose income exceeds the public-release cut-off amounts. Because these respondents are all assigned the rather high average income above the cut-off, their predicted probabilities are not reliable, whether produced by LPM or probit.

In order to incorporate the effects of different price elasticities at different income levels, we include an interaction between price and income and between price and income-squared. Our preferred specification is

$$\pi_i = \beta_0 + \beta_p p_i + \beta_I I_i + \beta_{I2} I_i^2 + \beta_{pI} p_i I_i + \beta_{pI2} p_i I_i^{\,2} + \beta_X{}' X_i + \beta_S{}' S_i + \beta_T T + \beta_{TI} T I_i + \beta_{TI2} T I_i^2 + \varepsilon_i \quad (18),$$

where p_i is the cigarette price, I_i is the family 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); Hispanic, non-Hispanic black, and non-Hispanic other race (non-Hispanic white is the omitted category); female; divorced, separated, widowed, and never-married (married is the omitted category); unemployed and not-in-the-labor-force (employed is the omitted category); the occupational categories blue-collar, service, farm, military, and never-employed (white-collar is the omitted category); and several continuous variables, including age and age squared, the number of children under 6 years old in the family, interactions between year and age and age-squared to allow time trends to differ by age, and an index measure of legal restrictions ("clean air index") on indoor smoking (Chaloupka & Saffer, 1992). Analogously, the preferred specification for second stage of conditional consumption is:

$$c_i = \gamma_0 + \gamma_p p_i + \gamma_I I_i + \gamma_{I2} I_i^2 + \gamma_{pI} p_i I_i + \gamma_{pI2} p_i I_i^2 + \gamma_X' X_i + \gamma_S' S_i + \gamma_T T + \gamma_{TI} TI_i + \gamma_{TI2} TI_i^2 + \nu_i \quad (19).$$

All regressions are performed with sample weights, specifically, the weights for self-reported smoking behavior, since we exclude proxy responses. We calculate robust standard errors, correcting for clustering at the state level, since taxes and prices only vary by state and year.

Our main specification includes state effects and a linear time trend in addition to interactions of year and age. A specification with no state effects ignores the possibility that 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. Ideally, we would include year dummies, but with only 6 years of data this turns out not to be feasible. Regressing price on just state dummies gives an R^2 of 0.2, while adding year dummies raises the R^2 to 0.93. Because the time dummies absorb so much of the price variation, we use linear time trends for our preferred model.

Alternative Econometric Specifications: Smuggling and Other Potential Biases

There are many potential biases in our, or any, model. Because our focus is on equity consequences, only biases that differ among income groups will undermine our basic results.

A traditional worry in estimating demand equations is that the price measure is endogenous. Certainly the actual price the consumer pays is endogenous, since he or she chooses the price, based on the cigarette type, brand, and quality he or she is willing to pay for. But whether the statewide average price, which we use, is exogenous to individual consumption has been debated. Evans, Ringel, and Stech (1999) argue that state cigarette taxes are better regressors than state prices because taxes are known with much less error and because even statewide average prices may reflect evolving unmeasured variables common to smokers in a given state. Chou, Grossman, and Safer (2006), however, argue that the use of taxes throws away a significant amount of variation in price that is due neither to demand nor to taxes, such as differences among states in transportation and marketing costs and in market shares among producers. In addition, they show that prices are unlikely to be endogenous to individual behavior in a market in which producers are oligopolies with flat marginal cost curves. Our main model follows Chou et al., but we evaluate whether price is endogenous by instrumenting for price, price-times-income, and price-times-income-squared with tax, tax-times-income, and tax-times-income-squared, and testing for a significant difference in the elasticities.

Another possible bias results from the assumption in our main model that smokers actually pay the cigarette tax prevailing in their states. This may not be true if smokers can buy cigarettes in nearby states with lower tax rates or from smugglers, who typically truck in cigarettes from the states where they are produced and which tax them lightly, such as North Carolina, Virginia, and Kentucky. Failing to account for the availability of cheaper out-of-state cigarettes biases our elasticity estimates downward (in absolute value), because a given increase in taxes would not raise the price a smoker pays by an equal amount, since he or she can just switch to an out-of-state source (Lewit & Coate, 1982; Coats, 1995). Thus the reduction in smoking is actually a response to a smaller rise in price than our equations assume.

We test whether our estimates are sensitive to possible cross-border shopping by including in our basic specification three additional variables: the distance from the respondent's county to the nearest state with a lower cigarette price, the difference between the price in the respondent's state and in the nearest cheaper state, and an interaction between distance and the price difference. With these variables the model becomes:

$$S_{ist} = \beta_1 price_{st} + \beta_2 \left(price_{st} - price_{nt}\right) + \beta_3 \left(price_{st} - price_{nt}\right) \text{distance}_{ist} + \beta_4 \text{distance} + X_{ist}\gamma + u_{ist} \quad (20),$$

where 'S' is either participation or conditional consumption, 'i' indexes persons, 's', the home state, 'n', the near state', 't', year, and X includes all the other covariates, including the constant. This model includes two relevant marginal effects of a change in the home-state price or tax, depending on what is held constant. One marginal effect assumes that we hold the *inter-state price difference* constant. That is, it assumes that all states raise their cigarette taxes by the same amount. In this case the marginal effect of a change in the home-state price is simply β_1. The other assumes that we hold the *near-state price* constant. Then the marginal effect of a change in the home-state price is:

$$\frac{\partial S}{\partial price_{st}} = \beta_1 + \beta_2 + \beta_3 distance_{ist} \quad (21).$$

We expect β_2 to be positive because, holding the near-state price constant, an increase in the home-state price induces more smokers to cross the border for cheaper cigarettes, and hence lowers (in absolute value) the effect on smoking of the home-state increase. Similarly, we expect β_3 to be negative, as an increase in distance to the border strengthens the effect of a rise in the home-state price. Since we are not interested in the effect of cross-border shopping in itself, but only in its effect on equity, we interact distance, the price difference, and distance-times-price-difference with income to see if low-income smokers respond to cross-state border prices differently from high-income smokers. We also interact these variables with price to allow for the possibility that price levels—not just price changes—influence the incentive to buy cigarettes in another state.

The public-use version of the CPS, which we use, gives the county of residence for only about a third of respondents. Nonetheless, this still leaves us with about 84,000 observations distributed over 10 years. Since we are including state effects and a year trend, the new parameters are identified by the variation among counties within a state in the distance to a cheaper state, and by the variation over time in the price differences among states.

A different bias may result from our use of a single price measure for all consumers, regardless of income. According to Hyland et al, (2005), lower-income smokers are more likely than upper-income smokers to buy generic or discount brands. If the average price rises solely because of an increase in the price of premium cigarettes, low-income smokers will be little affected, and it will falsely appear that they are price-insensitive. We test this possibility by estimating our preferred specifications for both participation and quantity with and without a variable that is the ratio of the average cigarette price excluding generics to the average price including them. If changes in the relative price of premium cigarettes matter, our price elasticity should change significantly when the relative price is held constant.

Prior studies that examined differences in price sensitivity by income group (Evans, Ringel, & Stech, 1999; Farrelly & Bray, 1998; Hersch, 2000; Farrelly, Bray, Pechacek, & Woolery, 2001; G&K, 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 estimate all our models stratified by family income terciles. The independent variables are the same as in our main model except that we leave out the price-income, price-income-squared, and time-income-squared interactions. We estimate the stratified models both with and without time trends.

Price-Sensitivity by Income Group

Marginal effects and elasticities are conventionally evaluated at sample means, which effectively treats the market as a single consumer. Such an approach is appropriate in welfare analysis under one condition—that the marginal effect of income is constant and the same for all consumers (Varian, 1992, p. 154). We prefer not to make such a strong assumption; hence we calculate marginal effects, elasticities, consumer surplus, and compensating variation at the individual level, and report the medians of these quantities by income tercile. Specifically, we compute the participation and conditional consumption elasticities for each individual using the regression coefficients and that individual's income, predicted smoking status, predicted conditional consumption, and the price prevailing in the respondent's state:

$$\varepsilon_i^p = (\hat{\beta}_p + \hat{\beta}_{pI} I_i + \hat{\beta}_{pI2} I_i^2) p_i / \hat{\pi}_i \quad (22)$$

$$\varepsilon_i^c = (\hat{\gamma}_p + \hat{\gamma}_{pI} I_i + \hat{\gamma}_{pI2} I_i^2) p_i / \hat{c}_i \quad (23).$$

To allow comparison to the conventional approach, we also calculate elasticities at the sample means for the entire sample and by tercile for the stratified models. We calculate income elasticities with analogous formulas. We calculate the standard errors of the marginal effects and elasticities using Stata's SUEST and NLCOM commands, the latter using the delta method (Stata, 2005).

Predicted Effects of Tax Increase

In order to assess the consequences of much higher cigarette taxes, we simulate the effect in 2003 of raising the cigarette tax by a dollar per pack (in $1997). This should be compared with the average cigarette tax in our data of 95.6 cents/pack and an average cigarette price of $3.41/pack in 2003. 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.

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 (Remler, Graff Zivin, & Glied, 2004). Since we have no choice but to use predicted consumption for the ending tax regime, to be consistent, we use predicted values for the starting regime as well. 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.[5]

All calculations of cigarette and tax spending as well as consumer surplus and compensating variation are limited to respondents who are imputed to be smokers at the initial tax levels. The imputation begins by assigning to each respondent a random uniform number between 0 and 1. Respondents whose predicted probability is greater than the random number are given a current smoking status of unity; otherwise, they are assigned a zero. Smoking status after a tax increase is assigned in the same way, using the same random number for each respondent, not assigning respondents new random numbers. Smokers whose new predicted probability of smoking is less than the random number assigned to them are considered to have quit.

Progressivity Calculations

The traditional assessment of whether or not a tax is progressive is based on how the tax expenditure shares in income vary by income group. Other researchers include consumer surplus and compensating variation, or these measures relative to income or wealth. As suggested by

[5] Out-of-sample predictions were not a major problem, with 3.5% of probability predictions being negative, 0.1% of conditional consumption predictions being negative and no probability predictions being greater than one.

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 use the individual as the unit of analysis in our estimation of smoking behavior. Although we calculate consumer loss for each imputed smoker in our data set, which includes the years 1993 to 2003, we display the equity of the results only for 2003, to give an idea of the effect on equity of raising taxes now.

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. Then we calculate for each individual the share of income that he pays in cigarette taxes and look at the median within each income tercile. To compare a welfare-based perspective with the tax expenditure-based perspective, we calculate, for each income tercile, the median change in consumer surplus and the median compensating variation as given by equations (14)–(16), in absolute amounts and as a share of income. We also report by tercile the medians of 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.

After presenting our main results, we apply G&K's model to our data to see whether our conclusions change if we assume all smokers are seeking commitment devices. We calculate the adjustment factor given in equation (4) for each income tercile and for a range of parameter values. Following G&K, we let $\beta = 0.6$ or 0.9, $\delta = 0.9$ or 0.97, and the value of a statistical life be, in 2003 dollars, \$4.2 million, \$7 million, and \$9.9 million. These values reflect the range of estimates in the literature on estimating the value of a statistical life (Viscusi, 1993). Thus we calculate 12 adjustment factors for each tercile, or 12 sets of three. The other parameters are kept the same for each of the 12 sets: we use our estimates of the median elasticity by tercile, and assume, like G&K, that $\lambda = 0.7$, $d = 0.6$, and that the income elasticity of H_s equals 0.5.

We then attempt to assess the share of smokers to which G&K's model applies. A reasonable assumption is that it applies only to smokers who are planning to quit or at least cut back. A complication is that this share is not a single number but depends on the time horizon. To shed light on this, we use the TUS to estimate the proportion of smokers considering quitting in the next six months and the proportion planning to quit in the next thirty days. We also look at the proportions planning to quit by income tercile. It may be that only upper-income smokers are trying to quit. If so, taxing all smokers burdens many persons for the benefit of a few. We note that the share of smokers that plans to quit overstates the share that benefits from taxes in G&K's model because it includes smokers who are time-consistent, but we have no way of excluding these persons.

RESULTS

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. The absolute change was similar among high- and low-income consumers, which implies the relative change was much larger among the former. The quantity of cigarettes smoked per day among smokers also declined during the years of our survey, but differed little by tercile, with only half a cigarette per day separating the top and bottom terciles in both 1993 and 2003. Real cigarette prices rose by about 70 percent over the time period we study, driven by tax increases.

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 BLS's 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. The comparison is not exact, since unlike the PCE, 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 underestimated 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. Moreover, it is possible that the under-reporting of tobacco consumption varies systematically with income. If high-income individuals find smoking less socially acceptable than do low-income individuals and therefore increasingly under-report their smoking, then cigarette taxes will be less regressive than our results imply.

Real cigarette prices rose by about 70 percent over the time period we study, driven by tax increases (Table 1A). At any point in time, there is substantial cross-state variation in cigarette prices, as shown by the standard deviation. The extent and form of both cross-state and time-series price variation is critical to our estimation. Regressing price on just state dummies gives an R^2 of 0.2, while adding year dummies raises the R^2 to 0.93. Consequently, there may simply be too little variation in price left to estimate statistically significant price coefficients when time effects are included.

Econometric Estimation Results

The results for both participation and conditional consumption are statistically significant at the market level, and robust among different models and specifications. The first column of Table 2 illustrates the participation results for our primary specification, providing estimates of the coefficients and price and income 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. The estimates imply a price elasticity of participation of -0.21 (0.046).

Participation declines monotonically with income, with an implied income elasticity of participation of -0.18 (0.012). Thus, cigarette consumption appears to be an inferior good. This might merely reflect an omitted variable bias, with higher income people less likely to smoke due to differences by income group in social stigma or rate of time preference. 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. If so, there are important policy implications for funding aids to quitting smoking.

The conditional consumption price coefficient is negative and statistically significant (column 2). The price-income interaction is not significant in any of the conditional consumption specifications, consistent with conditional consumption's lack of variation with income in the descriptive statistics. The conditional consumption elasticity is -0.10 (0.015), resulting in a total elasticity of -0.31, within the -0.3 to -0.5 consensus (Chaloupka & Warner, 2000). The income elasticity is small but statistically significant, at -0.018 (0.006). For both participation and conditional consumption, the demographics are as expected and robust to different specifications, and the clean air index is not significant.

The results of most of our alternate models differ very little from those of our main specification. Using a probit for participation and an OLS on the log of quantity yields an estimated participation elasticity of -0.20 (0.046), and a consumption elasticity of -0.08 (0.037), virtually the same as in the linear probability and OLS models. Instrumenting for price with the cigarette tax produces elasticities that are somewhat larger than our main specification, but less precisely estimated. The IV participation and consumption elasticities are -0.31 (0.15) and -0.1 (0.034), respectively. Including the relative price of premium cigarettes hardly changed the coefficients at all.

Controlling for cross-state buying produces somewhat different estimated elasticities from those of our primary specification, as conjectured in the Methods section. If we estimate our primary specification on the sample for which the nearest lower out-of-state price is known, we obtain estimates of the participation and consumption elasticities of -0.164 (0.049) and -0.106 (0.049), respectively. Controlling for cross-border shopping, we find that holding the near-state *price* constant, the estimated participation and conditional quantity elasticities fall to -0.11 (0.24) and -0.10 (0.13). Holding the *difference* between the home-state and near-state prices constant, the estimated elasticities rise to -0.195 (0.332) and -0.178 (0.136), for a difference in the total elasticity of about 0.16 in absolute value. Evaluated at the means of income, price, and distance, the estimated elasticities for low-, middle-, and high-income terciles each also increases by about 0.16 in absolute value. Thus while accounting for the availability of cheaper out-of-state cigarettes changes the elasticity estimates, it has little impact on the relative price responsiveness by income group.

The robustness of our results across specifications has one caveat: it depends on including time trends or effects. Without such controls, the estimated participation elasticities double and the consumption elasticities triple compared with models that include them. We use time trends because year dummies absorb too much variation to estimate price elasticity directly.

C. Price Sensitivity by Income Group

Our interest in equity led to an interest in how price-sensitivity varies by income group. Using our preferred specification, we calculate individual price elasticities and then take the median within each income tercile. The results are shown at the bottom of Table 2. The participation elasticities from our main specification are -0.243, -0.196, and -0.115 for the low, middle and high income groups, respectively. The conditional consumption elasticities are -0.127, -0.105, and -0.083 for the low, middle, and high income groups, respectively, a fairly flat pattern, with differences among income groups of less than the standard error of the price elasticity. The results are quite similar among the alternate specifications. In summary, the total elasticities differ by income group by modest amounts.

Models stratified by income group have been used by prior researchers who examined how price sensitivity varied by income group. We estimated stratified models both with and without time trends. The resulting participation elasticities, all around -0.2, are virtually identical across income groups, as are the conditional consumption elasticities, except that of the highest terctile, whose price sensitivity, at -0.047, is significantly below that of the others, which are around -0.11. Thus the elasticities estimated by stratified regressions differ less by income than those calculated from a single regression with interactions of price and income.

In the prior literature, the most dramatic variation in price sensitivity by income group is obtained by Hersch (2000), who finds for women a total elasticity of -1.18 for the bottom income quartile, -0.38 for the top income quartile and an elasticity of -0.97 for all income groups, results that differ substantially from ours. We were able largely to replicate her results and found that the use of the single 1993 cross-section, the categorical self-reported income groups, and the lack of weights were the primary drivers of the difference with our results. G&K (2004) use the Consumer Expenditure Survey between 1980 and 1998 with both state- and year-effects but no income controls. They find an elasticity of -1.1 for the bottom income quartile and -0.4 for the top income quartile, also quite different from our estimates. However, their dependent variable differs from ours in two important ways: it is a measure of consumer spending on cigarettes, rather than of cigarettes consumed; and it refers to cigarette consumption by the family (or, more precisely, by the "consumer unit"), rather than by the individual. In addition, their sample period is earlier, from 1980 to 1998, compared to ours of 1993 and 2003.

Our results are closer to two other studies using other large, nationally representative surveys. Farrelly et al. (2001) use pooled cross-sections from the NHIS from 1976–1993 (incomplete) and include state- and year-effects. They find an elasticity for the total population of -0.28, with -0.43 for those in the bottom half of the income distribution and -0.10 for those in the top half. These results are close to ours for median elasticities by income group, discussed below, though they differ from our less-precisely-estimated stratified estimates. Evans, Ringel and Stech (1999) use cross-sections of the Behavioral Risk Factor Surveillance Survey for 1985–1995. They find a total elasticity of -0.32 for the bottom half of the income distribution and -0.17 for the top half. These results and ours are close to the norm among studies using individual-level data, according to the meta-analysis by Gallet and List (2003).

Effect of Tax Increase on Vertical Equity

In order to evaluate the equity consequences of a tax increase, we predict the effect of tax increases on the median smoker in the low-, middle-, and high-income terciles. We present the effect of taxes in 2003, the final year in our sample, to give an idea of the equity consequences of raising taxes today.[6]

Rows 1 through 3 of Table 3 illustrate the vertical equity of the cigarette taxes in the actual starting regime of real smokers in 2003. Taxes absorb 1.9% of income for the median smoker in the lowest income tercile, 0.7% in the middle income and 0.3% in the high income. Thus, the initial pattern is unambiguously regressive and even strongly so.

Our simulations predict that a $1/pack (in $1997) tax increase causes declines in smoking participation of 2.3 percentage points among the low income, 1.7 percentage points in the middle income and 0.8 among the high income (row 6 of Table 3). We predict a reduction among smokers of about 0.5 cigarettes per day among all income groups (row 9).This predicted behavioral change implies that the share of income going to cigarette taxes in 2003 rises by 2.5, 1.1, and 0.6 percentage points for low-, middle-, and high-income smokers, respectively (row 11–row 10). 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

[6] Prior versions of this paper presented the effects of a tax increase on the full sample period.

elasticity by income group. Our results confirm the traditional view of cigarette tax increases as regressive and find a very small magnitude for the effect anticipated by Chaloupka and Warner (2000), due to our small estimated income-price interaction and the enormous differences in smoking prevalence by income group.

It is striking that 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. To examine this further, we explicitly calculate, 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 the last three rows of Table 3 illustrate that the top rectangle, the change in tax expenditures for continuing smokers, overwhelmingly dominates the other factors and drives the regressivity. The CS and expenditure-based measures differ by the sum of the triangle and the bottom rectangle. The triangle represents the "lost enjoyment" from price-induced quitting, included in CS but omitted from the tax-expenditure measure. The bottom rectangle, representing the income freed up by reduced cigarette consumption, is omitted from the partial equilibrium CS measure but included in the expenditure-based measure. Empirically, the expenditure and surplus measures of loss turn out to be very close to one another, with their variation across income groups driven by the price variation across income groups. Finally, the consumer surplus and compensating variation measures are nearly identical. Estimates of compensating variation and lost consumer surplus are also quite robust across specifications and models (table 4A), because the welfare loss from excise taxes depends mainly on the share of spending devoted to the item taxed, and only secondarily on the elasticity of demand.

None of our models, however, imply elasticity differences among terciles as large as those in Hersch (2000) and G&K (2004). Would larger differences among terciles change our results? Equation (10) tells us how elastic the low income need to be for the tax increases to be progressive. If the shares of cigarette spending in income among high- and low-income consumers are set to their values in 2003 (0.014 and 0.077, respectively), and we assume that high income smokers are completely inelastic and that the price increase is $1 (or 30 percent), the implied price elasticity among low-income consumers is -5.4, which is not possibly true. Thus no reasonable combinations of parameters will make a tax change progressive as we measure it.

Many advocates of high cigarette taxes emphasize the harm from environmental smoke to the smokers' families. If we consider those effects to be external but concentrated in the same income group as the smokers, what size external effects are needed to make tax increases progressive? We apply equation (12) with the same parameters above and our estimated elasticities. We find that externalities would need to be $7.84/pack. This is larger even than the $4.85/pack (in $1997) estimates of spousal effects found by Sloan et al. (2004)—numbers only relevant to married smokers.

A more substantial challenge to our findings is G&K's result that if smokers are time-inconsistent, cigarette taxes can be progressive, under plausible assumptions about the parameters in equation (4). Table 4 shows the effect on the progressivity of cigarette taxes of adjusting for time inconsistency using our estimates of elasticity by tercile and a range of values for the other parameters. Column 2 shows compensating variation as a percentage of income (CV/Y) unadjusted for time inconsistency, repeated from Table 3 (the main specification). Column 3 shows column 2 adjusted for time inconsistency using the parameters that G&K argue best reflect reality ($\beta = 0.6$, $\delta = 0.97$ and the present value of life equals $7 million). While the adjustment implies that a tax increase benefits all income groups, it is not progressive, since the benefit, the ratio of compensating variation to income, is greatest for the highest income tercile. In contrast, if we set $\beta = 0.9$, $\delta = 0.9$, and the present value of life to $4.2 million, as in column 4, adjusting for time inconsistency has virtually no effect on progressivity. Setting $\beta = 0.6$, $\delta = 0.97$, and the present value of life to $9.9 million implies that a tax increase is actually progressive, in that the benefit to low-income smokers as a share of income exceeds that to high-income smokers. Thus applying our data to G&K's model does not change their basic conclusion, that taxes can be progressive if smokers are highly time-inconsistent.

The above calculations refer only to sophisticated time-inconsistent smokers. Using corresponding formulas for naïve time-inconsistent smokers, G&K show that for these smokers the benefits of taxes are even greater. But neither the model nor subsequent research has shown how many smokers are time-inconsistent, nor, among the time-inconsistent smokers, how many have the combination of parameters that make taxes progressive. G&K suggest (p. 1963) that the number of time-inconsistent smokers must be large, because polls indicate that 80 percent of smokers say they want to quit someday. But G&K's model is more specifically about smokers planning to quit next period. Hence the more relevant population is the number of smokers trying to quit. Based on the TUS for 2003, about 39 percent of smokers are considering quitting within 6 months; presumably somewhat less than this are actually planning to quit. About 15 percent are planning to quit in the next 30 days. The model of G&K implies that this latter group contains mainly sophisticated time-inconsistent and time-consistent smokers, since they are most likely to accept present discomfort for future pleasure.

The share of smokers who are considering quitting in the next six months rises with income. These shares are 37 percent, 41 percent, and 44 percent for the low-, middle-, and high-income terciles. The same pattern is evident in those planning to quit this month, with 15 percent of the low- and middle-income smokers and 17 percent of high-income smokers planning to quit. Thus taxes and other hindrances on smoking benefit higher- more than lower-income smokers who are planning to quit.

Conclusions

A June 2007 paper by the Campaign for Tobacco Free Kids is entitled "Federal Cigarette Tax Increases Benefit Lower-Income Smokers and Families" (Lindblom, 2007). It states that although low-income individuals are much more likely to smoke, low-income smokers are "*much* more likely to quit because of tobacco tax increases" (italics not in original). While we find that the smoking of the low income is more price sensitive, it is only modestly so. This finding is based on better income data than that available in any previous study. It is based on specifications that are not subject to the biases of the cross-sectional studies. It is robust to a host of different specifications, including ones that incorporate border-crossing, smuggling, and generics—factors that could affect different groups differently.

Without benefit of any actual equity calculations, advocates of very high cigarette taxes use prior findings of differences in price sensitivity to deny the regressivity of cigarette taxes. Our study is the first nonbehavioral economic calculation of the equity implications of cigarette tax increases. Empirically, we find that the much higher prevalence of cigarette smoking among the low income dwarfs the effect of their greater price sensitivity. This regressivity finding is robust to many econometric specifications. Differences in price sensitivity much greater than the ones observed would be needed to make cigarette price increases progressive. Moreover, external effects from environmental smoke larger even than recent higher estimates (Sloan et al., 2004) do not change our regressivity finding.

Policy makers must acknowledge that cigarette taxes are truly regressive using any traditional notion of regressivity. It is increasingly and overwhelmingly the poor who smoke and so it is the poor that are hit harder as we rely more and more on cigarette taxes. The somewhat greater likelihood of the poor to quit does not come close to overturning this basic result.

A real challenge to the regressivity of cigarette taxes requires a different philosophical framework for assessing regressivity—frameworks that implicitly and explicitly often underlie very high cigarette tax advocacy (Remler, 2004). One such perspective is a traditional public health, paternalistic (or perhaps maternalistic!)[7] perspective. If one only cares about people's health and not their other consumption nor what they want, then anything that reduces the harmful health effects of smoking on smokers and others is good. Even this narrow perspective, however, still requires acknowledgement that high cigarette taxes could curtail other factors that support health, such as safe housing and nutritious food, for smokers and their families.

The most serious philosophical challenge to the idea of cigarette tax regressivity comes from behavioral economics. The idea is that everyone gains so much from quitting that if the low income are even slightly more affected by tax increases, they benefit dramatically more from the device. While the argument is qualitatively compelling, actual behavioral economic equity calculations are not much help in formulating policy, because as G&K found, and we confirm, any result is possible, depending on the behavioral economic parameters. Moreover, our survey results suggest that those who would like higher cigarette taxes to help them quit smoking might not be a large share of the population—an area that requires further research. Thus, even accepting the importance of the behavioral economic perspective, we cannot dismiss as quantitatively unimportant the financial harm done to those who continue to smoke and to their families.

If we continue to pursue the policies of ever higher cigarette taxes, anti-poverty and public health policies should be adjusted accordingly. First and most important, resources to help low-income smokers quit should be substantially expanded. New York City funded nicotine patches to help qualifying smokers to quit but only for a brief period (New York City Department of Health Bureau of Tobacco Control, 2007). Such support should be greatly expanded. Second, we need to protect at least the families of smokers—if not the smokers themselves—from the hardship due to the additional resources spent on cigarette taxes. Such protection could take the form of greater in-kind benefits to poorer families (for example, housing vouchers, food stamps,

[7] Thanks to Shoshanna Sofaer for suggesting this term.

health insurance, education) that can't be "wasted" on cigarettes. Overall, we need some consideration for the poor smokers who are poor quitters.

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Figure 1

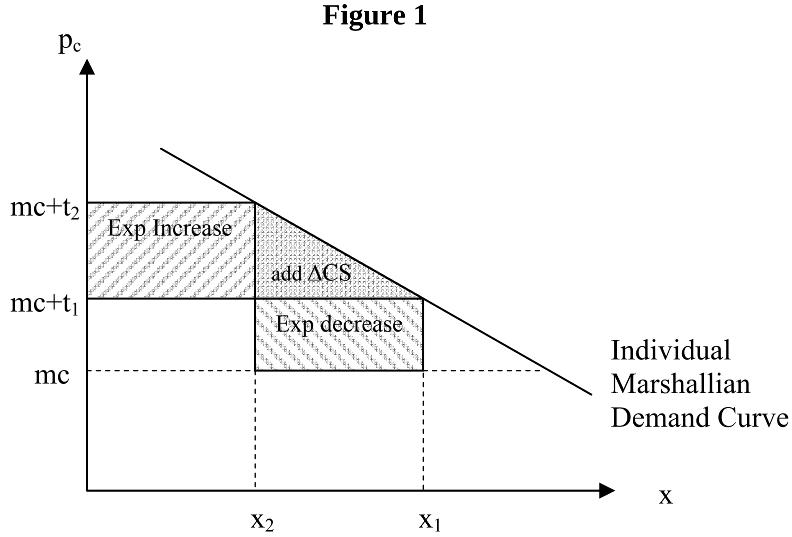
p_c
mc+t_2
Exp Increase
add ΔCS
mc+t_1
Exp decrease
mc
Individual
Marshallian
Demand Curve
x
x_2
x_1

Table 1: Descriptive statistics.
(Robust Standard Errors in Parentheses)

	All income groups	Low Income	Middle Income	High Income
Adult-equivalent income $1997	34,814 (75)	11,127 (18)	26,961 (19)	65,400 (158)
Smoking Prevalence 1993 (%)	23.2 (0.19)	27.9 (0.34)	23.5 (0.32)	17.5 (0.31)
Smoking Prevalence 1996 (%)	22.5 (0.21)	27.4 (0.38)	22.2 (0.35)	17.5 (0.33)
Smoking Prevalence 1999 (%)	20.7 (0.21)	25.5 (0.4)	21.3 (0.37)	15.8 (0.31)
Smoking Prevalence 2001 (%)	19.7 (0.44)	23.3 (0.85)	21.3 (0.8)	15.2 (0.67)
Smoking Prevalence 2002 (%)	19.6 (0.21)	23.8 (0.41)	21.1 (0.39)	14.3 (0.32)
Smoking Prevalence 2003 (%)	18.3 (0.19)	23.1 (0.36)	19.1 (0.34)	13.3 (0.27)
Cigarettes/day Among Smokers 1993	17.4 (0.1)	17.2 (0.2)	17.7 (0.2)	17.5 (0.2)
Cigarettes/day Among Smokers 1996	17.2 (0.1)	16.7 (0.2)	17.6 (0.2)	17.3 (0.2)
Cigarettes/day Among Smokers 1999	16.1 (0.1)	16 (0.2)	16.6 (0.2)	15.7 (0.2)
Cigarettes/day Among Smokers 2001	15.9 (0.3)	16.5 (0.5)	16.3 (0.5)	14.8 (0.5)
Cigarettes/day Among Smokers 2002	15.1 (0.1)	14.9 (0.2)	15.7 (0.2)	14.6 (0.3)
Cigarettes/day Among Smokers 2003	14.8 (0.1)	14.8 (0.2)	15.2 (0.2)	14.4 (0.2)
Less Than High School (%)	16.6 (0.08)	32.6 (0.18)	12.9 (0.13)	4.6 (0.08)
High School (%)	31.8 (0.1)	36.1 (0.18)	36.6 (0.18)	23.0 (0.16)
Some College (%)	27.0 (0.1)	22.5 (0.16)	30.2 (0.18)	28.2 (0.17)
College Degree (%)	16.5 (0.08)	6.8 (0.1)	15.1 (0.14)	27.2 (0.17)
Post-graduate (%)	8.1 (0.06)	2.0 (0.05)	5.1 (0.08)	16.9 (0.14)
Non-Hispanic White (%)	57.4 (0.11)	47.7 (0.19)	60.4 (0.19)	63.9 (0.19)
Non-Hispanic Black (%)	8.3 (0.07)	13.3 (0.14)	7.5 (0.11)	4.3 (0.08)
Non-Hispanic Other (%)	3.1 (0.04)	3.1 (0.07)	2.9 (0.07)	3.2 (0.07)
Hispanic (%)	10.0 (0.07)	16.8 (0.16)	8.4 (0.12)	4.7 (0.09)
Female (%)	52.7 (0.11)	59.6 (0.19)	51 (0.19)	47.6 (0.19)
Married (%)	58.4 (0.11)	42.5 (0.19)	61 (0.19)	71.6 (0.17)
Widowed (%)	7.3 (0.05)	13.4 (0.12)	5.7 (0.08)	2.9 (0.06)
Divorced (%)	10.5 (0.07)	13.1 (0.12)	10.7 (0.12)	7.7 (0.1)
Separated (%)	2.4 (0.03)	4.2 (0.08)	1.9 (0.05)	1.1 (0.04)
Never Married (%)	21.4 (0.1)	26.8 (0.18)	20.8 (0.17)	16.7 (0.15)
Employed (%)	64.8 (0.1)	46.0 (0.19)	69.2 (0.17)	79.1 (0.15)
Unemployed (%)	3.9 (0.05)	6 (0.1)	3.3 (0.07)	2.5 (0.06)
Not In Labor Force (%)	31.2 (0.1)	47.9 (0.19)	27.5 (0.17)	18.4 (0.14)
Service Occupation (%)	8.9 (0.06)	12.4 (0.13)	9.1 (0.11)	5.2 (0.09)
White Collar Occupation (%)	42.2 (0.11)	21.6 (0.16)	41.9 (0.19)	62.5 (0.18)
Blue Collar Occupation (%)	16.2 (0.08)	15.7 (0.15)	20.1 (0.16)	13 (0.13)
Farmer (%)	1.4 (0.03)	2.1 (0.06)	1.3 (0.04)	.7 (0.03)
Soldier (%)	0.017 (0.003)	0.02 (0.006)	0.018 (0.005)	0.012 (0.005)
Never Worked (%)	0.14 (0.009)	0.290 (0.023)	0.085 (0.012)	0.043 (0.009)

Age (years)	45.3 (0.038)	45.8 (0.076)	44.6 (0.065)	45.4 (0.055)
Number Of Children < 6	0.24 (0.001)	0.33 (0.003)	0.24 (0.002)	0.15 (0.002)

Notes to Table 1: High, Middle, and Low Income Groups are the top, middle, and bottom terciles of adult-equivalent income in 1997$. Data is from the CPS match of the TUS and March income supplements.

Table 2: Coefficients of OLS, Probit, Log-linear, and IV Estimation of Two-part model (Standard Errors in Parentheses)						
	LPM and OLS		Probit and Log-linear		Instrumental Variables	
	Smokes (Yes/No)	Cigarettes per day among smokers	Smokes (Yes/No)	Log of Cigarettes per day among smokers	Smokes (Yes/No)	Cigarettes per day among smokers
Price (dollars per cigarette)	-0.555***	-15.464***	-1.778***	-0.647	-0.775***	-15.247***
	(0.112)	(3.442)	(0.420)	(0.451)	(0.281)	(5.812)
Real Daily AE Income	6.354e-03	8.697e-01	4.376e-02	4.217e-02	9.171e-03	7.791e-01
	(1.421e-02)	(8.380e-01)	(6.316e-02)	(1.047e-01)	(1.681e-02)	(9.829e-01)
Real Daily AE Income-squared	9.732e-07***	1.021e-05	2.932e-06***	-9.369e-07	1.108e-06***	1.223e-05
	(1.116e-07)	(8.139e-06)	(4.239e-07)	(1.303e-06)	(1.911e-07)	(1.276e-05)
Income X Price	3.164e-03***	4.612e-02	7.640e-03**	-5.695e-03	3.868e-03***	4.619e-02
	(8.862e-04)	(4.417e-02)	(3.861e-03)	(6.628e-03)	(1.239e-03)	(6.292e-02)
Income-squared X Price	-3.437e-06***	-4.097e-05	-7.725e-06**	7.136e-06	-4.357e-06***	-5.480e-05
	(8.444e-07)	(5.038e-05)	(3.223e-06)	(1.022e-05)	(1.380e-06)	(8.288e-05)
Current Year	3.523e-03	1.601e-01	1.410e-02*	-1.731e-02*	5.116e-03*	1.359e-01
	(2.214e-03)	(1.059e-01)	(8.501e-03)	(1.020e-02)	(2.618e-03)	(1.067e-01)
Year X Income	-3.642e-06	-4.407e-04	-2.339e-05	-2.096e-05	-5.102e-06	-3.954e-04
	(7.147e-06)	(4.221e-04)	(3.176e-05)	(5.269e-05)	(8.467e-06)	(4.957e-04)
High School Graduate	-0.032***	-0.865***	-0.123***	-0.053***	-0.032***	-0.864***
	(0.008)	(0.161)	(0.026)	(0.014)	(0.008)	(0.160)
Some College	-0.077***	-1.922***	-0.278***	-0.172***	-0.077***	-1.921***
	(0.009)	(0.206)	(0.030)	(0.019)	(0.009)	(0.205)
College Graduate	-0.156***	-4.206***	-0.629***	-0.491***	-0.156***	-4.205***
	(0.010)	(0.259)	(0.031)	(0.024)	(0.010)	(0.258)
Some Graduate Education	-0.177***	-5.286***	-0.790***	-0.673***	-0.177***	-5.285***
	(0.010)	(0.371)	(0.033)	(0.044)	(0.010)	(0.370)
Female	-0.041***	-2.778***	-0.160***	-0.167***	-0.041***	-2.779***
	(0.003)	(0.120)	(0.015)	(0.011)	(0.003)	(0.120)
Hispanic	-0.132***	-7.524***	-0.496***	-0.916***	-0.132***	-7.525***
	(0.006)	(0.554)	(0.023)	(0.090)	(0.007)	(0.555)
Non-Hispanic Black	-7.100e-02***	-6.434e+00***	-2.570e-01***	-5.174e-01***	-7.158e-02***	-6.434e+00***
	(8.686e-03)	(2.821e-01)	(2.886e-02)	(2.221e-02)	(8.587e-03)	(2.850e-01)
Non-Hispanic Other Race	-4.421e-02***	-3.849e+00***	-1.692e-01***	-3.828e-01***	-4.481e-02***	-3.848e+00***
	(6.338e-03)	(3.821e-01)	(2.913e-02)	(4.892e-02)	(6.161e-03)	(3.807e-01)
Age	0.511***	38.190***	1.681**	0.888	0.519***	36.197***
	(0.189)	(9.709)	(0.769)	(0.888)	(0.188)	(9.256)
Age squared	-5.616e-03***	-4.577e-01***	-1.649e-02**	-1.833e-02*	-5.706e-03***	-4.359e-01***
	(1.846e-03)	(9.844e-02)	(8.072e-03)	(9.532e-03)	(1.837e-03)	(9.352e-02)

Clean Air Index	-2.848e-03	7.505e-02	-1.281e-02	4.505e-03	-4.641e-03	7.547e-02
	(2.211e-03)	(1.071e-01)	(1.017e-02)	(1.543e-02)	(3.218e-03)	(1.091e-01)
Widowed	6.004e-02***	2.130e-01	2.728e-01***	-3.215e-02	6.001e-02***	2.135e-01
	(3.876e-03)	(3.795e-01)	(1.709e-02)	(3.030e-02)	(3.867e-03)	(3.791e-01)
Divorced	1.297e-01***	1.167e+00***	4.303e-01***	8.252e-02***	1.296e-01***	1.167e+00***
	(5.219e-03)	(1.413e-01)	(1.260e-02)	(1.087e-02)	(5.199e-03)	(1.414e-01)
Separated	1.306e-01***	1.561e-01	4.184e-01***	-2.185e-03	1.304e-01***	1.545e-01
	(5.794e-03)	(2.578e-01)	(2.037e-02)	(3.666e-02)	(5.726e-03)	(2.575e-01)
Never Married	3.966e-02***	-1.807e-01	1.671e-01***	-3.050e-02*	3.970e-02***	-1.815e-01
	(3.544e-03)	(1.589e-01)	(1.254e-02)	(1.809e-02)	(3.540e-03)	(1.590e-01)
Unemployed	9.538e-02***	8.338e-01***	2.850e-01***	1.231e-01***	9.555e-02***	8.328e-01***
	(6.468e-03)	(1.976e-01)	(1.749e-02)	(2.652e-02)	(6.597e-03)	(1.982e-01)
Not in Labor Force	1.862e-02***	1.480e+00***	5.870e-02***	1.039e-01***	1.856e-02***	1.479e+00***
	(4.047e-03)	(1.369e-01)	(1.609e-02)	(1.790e-02)	(4.057e-03)	(1.370e-01)
Related persons in family under 6	-1.255e-02***	-3.786e-01***	-4.612e-02***	-4.905e-02***	-1.261e-02***	-3.795e-01***
	(1.803e-03)	(6.982e-02)	(6.795e-03)	(7.753e-03)	(1.786e-03)	(6.922e-02)
Service Occupation	3.350e-02***	6.940e-01***	9.909e-02***	6.602e-02***	3.352e-02***	6.940e-01***
	(4.311e-03)	(1.232e-01)	(1.282e-02)	(1.766e-02)	(4.316e-03)	(1.231e-01)
Blue Collar Occupation	5.500e-02***	1.660e+00***	1.439e-01***	1.303e-01***	5.496e-02***	1.659e+00***
	(5.418e-03)	(2.169e-01)	(1.454e-02)	(2.151e-02)	(5.424e-03)	(2.170e-01)
Farming Occupation	-9.776e-04	1.048e+00**	-2.415e-02	4.112e-02	-1.192e-03	1.047e+00**
	(9.705e-03)	(4.872e-01)	(3.247e-02)	(4.545e-02)	(9.745e-03)	(4.874e-01)
Soldier	-1.005e-01	-5.278e-01	-3.339e-01	1.628e-01	-9.999e-02	-5.214e-01
	(7.259e-02)	(2.737e+00)	(2.622e-01)	(2.505e-01)	(7.248e-02)	(2.739e+00)
Never Worked	-1.206e-01***	6.793e-01	-3.716e-01***	-1.059e-01	-1.201e-01***	6.744e-01
	(2.582e-02)	(1.734e+00)	(8.939e-02)	(2.135e-01)	(2.579e-02)	(1.734e+00)
Age X Year	-2.496e-04***	-1.877e-02***	-8.134e-04**	-4.177e-04	-2.538e-04***	-1.778e-02***
	(9.460e-05)	(4.857e-03)	(3.854e-04)	(4.444e-04)	(9.426e-05)	(4.630e-03)
Age-squared X Year	2.734e-06***	2.258e-04***	7.893e-06*	8.923e-06*	2.779e-06***	2.148e-04***
	(9.256e-07)	(4.923e-05)	(4.048e-06)	(4.768e-06)	(9.213e-07)	(4.677e-05)
Observations	294693	61176	294693	61176	294693	61176
Adjusted R-squared	0.086	0.152				
Market-level Price Elasticity	-0.206	-0.100	-0.201	-0.082	-0.316	-0.100
Price Elasticity se	0.046	0.015	0.046	0.037	0.149	0.034
Market-level Income Elasticity	-0.183	-0.018	-0.192	-0.018	-0.188	-0.022
Income Elasticity se	0.012	0.006	0.009	0.010	0.008	0.006
PE Tercile 1	-0.243	-0.127	-0.261	-0.102	-0.347	-0.125
PE Tercile 2	-0.196	-0.105	-0.221	-0.090	-0.296	-0.104
PE Tercile 3	-0.115	-0.083	-0.154	-0.082	-0.220	-0.087
Standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%						

Notes to Table 2: All regressions weighted with sample weights. Standard errors of elasticities calculated using the delta method.

Table 3: Distributional effects of a dollar/pack increase in the cigarette excise tax, 2003. (Median individual within tercile)			
	Low Income	Middle Income	High Income
Actual Data			
Cigarette Spending / Income Among Smokers	7.7%	3.1%	1.4%
Tax Spending Among Smokers	$188.8	$201.6	$198.4
Tax Spending / Income Among Smokers	1.9%	0.7%	0.3%
Simulated Smoking Behavior			
Starting Smoking Prevalence	23.0%	20.5%	13.5%
Ending Smoking Prevalence	21.1%	19.2%	13.7%
Change in Smoking prevalence	2.3 points	1.7 points	0.8 points
Starting Cigarettes Smoked Among Smokers	15.8	15.8	14.9
Ending Cigarettes Smoked Among Smokers	15.2	15.3	14.5
Change in Cigarettes Smoked	-0.7	-0.6	-0.5
Simulated Tax Burdens (Among Simulated Smokers)			
Tax Spending / Income In Starting Tax Regime	2.1%	0.8%	0.4%
Tax Spending / Income In Ending Tax Regime	4.6%	1.9%	1.0%
Simulated Changes in Tax Burden			
(Change in Consumer Surplus) / Income	2.3%	1.0%	0.5%
Compensating Variation / Income	2.3%	1.0%	0.5%
Components of Accounting and Welfare Based Measures			
Top Rectangle	$278.2	$281.4	$267.2
Bottom Rectangle	$6.9	$5.4	$2.4
Triangle	$4.4	$3.3	$1.4

Table 4.
Compensating variation as a share of income (%),
unadjusted and adjusted for the benefits of cigarette taxes.

1	2	3	4	5
Income Tercile	Compensating variation / income (%)	$\beta = 0.6$, $\delta = 0.97$, PV life = $7 million	$\beta = 0.9$, $\delta = 0.9$, PV life = $4.2 million	$\beta = 0.6$, $\delta = 0.97$, PV life = $9.9 million
Low	2.3	-0.3	2.2	-1.3
Middle	1.0	-0.6	0.9	-1.3
High	0.5	-0.6	0.4	-1.0

Notes to Table 4: The first column is unadjusted for hyperbolic discounting. Other columns are adjusted using the parameter values shown, and assuming $\lambda = 0.7$, $d = 0.6$, and that the income elasticity of Hs equals 0.5. Negative shares indicate a net benefit from taxes. G&K (2004) argue that the parameters in column 3 best reflect reality.

Appendix: Additional descriptive statistics and regression results for alternative specifications

Table A1: Cigarette Prices and Taxes

Year	Mean Cigarette Price ($1997 cents/pack)	Standard Deviation Cigarette Price ($1997 cents/pack)	Coefficient of Variation of Cigarette Price	Mean Cigarette Tax ($1997 cents/pack)	Standard Deviation Cigarette Tax ($1997 cents/pack)
1993	205.0	20.6	0.10	56.0	13.3
1996	193.5	25.6	0.13	60.8	18.5
1999	240.2	30.6	0.13	63.4	23.6
2001	309.1	37.6	0.12	74.9	28.6
2002	321.9	41.3	0.13	76.0	30.8
2003	341.3	59.0	0.17	95.6	41.2

Notes to Table 2: Data are from the Tax Burden on Tobacco, and refer to the average cigarette price including generic cigarettes. Prices are adjusted to 1997 values using the CPI-all urban consumers.

Table A2: Coefficients of Ordinary Least Squares Estimation of Two-part model Without Time Interactions (Standard Errors in Parentheses)				
	State- and Year-effects		State-effects and Year Trend	
	Smokes (Yes/No)	Cigarettes per day among smokers	Smokes (Yes/No)	Cigarettes per day among smokers
Price (dollars per cigarette)	-0.364***	2.890	-0.510***	-12.038***
	(0.113)	(5.213)	(0.087)	(2.189)
Real Daily AE Income	-8.563e-04***	-4.308e-03	-8.488e-04***	-4.494e-03
	(7.319e-05)	(3.366e-03)	(7.328e-05)	(3.383e-03)
Real Daily AE Income-squared	9.203e-07***	4.882e-06	9.146e-07***	5.064e-06
	(1.015e-07)	(7.169e-06)	(1.017e-07)	(7.260e-06)
Income X Price	2.614e-03***	-5.733e-03	2.595e-03***	-2.307e-03
	(5.885e-04)	(1.918e-02)	(5.852e-04)	(1.931e-02)
Income-squared X Price	-3.061e-06***	-7.053e-06	-3.047e-06***	-1.013e-05
	(7.595e-07)	(4.342e-05)	(7.582e-07)	(4.455e-05)
High School Graduate	-0.032***	-0.861***	-0.032***	-0.859***
	(0.008)	(0.159)	(0.008)	(0.161)
Some College	-0.077***	-1.924***	-0.077***	-1.920***
	(0.009)	(0.205)	(0.009)	(0.206)
College Graduate	-0.156***	-4.204***	-0.156***	-4.206***
	(0.010)	(0.256)	(0.010)	(0.258)
Post-Graduate	-0.176***	-5.271***	-0.176***	-5.268***
	(0.010)	(0.372)	(0.010)	(0.374)
Female	-0.041***	-2.782***	-0.041***	-2.778***
	(0.003)	(0.117)	(0.003)	(0.120)
Non-Hispanic Black	-0.075***	-6.591***	-0.071***	-6.425***
	(0.009)	(0.300)	(0.009)	(0.284)
Non-Hispanic Other Race	-0.048***	-4.026***	-0.044***	-3.844***
	(0.006)	(0.395)	(0.006)	(0.383)
Hispanic	-0.133***	-7.543***	-0.132***	-7.532***
	(0.006)	(0.557)	(0.006)	(0.554)
Age	1.159e-02***	6.707e-01***	1.154e-02***	6.674e-01***
	(5.221e-04)	(3.204e-02)	(5.202e-04)	(3.176e-02)
Age-squared	-1.517e-04***	-6.496e-03***	-1.511e-04***	-6.467e-03***
	(6.292e-06)	(3.697e-04)	(6.280e-06)	(3.653e-04)
Widowed	0.061***	0.228	0.060***	0.221
	(0.004)	(0.383)	(0.004)	(0.376)
Divorced	0.130***	1.175***	0.130***	1.173***
	(0.005)	(0.141)	(0.005)	(0.141)
Separated	0.131***	0.187	0.131***	0.158
	(0.006)	(0.270)	(0.006)	(0.262)
Never Married	0.040***	-0.172	0.040***	-0.190
	(0.004)	(0.158)	(0.004)	(0.158)
Unemployed	0.096***	0.879***	0.095***	0.836***
	(0.006)	(0.204)	(0.006)	(0.200)
Not in Labor Force	0.019***	1.479***	0.019***	1.480***
	(0.004)	(0.135)	(0.004)	(0.135)
Related persons in family under 6	-0.012***	-0.366***	-0.013***	-0.379***
	(0.002)	(0.070)	(0.002)	(0.069)
Service Occupation	0.033***	0.700***	0.034***	0.700***

	(0.004)	(0.126)	(0.004)	(0.125)
Blue Collar Occupation	0.055***	1.645***	0.055***	1.660***
	(0.005)	(0.216)	(0.005)	(0.216)
Farming Occupation	-0.003	0.986**	-0.001	1.059**
	(0.010)	(0.477)	(0.010)	(0.484)
Soldier	-0.101	-0.517	-0.101	-0.417
	(0.073)	(2.743)	(0.073)	(2.820)
Never Worked	-0.120***	0.758	-0.121***	0.646
	(0.026)	(1.693)	(0.026)	(1.721)
Clean Air Index	-0.004	0.009	-0.003	0.080
	(0.002)	(0.109)	(0.002)	(0.106)
Current Year 1996	-0.001	-0.229*		
	(0.003)	(0.135)		
Current Year 1999	-0.007*	-1.175***		
	(0.004)	(0.154)		
Current Year 2001	-0.007	-1.559***		
	(0.010)	(0.412)		
Current Year 2002	-0.013*	-2.251***		
	(0.008)	(0.300)		
Current Year 2003	-0.033***	-3.414***		
	(0.009)	(0.330)		
Current Year			-0.002**	-0.216***
			(0.001)	(0.022)
Observations	294693	61176	294693	61176
Adjusted R-squared	0.086	0.152	0.086	0.151
Price Elasticity	-0.110	0.019	-0.207	-0.101
Price Elasticity se	0.062	0.039	0.046	0.015
Income Elasticity	-0.188	-0.022	-0.186	-0.021
Income Elasticity se	0.008	0.006	0.008	0.006
Price Elasticity, Tercile 1	-0.151	0.025	-0.228	-0.110
Price Elasticity, Tercile 2	-0.107	0.021	-0.193	-0.105
Price Elasticity, Tercile 3	-0.034	0.016	-0.144	-0.120
Robust standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%				

Table A3: Stratified by Income, Model with Time Trend and State Effects

	Probability of Any Smoking			*Quantity of Cigarettes conditional on any smoking*		
	Low income	*Middle Income*	*High Income*	*Low Income*	*Middle Income*	*High Income*
Price (dollars per cigarette)	-0.292**	-0.330***	-0.065	-9.445	-8.295	5.478
	(0.133)	(0.111)	(0.130)	(6.799)	(5.597)	(10.010)
Daily Real Family Income	-2.047e-03***	6.855e-04	-1.917e-04***	2.065e-03	5.655e-02	-9.342e-03***
	(5.431e-04)	(9.797e-04)	(3.189e-05)	(2.474e-02)	(3.790e-02)	(2.987e-03)
Daily RFI squared	6.837e-06	-5.160e-06	1.187e-07***	-6.975e-05	-2.562e-04	8.153e-06***
	(6.242e-06)	(4.373e-06)	(2.749e-08)	(2.791e-04)	(1.695e-04)	(3.107e-06)
High School Graduate	-0.034***	-0.061***	-0.027***	-0.666***	-1.239***	-2.412***
	(0.009)	(0.009)	(0.010)	(0.221)	(0.284)	(0.440)
Some College	-0.070***	-0.114***	-0.084***	-2.208***	-2.711***	-3.915***
	(0.010)	(0.010)	(0.012)	(0.265)	(0.392)	(0.468)
College Graduate	-0.168***	-0.212***	-0.171***	-4.216***	-5.563***	-6.806***
	(0.012)	(0.013)	(0.014)	(0.486)	(0.485)	(0.533)
Some Graduate Education	-0.187***	-0.236***	-0.194***	-5.623***	-5.513***	-7.945***
	(0.013)	(0.013)	(0.014)	(1.065)	(0.753)	(0.728)
Female	-0.067***	-0.045***	-0.036***	-2.735***	-2.771***	-3.468***
	(0.004)	(0.005)	(0.003)	(0.220)	(0.173)	(0.259)
Non-Hispanic Black	-0.088***	-0.068***	-0.033***	-7.160***	-7.112***	-6.002***
	(0.009)	(0.015)	(0.011)	(0.313)	(0.397)	(0.618)
Non-Hispanic Other Race	-0.084***	-0.059***	-0.030***	-4.030***	-3.910***	-4.380***
	(0.017)	(0.011)	(0.006)	(0.562)	(0.630)	(0.532)
Hispanic	-0.190***	-0.146***	-0.070***	-8.773***	-8.161***	-7.256***
	(0.012)	(0.008)	(0.006)	(0.682)	(0.740)	(1.045)
Age	0.014***	0.013***	0.007***	0.757***	0.712***	0.728***
	(0.001)	(0.001)	(0.001)	(0.041)	(0.041)	(0.047)
Age squared	-1.881e-04***	-1.709e-04***	-9.630e-05***	-7.490e-03***	-6.876e-03***	-6.510e-03***
	(9.934e-06)	(8.408e-06)	(1.029e-05)	(4.550e-04)	(4.505e-04)	(5.366e-04)
Clean Air Index	0.006	-0.011***	-0.006**	0.283*	-0.015	0.434
	(0.004)	(0.003)	(0.003)	(0.160)	(0.265)	(0.272)
Year of Interview	-0.000	0.003*	-0.002	-0.110*	-0.143***	-0.366***
	(0.002)	(0.001)	(0.002)	(0.066)	(0.053)	(0.091)
Observations	77281	77280	77277	18891	17957	13040
Adjusted R-squared	0.098	0.060	0.044	0.149	0.138	0.143
Price Elasticity	-0.147	-0.178	-0.052	-0.074	-0.065	0.047
Price Elasticity se	0.068	0.061	0.102	0.054	0.043	0.086
Income Elasticity	-0.250	-0.226	-0.203	-0.011	-0.006	-0.086
Income Elasticity se	0.013	0.043	0.028	0.013	0.032	0.027

Robust, cluster-corrected standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Income Groups are the lowest, middle and highest income terciles using family income. Because family income has not been adjusted for family size, the results in this table are not directly comparable with those of preceding tables.

Table A4:
Median Total Elasticity and Shares of Compensating Variation in Income
By Income Tercile, 2003

	Low Income	*Middle Income*	*High Income*
State Effects			
Elasticity	-0.87	-0.81	-0.84
CV/Income	0.0217	0.0092	0.0045
Year Effects			
Elasticity	-0.59	-0.53	-0.46
CV/Income	0.0219	0.0094	0.0046
State- and Year-Effects			
Elasticity	-0.22	-0.16	-0.05
CV/Income	0.0231	0.0098	0.0049
State-Effects and Year Trend			
Elasticity	-0.48	-0.42	-0.36
CV/Income	0.0228	0.0097	0.0048
State-Effects, Year Trend and Trend-Income Interaction			
Elasticity	-0.52	-0.43	-0.28
CV/Income	0.0229	0.0097	0.0048
State-Effects, Year Trend, and Trend-Income and Income-squared Interactions			
Elasticity	-0.5	-0.43	-0.31
CV/Income	0.0229	0.0097	0.0048
Probit and Log-quantity			
Elasticity	-0.48	-0.42	-0.31
CV/Income	0.0227	0.0096	0.0046
Instrumental Variables			
Elasticity	-0.66	-0.56	-0.43
CV/Income	0.0217	0.0096	0.0046
Zero Price Differences Assumed Among States			
Elasticity	-0.43	-0.29	-0.02
CV/Income	0.0204	0.0088	0.0045
Price Differences Among States Ignored			
Elasticity	-0.54	-0.41	-0.21
CV/Income	0.0199	0.0088	0.0044