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The effect of cigarette prices on youth smoking

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Summary

Prior economic research provides mixed evidence on the impact of cigarette prices on youth smoking. This paper empirically tests the effects of various price measures on youth demand for cigarettes using data collected in a recent nationally representative survey of 17 287 high school students. In addition to commonly used cigarette price measures, the study also examined the effect of price as perceived by the students. This unique information permits the study of the effect of teen-specific price on cigarette demand. The analysis employed a two-part model of cigarette demand based on a model developed by Cragg (1971) in which the propensity to smoke and the intensity of the smoking habit are modeled separately. The results confirm that higher cigarette prices, irrespective of the way they are measured, reduce probability of youth cigarette smoking. There is also some evidence of negative price effect on smoking intensity, but it is sensitive to the price measure used in the model. The largest impact on cigarette demand has the teen-specific, perceived price of cigarettes. Copyright © 2002 John Wiley & Sons, Ltd.

Keywords youth smoking; price effects

Introduction

Smoking is associated with several market failures such as negative externalities and imperfect information of the market participants. The health consequences of smoking result in huge health care expenses partly paid from public funds. In addition, the cost of medical treatment for smokers inflates health insurance premiums for everyone regardless of smoking participation. Lower labor market productivity is another result of engagement in tobacco consumption. These market failures can justify government interventions in the market for tobacco products.

Youth is of particular interest to public policy makers and economists because it is the most effective group to target for smoking prevention programs [1] and because there are some additional externalities associated with youth smoking. Almost all first use of cigarettes occurs during the high school years. At that age, consumers are either not well informed or they do not consciously process information on the health hazards of smoking. In addition, youth typically underestimates the risk of cigarette addiction.

The annual prevalence of cigarette smoking in the United States stabilized in 1990s with approximately 62 million smokers in 1996, which represented 23.2% of the US population [2]. Even though this figure is not high relative to smoking in other countries (the world average smoking prevalence in 1997 was 29% [3]), the declining trend in cigarette consumption from the 1980s ended. It is particularly troubling that the slight decrease in smoking prevalence among adults in the 1990s was accompanied by an increase in smoking participation among youth and young adults. According to

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the Centers for Disease Control and Prevention [4], the number of 12th grade high school students who started smoking as a daily habit jumped from 708 000 in 1988 to 1 200 000 in 1996, an increase of 73%.

There is an economic explanation for this rising trend. Even though the Federal cigarette excise tax was raised twice in the beginning of the1990s, the real cigarette prices in the subsequent period fell. Between 1993 and 1996, the real price of a pack of cigarettes adjusted for inflation fell by 10% [5]. It was partly a result of the Philip Morris Company's decision to reduce the price of Marlboro cigarettes, which was followed by competitive price adjustments by other major cigarette manufacturers. The lower price of Marlboro cigarettes provided an additional economic motivation for youth to increase the demand for cigarettes because Marlboro is the most preferred brand among teenagers. In 1993, Marlboro was the brand of choice for 60% of teenagers, but the overall market share for this brand was only 23.5% [6]. The stable smoking rates of adults in the 1990s and increasing smoking prevalence among youth in the same period would support the hypothesis of higher cigarette price responsiveness of younger age groups.

To discourage the use of tobacco products among the teenage population, public officials adopted numerous anti-smoking policies in the 1990s. The most significant among them are tobacco excise taxes, smoke-free indoor air laws, laws restricting access of minors to tobacco (including retail tobacco licensing), advertising and promotion restrictions on tobacco products, requirements for warning labels on tobacco products, and requirements for product ingredient disclosure.

Not all states were similarly active with respect to these policies, and, over time, the differences between states began to widen. The largest gap developed between tobacco producing and non-producing states. For example, as of 31 December 1999, state excise taxes ranged from 2.5 cents a pack in the state of Virginia to $1 a pack in Hawaii and Alaska [7]. The tax differences motivate smokers to 'shop around' and look for lower cigarette prices in other localities. If the purchase of cigarettes occurs in a low-tax state and the consumption or sale of the product in a high-tax state then the transaction is defined as smuggling.

In the 1990s, the federal government became more actively involved in the enforcement of tobacco related laws. In July 1992, Congress passed the Synar Amendment requiring states to enact and enforce laws that prohibit tobacco sales to consumers under the age of 18. Under the regulations of this Amendment, states must demonstrate (by conducting annual, random, and unannounced compliance checks of retailers selling tobacco products) that age limits access laws are being enforced. Otherwise, they are subject to reductions in their Substance Abuse Block Grant funds.

The United States, with their different prices and public policy measures across states, provide excellent opportunities for health economists to study the effects of prices and other anti-smoking measures on the demand for cigarettes. The main purpose of this study is to evaluate price effects on smoking among young people while controlling for the effect of other tobacco control policies.

Previous research

One of the first micro level studies on the economics of youth smoking appeared in the 1980s. Lewit *et al.* [8] studied the smoking behavior of young respondents (12–17 years old) in years 1966–1970. Using a two-part model they estimated an overall price elasticity of −1.44, which largely exceeded the previous estimates based on the macro data studies. The authors hypothesized that young consumers might be more price responsive than adults because of lower disposable income. They also found that anti-smoking advertising had a negative effect on smoking participation but it did not change the number of cigarettes consumed by smokers.

The study of Lewit and Coate [9] from 1982 confirmed the hypothesis about the higher price elasticity among youth, perhaps also due to shorter smoking history (the addiction to nicotine did not have a chance to fully develop), higher discount rate for future consumption, and the multiplying effect of peer pressure which is stronger for young adults than for older consumers. In addition, the presence of smuggling incentives was found to bias results if not controlled for.

After including state level antismoking regulations in the cigarette demand model, Wasserman *et al.* [10] found insignificant effects

of prices on the amount smoked by young smokers. The result was attributed to a positive correlation between cigarette prices and state tobacco control policies and it suggested that the results of previous studies are biased upwards. However, this conclusion was supported by a relatively small sample with only 1891 respondents.

Chaloupka in his [11–13] publications studied the addictive nature of smoking. He applied his rational addiction model on longitudinal data from the Second National Health and Nutrition Examination Survey (1976–1980). He found adjacent complementarities in cigarette consumption, supporting the hypothesis of rational addiction. Chaloupka also found young adults to be less price sensitive compared to older age groups supporting the results of Wasserman *et al*. (1991). It cast serious doubt on the hypothesis of higher price sensitivity of youth as it was supported by a much larger respondents' sample.

Chaloupka and Grossman [14] used the Monitoring the Future data on 110 717 high school students from 1992 to 1994 to study price elasticities, the effects of smoking restrictions, and the effects of rules limiting youth access to tobacco products. Their two-part model controlled for cigarette excise taxes and estimated price elasticities between −0.846 and −1.450 supporting the hypothesis about higher responsiveness of youth to cigarette price changes.

Chaloupka and Pacula [15] examined the effects of limits on youth access on smoking rates controlling for their enforcement and compliance with them. Using the 1994 Monitoring the Future data the authors estimated the total price elasticity of cigarette demand at −1.141, with the price elasticity of participation −0.618 and the conditional price elasticity −0.523. Most state and local non-tax tobacco control policies did not have statistically significant effects on youth smoking with the exception of relatively strong restrictions. However, the combined effect of all non-tax policies on smoking participation was significant.

The single most consistent conclusion from the economic literature on the demand for cigarettes is that consumers react to price changes according to general economic principles – an increase in price leads to a decrease in consumption. Prices not only control the quantity of cigarettes consumed, but they also affect youth smoking prevalence. While the estimates of price sensitivity vary from study to study, the current consensus for the overall price elasticity of youth cigarette demand centers in the range from −0.9 to −1.5 [16].

Data and methods

The data on cigarette smoking among high school students were collected for the project "The Study of Smoking and Tobacco Use Among Young People" funded by the Robert Wood Johnson Foundation. Audits & Surveys Worldwide (ASW) conducted the survey between March and June of 1996. All 17 287 completed questionnaires were self-administered and participants were assured of the anonymity and confidentiality of their responses.

The original sample of 200 US high schools of all types (public, private, and parochial) was drawn in four parts. The first part represented a core sample of 100 US high schools. The second part was a supplementary sample of 40 schools from areas heavily populated by the African–American population. The third part, also a supplementary sample, consisted of 40 schools from areas heavily populated by the Hispanic population. The last part was drawn from a supplementary sample of 20 schools from high poverty areas.

The core school sample was selected in three stages. In the first stage, a sample of counties was randomly chosen, with probability proportional to population. In the second stage, a sample of schools was drawn from the selected counties, with probability proportional to the number of students enrolled in grades 9 through 12. Then, one class per grade was randomly selected allowing each school to be represented by four classes. All students enrolled in the selected classes constituted the sample of respondents.

Twenty-seven% of the originally selected 200 high schools refused to cooperate or did not respond to the request to conduct the survey. Similar ones based on the original school's demographic profile replaced these schools. In the end, the total number of participating institutions exceeded the originally intended 200 high schools by 2 due to later agreement with schools for which a substitute had already been recruited. Because the survey oversampled schools in African–American, Hispanic, and high poverty communities, different sampling weights were employed to account for this fact.

Four measures of youth cigarette smoking are constructed from the survey data. The first is a dichotomous indicator of smoking participation, assuming a value of 1 if a person smoked at least one day in the last 30 days before the survey, 0 otherwise. This variable defined a smoker for the purpose of this study. There are 27.8% of smokers among the 16 514 students who answered the question about smoking participation. However, when the observations are properly weighted, the estimated smoking prevalence among high school population is 31.4%. This figure is comparable to other nationally representative surveys from the same period [4,17].

The next three measures of smoking are continuous variables and describe the smoking intensity of those qualified as smokers. The intensity variables are: the average number of days during the last 30 days before the survey when the respondent smoked at least one cigarette, the average number of cigarettes smoked in a day when the respondent smoked, and the average number of cigarettes consumed during the last 30 days before the survey. The descriptive statistics of these variables in Table 1 reflect the smoking behavior of high school smokers.

About 34% of smokers in the sampled population smoked daily, but a half of them smoked less than 20 days during a month. They consumed on average 6.5 cigarettes per day, but a half of them smoked 3 or less cigarettes in a day when they smoked. About one-fifth of smokers consumed only 1 cigarette a day. The low median monthly consumption (58 cigarettes or less per month for a half of the smokers) indicates that the majority of the high school smokers still belong to the category of infrequent cigarette users.

One of the unique features of this survey is that it obtained information from both smoking and non-smoking students on their perception of cigarette prices. Two measures of teen-specific local cigarette price in US dollars were constructed from this information: Individually Perceived Price, and Average Perceived Price for a high school. In addition to the perceived prices, three other price measures were matched to the survey based on the location of the respondent's high school. The first is State Average Price (in cents) for a pack of cigarettes, obtained from the Tobacco Institute (TI) [5]. It is a weighted average of single pack, carton, and vending machine cigarette prices in a state, including state excise taxes. Prices of both branded and generic cigarettes are used to compute the average. The second merged price is State Excise Tax (in cents) levied on a pack of cigarettes (also obtained from the TI). The source of the third price measure was the ACCRA Cost of Living Index, a quarterly publication of the American Chamber of Commerce Researchers Association (ACCRA) [18]. It represents an average price (in $) of a carton of Winston cigarettes in selected metropolitan statistical areas (MSA) in the first and second quarters of 1996, respectively. Table 2 summarizes the descriptive statistic for the price measures, and Table 3 informs on their correlation coefficients. Even though all correlation coefficients are significant at least at a 5% level, some associations are not very strong. Cigarette price as reported by students has the smallest correlation coefficients. Students' cigarette price perception is affected by their smoking status, causing endogeneity problem in the model of cigarette demand. Averaging the individual student's answers for each school partly eliminates this problem and improves correlation with the remaining price measures. Still, these correlation coefficients indicate that there are differences between prices reported in the survey and the external price measures. Examining these differences helps to determine suitability of a

Table 1. Descriptive statistics for smoking intensity variables

Variable's name	Mean	Median	Mode	Standard Error
No. of "smoking days"	17.554	19	30 (34.2%)	0. 483
No. of cigarettes/day	6.503	3	1 (20.7%)	0. 265
No. of cigarettes/month	163.335	58	2 (5.2%)	8.673

Source: Computed from the survey data by the author.
Note: Estimates based on 4 348 smokers weighted by sampling weights with 95% response rate.

Table 2. Price measures

Variable	*N*	Mean	Std. error
State average cigarette price per a pack in cents (TI)	16 514	188.985	0.168
State cigarette excise tax per a pack in cents	16 514	36.068	0.122
ACCRA price, 1st quarter	15 328	17.631	0.021
ACCRA price, 2nd quarter	15 328	17.609	0.020
Individually perceived price of a cig. pack in $	15 156	2.381	0.006
Average perceived price of a cig. pack in a high school in $	16 514	2.378	0.002

Source: Computed by the author, from the Tobacco Institute information survey, and from the American Chamber of Commerce.

Table 3. Correlation structure of price measures

	TI price	State tax	ACCRA, 1st quarter	ACCRA, 2nd quarter	Individually perceived price	Average perceived price
TI price	1.000					
State tax	0.930*	1.000				
ACCRA, 1st quarter	0.896*	0.901*	1.000			
ACCRA, 2nd quarter	0.890*	0.871*	0.970*	1.000		
Individually perceived price	0.252*	0.224*	0.220*	0.226*	1.000	
Average perceived price	0.760*	0.675*	0.663*	0.681*	0.300*	1.000

Note: Only observations with all price measures are included. $N = 14679$.
*Correlation coefficient significant at least at 5% level.

particular price measure for the analysis of youth cigarette demand, and to correctly interpret results from the regressional analysis.

One of the primary advantages of the Individually Perceived Price is that it is teen-specific. Young smokers generally differ from adult smokers in brand choices, packaging, points of sales, and sources of cigarettes. Given the relatively low reported monthly cigarette consumption, preferred packaging and usual purchasing places of the survey sample, it can be expected that teens are buying their cigarettes in places with higher average sales prices than an average point-of-sale (used, for example, for computing State Average Price by the Tobacco Institute). Comparing the means of perceived prices with the mean of State Average Price confirms this behavior. The second advantage of perceived prices is that they are local-specific, reflecting the existence of local cigarette taxes and price promotions that are not captured by State Average Prices.

The main disadvantage of perceived prices is their potential endogeneity.[a] Those who smoke have incentives to search for lower cigarette prices, causing a downward bias in the perceived price. On the other hand, smokers may have better information than non-smokers as far as true cigarette prices in the area. The problem of endogeneity was partly alleviated by creating Average Perceived Price across students in a high school excluding the individual's own perception. In order the retain observations on students who did not provide their perception of cigarette price, a school average perceived price (based on the rest of the students who answered the question) was assign to them. Thus individuals within a school who reported cigarette price have slightly different average price measures. Most variation of the Average Perceived Price is attributable to price differences between different school locations.

The advantage of State Average Price is that it is an exogenous, comprehensive measure of cigarette price. It takes into account various brands and various types of sale. However, it represents an average price for an average smoker, including adults, and this price may not accurately reflect prices that high school students face. In addition, State Average Price is not local-specific – it neither includes local cigarette taxes nor local price promotions.

The advantage of State Excise Tax as a price measure is that all cigarette buyers are subject to it.

Moreover, it is the cigarette tax that is a public policy tool used to manipulate prices. The disadvantage is that the state tax is not local-specific; it represents a different portion of the total cigarette price (depending on local prices, the brand of choice and the type of sale) and it is only a small fraction of the total cigarette price. The recent strategy of tobacco companies to run price promotions in states with high excise taxes even weakens the effect of taxes on cigarette consumption.

The main advantage of ACCRA prices is that they are local-specific. This advantage is substantially reduced by the fact that only 28% of high school locations are covered by the ACCRA price information. For the rest of the locations, a price from the closest possible ACCRA location was assigned with information on the quality of the match. The primary disadvantage of the ACCRA price is the choice of cigarette brand (Winston) and of packaging (a carton), neither of which is popular among high school students. Winston is a brand of choice for only 0.9% smokers in the analyzed sample, and cigarettes by cartons are bought by only 4.6% of them.

There are nine additional price related variables matched to the survey. Two of them control for smuggling between states. If the possibility of smuggling is not accounted for, it can lead to an underestimating of the price elasticity of the cigarette demand equation. The first ''smuggling'' variable is defined as the difference between State Average Price in each youth's state of residence and State Average Price in the lowest-price state within 25 miles of the youth's county of residence. If the respondent lives in a county that is more than 25 miles from the state border, or the state across the border has higher cigarette prices, the value of this variable is zero. The second ''smuggling'' variable is defined similarly to the first one but it represents the difference in State Excise Taxes between states for those respondents who live in a county within 25 miles of the neighboring state. The difference between average state prices controls for smuggling in models using State Average Price; the difference between state taxes is used in models employing the other price measures. This approach to modeling smuggling incentives is frequently encountered in the economic literature. It is equivalent to controlling for an interaction term between an indicator for the presence of a nearby state with lower prices and the difference between local and neighboring state prices.

The seven remaining price quality indicators capture the degree of match between the ACCRA price locations and the survey locations. There are three quality-of-match dichotomous variables for each of the two quarters – a perfect match, a match within MSA or county, and a match outside MSA or county but within 100 miles. The seventh variable assumes a value of one if the ACCRA location changes between first and second quarter of 1996, zero otherwise.

Numerous measures describing tobacco control policies were merged with the survey data based on each respondent's location code. These policies can be important determinants of youth smoking. They can also capture state and local sentiment towards smoking and towards youth access to tobacco products, which makes them potentially endogenous. Their exclusion, on the other hand, may lead to an omitted variable bias in the estimates of price coefficients. To improve the quality and precision of the price estimates, all models control for the existence of state and local public policies.

There are two groups of public policies: one imposing smoking restrictions, and the other limiting youth access to tobacco products. Clean Indoor Air (CIA) laws regulate smoking in private workplaces, in restaurants, in shopping areas, and in other places (including government workplaces). Because the existence of these limitations is highly correlated, it was necessary to create a CIA index to avoid the estimate's imprecision and instability resulting from the presence of multicollinearity in the models. The index was constructed by adding up dichotomous indicators representing the existence of a particular CIA restriction. The information on CIA policies was obtained from the Centers for Disease Control and Prevention, CDC (for the state level) [19] and from the Americans for Non-smokers' Rights organization, ANR (for the county and city levels) [20].

Apart from the CIA index, one additional dichotomous indicator controls for a legislative aspect of the Clean Indoor Air laws – the existence of state law preemption over local legislation recorded from State Synar Profiles [21]. Preemption is a law provision (state or federal), which eliminates the power of local (or state and local) governments to regulate tobacco. Preempting local tobacco control with weaker state or federal laws can positively affect demand for cigarettes.

The second group of public policies pertains to Youth Access restrictions on tobacco. Several

previous studies testing these restrictions in a cigarette demand function found very little or insignificant effects of these laws, possibly due to the lack of their active enforcement [14,15]. In order to measure the real effect of Youth Access laws, the data on their enforcement and compliance with them obtained from State Synar Profiles were merged with the survey. A simple regression analysis revealed that compliance with the laws is a positive function of all enforcement measures. Compliance is also a positive function of the two Youth Access indices (one created from the CDC and ANR information, the other obtained from Tobacco Control journal) [22]. Therefore, the models used the level of retailers' compliance with the Youth Access laws as a proxy for the laws' existence and their active enforcement. This approach can reveal whether Youth Access legislation that is complied with has a effect of on youth cigarette demand.

Because some of the dependent variables are of a limited nature, corresponding econometric methods had to be employed. A two-part model of cigarette demand is estimated based on a model developed by Cragg (1971) in which the propensity to smoke and the intensity of cigarette consumption are modeled separately. In the first step, a smoking participation equation is estimated by using a Probit specification for complex survey samples.

The second part of the model estimates smoking intensity (monthly cigarette consumption) only for those who are defined as smokers. Because the error term in this equation is heteroscedastic and not normally distributed, several methods are employed to obtain both results comparable with the existing literature and unbiased estimates of price elasticity. The first approach is based on OLS regression when the natural logarithm of the dependent variable is estimated as a function of a set of independent variables. Converting the dependent variable to its log form deals with its non-linearity by creating a variable more closely following a normal distribution. The majority of studies employing the two-part model use directly the price coefficient from this equation to compute price elasticity. However, an emerging literature suggests that this approach can result in bias in the presence of heteroscedasticity [23,24]. Therefore, the second approach retransforms the results of the OLS regression in order to obtain consistent estimates of price elasticity. The retransformation is done by multiplying raw scale predictions of the dependent variable from the OLS regression by a retransformation factor. This factor is equal to the expected value of the heteroscedastic error term and it is obtained by regressing raw scale residuals from the OLS regression on the whole set of independent variables. The third approach uses the generalized linear model (GLM). A diagnostic Park Test for correct distributional function suggested the use of a gamma family distribution with a log link function for GLM [25,26]. Computing price elasticity estimates by all three methods allows assessment of the extent to which heteroscedasticity of the error term affects the results.

The cigarette demand model controls for basic socio-demographic characteristics of an individual, various income variables, smuggling incentives, Clean Indoor Air laws (by an index reflecting both state and local restrictions), preemption of local laws, Youth Access laws (by the compliance proxy), and for cigarette prices. The estimates are obtained using the complex survey capacity of STATA software.

An analysis evaluating the effects of an aggregate variable (such as State Average Price) on micro level data (e.g. smoking among survey participants) can bias estimates of standard errors downward if individual disturbances are not independent within a group. Even though this interdependence does not bias coefficients, not accounting for it can lead to spurious findings of statistical significance of aggregate regressors (aggregate price measures and public policies in this case). To avoid this bias, the *t*-values are adjusted for clustering at the state level using the STATA cluster form of Huber–White variance estimator, which is robust both to heteroscedasticity and to within-cluster dependence. The state level clustering option controls for the multiple levels of clusters because the STATA variance estimator used for complex sampling surveys allows any amount of correlation or clustering within the primary sampling units. This estimator is more robust compared to those explicitly accounting for secondary sampling, because they rely on more assumptions [27].

For all models, the effect of price is expressed as price elasticity. It is possible to compute three types of price elasticity from the two-part model: participation (or prevalence) price elasticity, conditional demand (or consumption intensity) price elasticity, and total price elasticity. Participation price elasticity is computed using the average of

the partial derivatives from the Probit regression models. It represents the%age change in the prevalence of smoking at the personal level caused by a 1% change in price of cigarettes.

Conditional demand price elasticity is calculated by three different methods: using simple OLS log-linear estimates, using retransformed results from the OLS log-linear regression, and by using price coefficients from the generalized linear model with a gamma family distribution and log link function. The conditional demand price elasticity measures the%age change in the average number of cigarettes at the personal level smoked by those who continue to smoke even after a 1% change in the cigarette price.

Total price elasticity was calculated by two different methods. The first method was applied to the results from the two-part model without retransformation. In this case, total price elasticity is a sum of participation and conditional price elasticities. These estimates enable comparison with similar estimates in the literature where this simple approach is frequently used when two part models are employed.

The second method takes into account that both the probability of smoking and smoking intensity are represented by non-linear functions. The slope used for computing the total elasticity is the average of the sum of the partial derivative of smoking probability multiplied by conditional demand and the partial derivative of smoking intensity among smokers multiplied by the probability of smoking. This slope represents the marginal effect and it is evaluated at the sample means.

Results

Table 4 displays the effects of the six price measures on smoking participation among high school students. Each line of the table represents one model of smoking participation, which differs from the others by the price measure employed in the equation. The Probit coefficients (with *t*-values in parentheses) are adjusted for clustering; the marginal effects indicate how the chance of a person becoming a smoker changes if the price is changed by one unit. Participation price elasticities for each model are computed from the average of marginal effects, average prices and average smoking participation.

Price has a negative effect on smoking participation independent of the selected price measure. However, there are differences in terms of the statistical significance of the results and elasticities computed for different prices. The smallest participation price elasticities were computed for state excise tax and for ACCRA prices, a possible result of these price measures' weaknesses described above. In addition, the quality-of-match indicators for the ACCRA prices are statistically significant, indicating that the quality of price match is important for obtaining accurate estimates. The difference between price elasticities computed for

Table 4. Participation price effects

Price	Coefficient	Marginal effect	Elasticity
State average cigarette price	−0.0018*	−0.0006*	−0.351*
	(−1.71)	(−1.72)	
State cigarette excise tax	−0.0013	−0.0004	−0.255
	(−1.04)	(−1.04)	
Individually perceived price	−0.3033*	−0.0976*	−0.703*
	(−10.26)	(−10.99)	
Average perceived price	−0.2070*	−0.0657*	−0.492*
	(−2.40)	(−2.41)	
ACCRA price, 1st quarter	−0.0120	−0.0038	−0.213
	(−1.25)	(−1.25)	
ACCRA price, 2nd quarter	−0.0166*	−0.0053*	−0.297*
	(−1.69)	(−1.68)	

Note: The numbers in parentheses are *t*-values. The critical values are 1.64 and 1.28 at the 5 and 10% significance levels, respectively, based on a one-tailed test. Constant included.
*Variable significant at 5% level based on one-tailed test after its standard error was adjusted for clustering.

the ACCRA 1st and 2nd quarter prices also suggests that the use of this price measure is questionable for the data at hand.

Table 5 summarizes the effects of the six price measures on the number of cigarettes consumed during a month if a student continues to smoke even after the cigarette price has been changed. The first two lines for each price measure summarize results from the log-linear model of smoking intensity; the third line represents results from the Generalized Linear Model. The coefficients (with their *t*-values in parentheses) are adjusted for clustering and represent marginal effects on log-scale monthly cigarette consumption. The price elasticities of conditional demand in the last column were computed differently based on the methods of obtaining marginal effects. The first result for each price was obtained by multiplying the average of marginal price effects on the log-scale dependent variable by the average cigarette price. This estimate allows comparison with most of the existing literature. The second approach augments the first method by taking into account the heteroscedastic nature of the error term in the log-scale equation and adds the relative marginal price effect on the retransformation factor to the elasticity formula. The third method is similar to the first one except it uses marginal price effects from the Generalized Linear Model.

The results demonstrate that price also has a negative effect on smoking intensity regardless of the model. However, the magnitude of the price effect and its statistical significance are affected by the price measure and the estimating method. It seems that ignoring the heteroscedasticity of the error term overestimates the price elasticity compared to the retransformed OLS and GLM models, which produce comparable results. Price elasticities of external price measures are lower compared to their effects in the first part of the model; perceived prices split their effect almost equally between participation and smoking intensity. With the exception of State Excise Tax and GLM for external price measures, the results are statistically significant. As in the first part of the model, the perceived prices have the largest impact, and there is a difference between 1st and 2nd quarter ACCRA results. The estimates cast doubt on the use of taxes (the only price measure with all results statistically insignificant) and ACCRA prices (results for consecutive quarters differ and quality-of-match indicators are statistically significant) as appropriate price measures for the analysis of the data at hand.

Table 6 lists three total price elasticity estimates for each price measure. These elasticities are computed as the sum of the price elasticity of participation (Probit models) and the price elasticity of the conditional demand in the case of the simple OLS model. A non-linear formula for total elasticity described above was applied to obtain estimates for the remaining two models – the OLS retransformation model and the GLM model. Both measures of perceived price exhibit the largest total price elasticities and suggest that the demand for cigarettes is price-elastic. The models using the less endogenous perceived price and taking into account the heteroscedastic nature of the error term predict that a 1% increase in average perceived price will decrease smoking among high school students by about 1%. The total price elasticity of State Average Price is about two-third of this magnitude. The current-literature elasticity estimates for young smokers range from -0.9 to -1.5, but these studies usually do not address the issue of the heteroscedastic error term. The corresponding total price elasticity estimates based on State Average Price and Average Perceived Price lie between -0.99 and -1.71, which is only slightly higher than that the range agreed upon among health economists.

To summarize the price effect, it is larger for perceived prices than for the conventional price measures such as State Average Price. In addition, the price effect on youth smoking would be overestimated if the heteroscedastic nature of the error term in this data were not taken into account.

The performance of other variables of interest is summarized in Table 7. Each column represents one model using the price measure indicated by the column heading. Results for the probability of smoking participation are summarized in the top part of the table; the bottom part shows results for the conditional demand estimated by GLM.

The index representing Clean Indoor Air (CIA) laws has a negative coefficient in both parts of the model, independent of the price measure. However, the results are statistically significant only in the first part of the model using ACCRA prices. A possible interpretation of the lower statistical significance of these measures is that the selected restrictions are less important to high school students. For example, it can be expected that smoking restrictions in private or government

Table 5. Conditional demand price effects

Price	Method	Coefficient/marginal effect	Elasticity
State average cigarette price	OLS	−0.003* (−1.39)	−0.641*
	OLS, retransformation	−0.001* (−1.39)	−0.138*
	GLM	−0.001 (−0.67)	−0.199
State cigarette excise tax	OLS	−0.003 (−0.82)	−0.503
	OLS, retransformation	−0.0005 (−0.82)	−0.088
	GLM	−0.001 (−0.36)	−0.145
Individually perceived price	OLS	−0.503** (−6.38)	−1.094**
	OLS, retransformation	−0.323** (−6.38)	−0.703**
	GLM	−0.358** (−5.98)	−0.779**
Average perceived price	OLS	−0.521** (−2.46)	−1.215**
	OLS, retransformation	−0.223** (−2.46)	−0.521**
	GLM	−0.241** (−1.73)	−0.562**
ACCRA price, 1st quarter	OLS	−0.024* (−1.33)	−0.418*
	OLS, retransformation	−0.004* (−1.33)	−0.072*
	GLM	−0.007 (−0.55)	−0.124
ACCRA price, 2nd quarter	OLS	−0.034** (−1.65)	−0.590**
	OLS retransformation	−0.007** (−1.74)	−0.121**
	GLM	−0.012 (−0.87)	−0.204

Note: The numbers in parentheses are *t*-values. The critical values are 1.64 and 1.28 at the 5 and 10% significance levels, respectively, based on a one-tailed test. Constant included.
*Variable significant at 10 % level based on one-tailed test after its standard error was adjusted for clustering.
**Variable significant at 5 % level based on one-tailed test after its standard error was adjusted for clustering.

workplaces will not affect the smoking behavior of a person who is a full time student. There is also a possibility of measurement error in the CIA variable, particularly with respect to restrictions at local levels, and this error can bias coefficients towards zero.

The coefficient of the Preemption variable, which controls for non-existence of local tobacco controls, is positive irrespective of the model, and statistically significant in four out of six smoking participation equations. It can be interpreted as local laws creating (more effectively than state

Table 6. Total price elasticity

Method	State average price	State excise tax	Individually perceived price	Average perceived price	ACCRA price, 1st quarter	ACCRA price, 2nd quarter
OLS	−0.992**	−0.758	−1.797**	−1.707**	−0.631	−0.887**
OLS, retransformed	−0.670**	−0.353	−1.514**	−1.020**	−0.294*	−0.430**
GLM	−0.722*	−0.393	−1.493**	−0.997**	−0.333	−0.490*

*Variable significant at 10% level based on one-tailed test after its standard error was adjusted for clustering.
**Variable significant at 5% level based on one-tailed test after its standard error was adjusted for clustering.

Table 7. Coefficients of public policies and smuggling variables

Model Variable	State average price	State excise tax	Individually perceived price	Average perceived price	ACCRA price, 1st quarter	ACCRA price, 2nd quarter
Smoking probability – PROBIT						
CIA index	−0.008	−0.015	−0.004	−0.008	−0.020*	−0.022*
	(−0.38)	(−0.79)	(−0.18)	(−0.42)	(−1.30)	(−1.49)
Preemption	0.118**	0.106**	0.086*	0.098**	0.062	0.061
	(2.17)	(2.06)	(1.50)	(1.84)	(1.20)	(1.22)
Compliance	−0.310**	−0.355**	−0.329**	−0.334**	−0.509**	−0.502**
	(−1.87)	(−2.10)	(−1.78)	(−1.82)	(−2.96)	(−3.11)
Smuggling	0.003**	0.005**	0.006**	0.005**	0.005**	0.005**
	(3.00)	(3.36)	(4.317)	(4.11)	(3.77)	(3.95)
Conditional demand – GLM						
CIA index	−0.023	−0.026	−0.002	−0.018	−0.010	−0.009
	(10.54)	(−0.60)	(−0.05)	(−0.47)	(−0.24)	(−0.21)
Preemption	0.019	0.017	0.046	0.010	0.008	0.009
	(0.21)	(0.18)	(0.49)	(0.11)	(0.09)	(0.09)
Compliance	−0.116	−0.142	0.039	−0.072	−0.076	−0.057
	(−0.31)	(−0.40)	(0.12)	(−0.20)	(−0.19)	(−0.14)
Smuggling	−0.0004	−0.001	−0.001	0.0002	−0.001	−0.001
	(−0.23)	(−0.44)	(−0.45)	(0.08)	(−0.39)	(−0.29)

Note: The numbers in parentheses are *t*-values. The critical values are 1.64 and 1.28 at the 5 and 10% significance levels, respectively, based on a one-tailed test. Constant included.
*Variable significant at 10% level based on one-tailed test after its standard error was adjusted for clustering.
**Variable significant at 5% level based on one-tailed test after its standard error was adjusted for clustering.

laws) an atmosphere where smoking is a behavior of lower social acceptance. The hypothesis about tobacco control policies being a reflection of local sentiment toward tobacco would correspond to this finding.

Retailers' compliance with Youth Access laws, which serves as a proxy for the laws' existence and their active enforcement, has a negative and statistically significant effect on smoking participation in all estimated models. The results suggest that the previous findings of insignificant effect of these measures might have been affected by the failure to control for actual compliance with these laws. Limiting youth access to cigarettes may also reduce smoking intensity among young smokers (with the exception of one model), but the results are not statistically significant. The estimates of the Youth Access laws' effects are subject to the assumption that the compliance variable is not endogenously influenced by local sentiment towards smoking.

The variable controlling for smuggling has the expected positive effect on smoking participation, but exhibits insignificant impact on smoking intensity. Smuggling incentives may not affect the

intensity of the smoking habit among high school students because they are less mobile and buy smaller numbers of cigarettes compared to adult smokers. It makes cigarette shopping outside the state less attractive. However, the smuggling incentives may affect youth smoking participation indirectly through higher adults smoking, which increases peer pressure and enhances social sources of cigarettes.

The estimates of the socioeconomic and demographic determinants of cigarette demand are presented in Table 8 (the model with State Average Price). The results show that both the probability of becoming a smoker and monthly cigarette consumption raise with age. Female high school students are more likely to smoke than their male counterparts, but men smoke with higher intensity once they decide to pursue the habit. White students are more likely to smoke than Black, Hispanic and Asian students, and they also smoke more cigarettes in a month. Black students are the least likely to smoke and if they do, they smoke the smallest amount of all races.

Frequent attendance at religious services has a strong inverse relationship with smoking, and even weaker religiosity reduces smoking intensity. Living arrangement is another important determinant of smoking participation and conditional demand for cigarettes. Those who live alone have a higher probability of smoking, and if they already smoke, they consume more cigarettes compared to those who live with parents. An incomplete family where the parents are either separated or divorced, or one of them is deceased, also positively affects youth smoking. Parental educational attainments, which can serve as a proxy for the family income, is mostly not significant for smoking decision with the exception of more educated fathers who may have a negative influence on their children's smoking participation. On the other hand, the youth's personal income as described by the number of hours worked and by the amount of pocket money, has positive and significant effect on cigarette demand.

Summary

The results of this analysis indicate that higher cigarette prices would result in substantial reductions in both smoking participation and average cigarette consumption among high school students. For example, if state average prices rise by $0.50 (i.e. 26.5%), youth cigarette demand can decline by 17.8 to 19.1%: participation would drop from 31.4 to 28.5% and the average monthly consumption among smokers would decrease from 163 to 157 or 154 cigarettes.

The choice of price variable and the method of computing price elasticity affect the predicted reaction among high school smokers. Given each price measure's advantages, disadvantages and their subsequent performance in the cigarette demand equation, the most appropriate prices for the data-at-hand are State Average Price and Average Perceived Price. In order to avoid bias in estimating price coefficients, the correct method for estimating price elasticity takes into account the heteroscedastic nature of the error term.

Based on the preferred model specification, the estimated total price elasticity of cigarette demand fell between -0.67 and -1.02. The estimates support the hypothesis that youth is more price responsive than adults in their demand for cigarettes (adults' price elasticity usually falls in a range of -0.3 to -0.5 [28]). A unique contribution of this study to the economic literature is that it compared responsiveness of high school students to youth specific and to more commonly used state average prices. Adolescents were found to be more responsive to youth specific cigarette price than to overall average state price. If the perceived prices accurately reflect the prices youth is paying for their cigarettes, the price elasticity of this consumer group is even higher than previously thought. The second major finding of this analysis is that the heteroscedastic nature of the error term in the two-part model, which is frequently used to analyze cigarette demand, can bias the elasticity estimates upwards.

The effect of public policies on youth smoking was measured by high school students' reaction to Clean Indoor Air laws and to Youth Access laws. The laws restricting smoking in various places (CIA laws) have a negative effect on both smoking probability and smoking intensity among the studied group. However, the effect is not statistically significant at conventional levels, which can be explained by the lower importance of the selected laws for population enrolled full time at school.

Using the actual level of retailers' compliance as a proxy for the existence of laws limiting youth access to cigarettes is a unique approach eliminating the necessity to control for the law enforcement. The lack of active enforcement is

Table 8. Effect of the socioeconomic and demographic determinants on cigarette consumption

Variable	Probit, marginal effect	GLM, marginal effect
Age	0.011**	0.076**
	(2.10)	(2.35)
Male (Female left out)	−0.017**	0.091
	(−2.15)	(2.19)
Black (White left out)	−0.180**	−0.891**
	(−13.25)	(−4.98)
Hispanic (White left out)	−0.074**	−0.751**
	(−5.99)	(−9.56)
Asian (White left out)	−0.133**	−0.065
	(−8.87)	(−0.25)
Other race (White left out)	−0.026	0.017
	(−1.21)	(0.14)
Infrequent religious services	0.002	−0.243**
(No services left out)	(0.20)	(−5.54)
Frequent religious services	−0.088**	−0.539**
(No services left out)	(−5.62)	(−9.75)
Live with others	−0.003	−0.032
(Live with parents left out)	(−0.14)	(−0.21)
Live alone	0.127**	0.470*
(Live with parents left out)	(2.57)	(1.60)
Live in city	−0.008	0.014
(Live in town, village left out)	(−0.56)	(0.26)
Live in suburbs	−0.010	−0.053
(Live in town, village left out)	(−0.57)	(−0.72)
Parents never married	0.018	0.102
(Parents married left out)	(0.90)	(0.74)
Parents separated	0.053**	0.278**
(Parents married left out)	(2.13)	(2.18)
Parents divorced	0.069**	0.206**
(Parents married left out)	(5.50)	(3.52)
Both parents deceased	0.036	0.146
(Both parents alive left out)	(0.70)	(0.41)
Farther deceased	0.017	0.450**
(Both parents alive left out)	(0.61)	(3.37)
Mother deceased	0.089**	0.638**
(Both parents alive left out)	(1.96)	(1.77)
Father completed high school	−0.019	−0.048
(Father less than HS left out)	(−1.27)	(−1.69)
Father has some college	−0.038**	−0.084
(Father less than HS left out)	(−2.54)	(−1.02)
Father completed college	−0.024*	−0.136
(Father less than HS left out)	(−1.54)	(−1.17)
Father more than college	−0.013	−0.079
(Father less than HS left out)	(−0.60)	(−0.96)
Mother completed high school	0.016	0.063
(Mother less than HS left out)	(1.11)	(0.63)
Mother has some college	0.0002	−0.023
(Mother less than HS left out)	(0.01)	(−0.20)
Mother completed college	0.015	−0.162*
(Mother less than HS left out)	(0.86)	(−1.40)
Mother more than college	0.015	−0.066
(Mother less than HS left out)	(0.73)	(−0.41)
Father not working	0.023*	0.239**
(Father working left out)	(1.63)	(2.54)
Mother not working	−0.015	0.187**
(Mother working left out)	(−1.16)	(3.01)
Average hours worked per week	0.003**	0.009**
	(6.02)	(3.77)
Pocket money per week	0.001**	0.002**
	(5.44)	(4.20)

*Variable significant at 10% level based on one-tailed test after its standard error was adjusted for clustering.
**Variable significant at 5% level based on one-tailed test after its standard error was adjusted for clustering.

frequently cited as the reason for mixed findings with respect to these measures. This study found that the compliance level has a negative and statistically significant effect on the probability of smoking regardless of model specification suggesting that Youth Access laws are an important component of public policies designed to curb youth smoking.

Preemption of local laws by state legislation may have a positive effect on smoking probability. However, this finding, as well as findings regarding other public policies, is subject to the condition that a policy does not reflect state sentiments towards smoking. In that case, the interpretation of a policy's effect can be problematic. Nevertheless, their inclusion in the cigarette demand equation alleviates a potential omitted variable bias with respect to price estimates.

It will be interesting to follow smoking trends in the US at the turn of the century when cigarette prices are rising thanks to the $206 billion settlement with the tobacco industry. If the predictions of this settlement are correct and state average cigarette prices increase from 25 to 45 cents over the next 25 years, then youth smoking will decline by 13.4 to 25.1% using the Average Per-ceived Price elasticity estimate, or by 6.5 to 13.1%, using the State Average Price elasticity estimate.

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Note

a. A statistical test for the endogeneity of the perceived price variable cannot be performed because the second equation of the system with the perceived price as the dependent variable cannot be identified.

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