

# **Cigarette Consumption by U.S. Men**

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## Cigarette Consumption by U.S. Men

### **Abstract**

Heckman's sample selection model is derived from maximization of a utility function with stigma and health concern effects. The model outperforms the Tobit model and suggests that social stigma and health concerns play important roles in cigarette consumption.

There is a long-standing interest in public policies of cigarette smoking. The Surgeon General has warned of the risk of cigarette smoking as the single most important preventable cause of death in our society (U.S. Department of Health and Human Services). In 1996 an entire issue of *JAMA* was devoted to tobacco, resulting in media headlines. Amidst presidential politics, President Clinton on August 23, 1996 endorsed the Food and Drug Administration's scheme to regulate nicotine as an addictive drug. The issues of tobacco advertising were also the subjects of recent supreme court rulings. With so much public attention to cigarette smoking, public policies on smoking intervention remain both timely and important, and information on the factors affecting cigarette smoking is crucial to formulation and implementation of these policies.

Recent studies of cigarette demand have utilized microdata in the estimation of cigarette demand (Jones 1989, 1994; Labeaga; Mullahy). The use of microdata allows the investigation of the effects of detailed demographic characteristics on smoking that are otherwise not possible in aggregate time series. However, a common feature of micro data is that the sample often contains observations in which the dependent variable is zero. This problem of censoring needs to be addressed in empirical analysis.

Most microeconomic studies of demand for cigarettes seem to have settled with the premise that consumption is subject to two decisions: whether to consume and how much to consume (Jones 1989, 1994; Mullahy). Beside economic reasons, other factors like health concerns and social stigma may also have deterring effects on cigarette smoking. With the wide-spread public-health campaigns by the government, public, and non-profit organizations, the concerns for health and physical well-being may stop a

nonsmoker from starting smoking and cause a current smoker to smoke less or quit.

Likewise, smoking bans in public facilities and public resistance to smokers in the work place make cigarette smoking a personally inconvenient and socially stigmatic act.

In this paper, we adopt a theoretical model to explore the role of social stigma and health concerns in consumer choice. The formulation provides a micro foundation for Heckman's sample selection model. In the absence of stigma effects the sample selection model reduces to the Tobit model. We estimate these alternative models using cross-sectional survey data from the United States, and test the hypothesis that social stigma and health concerns play a role in cigarette smoking.

### **Social Stigma, Health Concerns, And Cigarette Smoking**

We draw on an economic model with “welfare stigma” (Moffitt). Consider the number of cigarettes  $C$  with price  $m$ , a composite commodity for all other goods  $N$  with price normalized to unity, and total budget  $Y$ . Our premise is that, due to social stigma and health concerns, disutility results from participating in smoking and also from smoking additional amount. Define a binary variable  $P \in \{0,1\}$  which equals one if the individual “participates” in smoking (i.e.,  $C > 0$ ) and zero otherwise. Then, the utility function is

$$(1) \quad U = U(N, P^\gamma C) - P\psi,$$

where  $\gamma$  and  $\psi$  are the stigma parameters. Assume that, in the case of  $P = 1$ , the utility function (1) is regular strictly quasi-concave and has positive first partial derivatives. If  $\psi > 0$ , participation in cigarette smoking brings disutility. If  $0 < \gamma < 1$ , then both utility ( $\gamma > 0$ ) and disutility ( $\gamma < 1$ ) result from smoking additional cigarettes. The individual

maximizes the utility function (1) subject to the budget constraint  $N + mC = Y$  by choosing the values of  $N$ ,  $C$ , and  $P$ . That is,

$$(2) \quad \underset{N,C,P}{\text{Maximize}} \quad [U(N, \gamma PC) - \psi P \mid N + mC = Y].$$

Following Moffitt and Scott and Garen, the constrained utility maximization problem (2) with discrete variable  $P$  can be solved by finding the values of  $N$  and  $C$  holding  $P$  constant and then determining the value of  $P$ . Solving the first-step problem yields

$$(3) \quad \gamma P U_C / U_N = m,$$

which leads to the notional demands for  $N$  and  $C$ :

$$(4) \quad \begin{aligned} N^* &= N(Y, m, \gamma P), \\ C^* &= C(Y, m, \gamma P). \end{aligned}$$

These notional demands are results of constrained utility maximization without non-negativity constraints and without the flat stigma effect ( $\psi$ ). If  $C^* > 0$ , then  $C^*$  is the number of cigarettes observed; if  $C^* < 0$  then the number of cigarettes smoked is censored at zero. With the flat stigma effect ( $\psi$ ) resulting from social stigma and health concerns, the first-step solution (4) is no longer utility maximizing, for even if  $C^* > 0$ , the individual will not smoke unless the utility gain from smoking exceeds the utility loss. Thus, smoking occurs if and only if  $C^* > 0$  and

$$(5) \quad U(N^*, \gamma C^*) - \psi - U(Y, 0) > 0,$$

where the left-hand side of (5) represents the net utility gain from cigarette smoking.

To further develop the econometric model of cigarette demand with social stigma and health concerns, consider the reservation price of cigarette  $m^o$  and reservation

consumption  $C^o$ . The reservation price  $m^o$  is that level of price at which the net utility gain from cigarette smoking is zero and therefore can be derived by solving

$$(6) \quad U(N(Y, m^o, \gamma), C(Y, m^o, \gamma)) - \psi - U(Y, 0) = 0.$$

Thus, the reservation price  $m^o$  is a function of income and stigma parameters:

$$m^o = m^o(Y, \gamma, \psi).$$

The level of  $C$  at price  $m^o$  is the reservation consumption:

$$(7) \quad C^o = C(Y, m^o, \gamma) = C(Y, m^o(Y, \gamma, \psi), \gamma).$$

In the usual case when  $\psi = 0$ , the reservation consumption  $C^o = 0$  by definition.

However, because of the monotonicity assumption on the utility function,  $C^o > 0$  when  $\psi > 0$ . If the reservation price exceeds the actual price, i.e.,  $m < m^o$ , then  $C^* > C^o$  and positive consumption occurs. On the other hand if the actual price exceeds the reservation price ( $m > m^o$ ), then  $C^* < C^o$  and consumption equals zero.

Denote as  $x$  the vector of income and other variables affecting the variable stigma parameter  $\gamma$ . The price,  $m$ , does not vary in the sample we use so it is included in the constant term. Also, let random error  $u$  reflect unobservables including those affecting  $\gamma$ . Then, the first-order linear approximation to  $C^*$  is

$$(8) \quad C^* = x'\beta + u,$$

where  $\beta$  is a conformable parameter vector. The reservation consumption (7) suggests that it is affected by income and other factors that affect the stigma parameters  $\gamma$  and  $\psi$ , which is the vector  $x$ . Since both  $\gamma$  and  $\psi$  determine the reservation consumption in (7) it

is expected that both  $x$  and the unobservables affect  $C^o$  differently from they affect  $C^*$ , so we use a different parameter vector and a different error term in the reservation consumption equation. Therefore, a first-order linear approximation to  $C^o$  is

$$(9) \quad C^o = x'\alpha + v,$$

where  $\alpha$  is a conformable parameter vector and  $v$  is a random error. The above discussion suggests a censoring rule in which consumption occurs if  $C^* > C^o$ , that is, if  $x'\beta + u > z'\alpha + v$ ; and zero otherwise. Define the parameter vector  $\delta = \beta - \alpha$  and error term  $\eta = u - v$  with constant and non-zero variance. Then the censoring rule can be stated as

$$(10) \quad \begin{aligned} C &= x'\beta + u & \text{if } x'\delta + \eta > 0, \\ &= 0 & \text{if } x'\delta + \eta \leq 0. \end{aligned}$$

Assuming a bivariate normal distribution for the error terms  $[\eta, u]'$ ,

$$(11) \quad \begin{bmatrix} \eta \\ u \end{bmatrix} \sim N\left(0, \begin{bmatrix} 1 & \rho\sigma \\ \rho\sigma & \sigma \end{bmatrix}\right).$$

the likelihood function can be written as (Heckman 1976, 1979)

$$(12) \quad L = \prod_{C=0} [1 - \Phi(z'\alpha)] \prod_{C>0} \Phi\left\{\left[z'\alpha + \rho\left(\frac{C - x'\beta}{\sigma}\right)\right] / (1 - \rho^2)^{1/2}\right\} \frac{1}{\sigma} \phi\left(\frac{C - x'\beta}{\sigma}\right),$$

where  $\Phi$  and  $\phi$  are the cumulative distribution function and probability density function of the univariate standard normal. This was the model used by Scott and Garen in estimating lottery demand.

Without stigma factors and health concerns, the stigma parameters  $\gamma = 1$  and  $\psi = 0$ . In this case, the reservation consumption  $C^o = 0$  by definition and the censoring rule is



$$(13) \quad \begin{aligned} C &= x'\beta + u & \text{if } x'\beta + u > 0, \\ &= 0 & \text{if } x'\beta + u \leq 0. \end{aligned}$$

With normality assumption of  $u$ , this is the Tobit model (Tobin), with likelihood function

$$(14) \quad L = \prod_{C=0} \left[ 1 - \Phi\left(\frac{x'\beta}{\sigma}\right) \right] \prod_{C>0} \frac{1}{\sigma} \phi\left(\frac{C - x'\beta}{\sigma}\right).$$

Thus, although the flat and variable stigma parameters  $\gamma$  and  $\psi$  are not estimable and separable, whether social stigma and health concerns play a role is a testable hypothesis and can be investigated by testing the Tobit against its more generalized alternative. Since the Tobit is not nested in Heckman's model, selection between the two models can be accomplished using the nonnested test of Vuong. In particular, let  $f$  and  $g$  be  $n$ -vectors containing the log-likelihoods of the two competing models,  $\mathbf{1}$  be an  $n$ -vector of ones, and define  $d = f - g$ . Then, Vuong's standard normal statistic (Vuong, eq. (5.6)) can be calculated as  $z = \mathbf{1}'d / [d'd - (\mathbf{1}'d)^2 / n]^{1/2}$ .

## Data

We investigate cigarette consumption by men in the United States. The sample is drawn from the 1989–91 Continuing Survey of Food Intakes by Individuals (CSFII), conducted by the U.S. Department of Agriculture. The dependent variable is the number of cigarettes smoked per day. The explanatory variables include income, household size, body mass, education, and age. Also included are dummy variables indicating urbanization (city), region (Northeast, Midwest, South), race (black), ethnicity (Hispanic), self-evaluated health status, gender, and whether the individual was homeowner, or white-

collar worker. Price information is not available in the CSFII, and so is included in the constant terms. The final sample contains 4,064 men, of whom 1,264 (31.1 percent) reported smoking cigarettes. The mean number of cigarettes smoked per day is 6.47 for the full sample and 20.79 among the smokers. Detailed definitions and sample statistics for all variables are available from the author.

### **Estimation Results**

Heckman's and Tobit models are estimated by maximum-likelihood method. Based on the log-likelihood values, Vuong's standard normal statistic is calculated as  $z = 7.06$  ( $p\text{-value} < 0.0001$ ), rejecting the Tobit. Thus, social stigma and health concerns play important roles in cigarette consumption.

Table 1 presents parameter estimates of both models. Parameter estimates for Heckman's model suggest that Homeowner has significant and conflicting effects on participation and consumption. Conflicting effects of variables are typical in many sample selection models but are not allowed in Tobit.

### **Elasticities**

As the two models are parameterized differently, comparisons of parameter estimates are difficult between the models. The effects of explanatory variables are examined by decomposing the mean of the dependent variable and calculating elasticities of these components of the mean. For Heckman's model, the probability of consumption is

$$(15) \quad P(C > 0) = P(\eta > -z'\alpha) = \Phi(z'\alpha),$$

and the conditional mean of  $C$  is (Heckman 1979)

$$(16) \quad E(C|C > 0) = E(C|\eta > -z'\alpha) = x'\beta + E(u|\eta > -z'\alpha) = x'\beta + \rho\sigma \left[ \frac{\phi(z'\alpha)}{\Phi(z'\alpha)} \right].$$

Then, the unconditional mean is

$$(17) \quad E(C) = P(C > 0) E(C|C > 0),$$

using the expressions for the probabilities and conditional means above. The probability and mean expressions for the Tobit model are available in Maddala. To examine the effects of continuous variables, elasticities can be derived by differentiating (15)–(17).

Finally, for statistical inferences, standard errors of elasticities can be derived by first-order Taylor's series approximation.

The elasticities of probability, conditional level, and unconditional level with respect to continuous variables are calculated at the sample means of all independent variables and are presented in Table 2. Overall, the elasticities differ between the two models. The elasticities with respect to income are notably different. In particular, Heckman's model suggest that income has negative and significant effects on the conditional level (and therefore the unconditional level) of consumption, whereas the Tobit model suggests insignificance of income.

Judging from results of Heckman's model, our preferred model, body mass, education, and age have significant and negative effects on the probability of consumption. Higher educational attainment is also likely to enhance health awareness and, therefore, discourage smoking. The negative effect of age on probability likely reflects smoking activities among teenagers and younger adults. These results suggest that policy measures

directed toward raising income and education and programs directed toward youngsters will likely be very effective in reducing the size of the smoking population. Conditional on consumption, income and education decrease the level of cigarette smoking. Overall, judging from the elasticities of the unconditional level, income, body mass, education, and age all have significant and negative effects on the level of cigarette smoking, while household size has a positive effect. Most of these elasticities are quite small (less than unity). For instance, a one percent increase in educational attainment decreases the probability of smoking by 0.56 percent, the conditional level by 0.13 percent, and the unconditional level by 0.68 percent. The elasticity of unconditional level with respect to age is also relatively low, while the elasticities with respect to income and body mass are even lower.

Also presented in Table 2 are the effects of binary variables. For these discrete variables, we examine the changes in probability, conditional level, and unconditional level resulting from a finite change (i.e., from zero to one) in each variable. The effects of these discrete variables differ, notably so in some cases, between the two models. For instance, results of Heckman's model suggest that, relative to others, a black is 0.04% less likely to smoke cigarette, smoke 5.5 less cigarettes conditional on smoking and 1.7 less cigarettes unconditional on smoking. The corresponding results are 0.07, 1.4, and 1.6 based on the Tobit model.

## **Summary and Conclusions**

Unlike other food commodities, the consumption of health hazardous and socially stigmatic goods, is often the results of two different decisions: whether to consume and, if so, how much to consume. This is the premise of earlier empirical studies on cigarette smoking. We construct a theoretical model which allows investigation of the role of social stigma and health concerns on cigarette smoking. This theory provides a foundation for Heckman's sample selection model. We estimate and test this model against the restricted Tobit alternative, and find that the Tobit model is rejected.

One important implication of our findings is that social stigma and health concerns play important role in cigarette smoking. Thus, public policies against smoking in public facilities and the work place and educational campaigns that raise the health awareness of the public will be effective in preventing and reducing smoking activities. Programs directed toward the young and the poor will also help reduce the size of the smoking population.

Although we consider only cigarette smoking in our empirical application, the econometric models developed here are equally applicable in modeling demand for other food commodities in which health concerns may play a role. Possible applications might include consumption of alcohol, red meats, shell fish, raw meat/fish, and high-fat, high-cholesterol, and low-fiber products.

**Table 1. Maximum-Likelihood Estimates**

		Heckman's model					
		Participation eq.		Level eq.		Tobit model	
Variable	Definition	Param.	Std. err.	Param.	Std. err.	Param.	Std. err.
Constant		1.184 <sup>a</sup>	0.195	23.158 <sup>a</sup>	4.110	31.857 <sup>a</sup>	5.213
Income	Per-capita income (\$000)	−0.002	0.002	−0.108	0.053	−0.091	0.066
Household size	Number of household members	−0.006	0.014	0.229	0.307	−0.078	0.388
Body mass	(weight in kg) / (height in m) <sup>2</sup>	−0.019 <sup>a</sup>	0.005	−0.168	0.103	−0.440 <sup>a</sup>	0.131
Education	Years of formal education	−0.040 <sup>a</sup>	0.008	−0.791 <sup>a</sup>	0.176	−1.145 <sup>a</sup>	0.219
Age	Age in years	−0.010 <sup>a</sup>	0.001	−0.137 <sup>a</sup>	0.032	−0.270 <sup>a</sup>	0.039
City	Resides in city	−0.056	0.048	−1.447	1.109	−1.755	1.294
Northeast	Resides in the Northeast	0.133 <sup>b</sup>	0.067	4.037 <sup>a</sup>	1.426	4.212 <sup>b</sup>	1.808
Midwest	Resides in the Midwest	0.093	0.064	3.507 <sup>b</sup>	1.367	3.341 <sup>c</sup>	1.728
South	Resides in the South	0.253 <sup>a</sup>	0.059	6.900 <sup>a</sup>	1.263	7.679 <sup>a</sup>	1.602
Black	Individual is black	−0.125 <sup>c</sup>	0.072	−7.315 <sup>a</sup>	1.480	−5.461 <sup>a</sup>	1.931
Hispanic	Individual is Hispanic	−0.291 <sup>a</sup>	0.082	−11.401 <sup>a</sup>	1.715	−10.710 <sup>a</sup>	2.215
Homeowner	Individual is a homeowner	−0.214 <sup>a</sup>	0.048	2.992 <sup>a</sup>	1.000	−5.507 <sup>a</sup>	1.290
Health	Health is fair or better	−0.193 <sup>a</sup>	0.061	−4.803 <sup>a</sup>	1.253	−5.810 <sup>a</sup>	1.617
White collar	Indiv. is white collar worker	−0.197 <sup>a</sup>	0.058	−2.758 <sup>b</sup>	1.243	−5.072 <sup>a</sup>	1.562
σ				20.181 <sup>a</sup>	0.629	28.285 <sup>a</sup>	0.658
ρ				0.961	0.006		
Log-likelihood		−7234.107				−7370.483	

<sup>a</sup> Significant at 1% level.<sup>b</sup> Significant at 5% level.<sup>c</sup> Significant at 10% level.

**Table 2. Effects of Explanatory Variables**

Variable	Heckman's model			Tobit model		
	Prob- ability	Cond. level	Uncond. level	Prob- ability	Cond. level	Uncond. level
Elasticities with respect to Continuous variables						
Income	−0.024 (0.032)	−0.046 <sup>b</sup> (0.019)	−0.070 <sup>c</sup> (0.040)	−0.041 (0.030)	−0.015 (0.011)	−0.057 (0.041)
Household size	−0.021 (0.050)	0.046 (0.030)	0.025 (0.061)	−0.009 (0.047)	0.003 (0.017)	−0.013 (0.064)
Body mass	−0.562 <sup>a</sup> (0.146)	0.126 (0.084)	−0.436 <sup>b</sup> (0.177)	−0.455 <sup>a</sup> (0.135)	−0.168 <sup>a</sup> (0.050)	−0.624 <sup>a</sup> (0.185)
Education	−0.557 <sup>a</sup> (0.112)	−0.127 <sup>b</sup> (0.070)	−0.684 <sup>a</sup> (0.138)	−0.548 <sup>a</sup> (0.105)	−0.203 <sup>a</sup> (0.039)	−0.751 <sup>a</sup> (0.144)
Age	−0.511 <sup>a</sup> (0.075)	0.006 (0.046)	−0.505 <sup>a</sup> (0.093)	−0.485 <sup>a</sup> (0.070)	−0.180 <sup>a</sup> (0.026)	−0.665 <sup>a</sup> (0.096)
Effects of discrete variables						
City	−0.019	−0.644	−0.196	−0.022	−0.470	−0.538
Northeast	0.044	2.104	0.532	0.050	1.083	1.195
Midwest	0.031	2.149	0.543	0.040	0.851	0.930
South	0.087	3.277	0.828	0.095	2.051	2.344
Black	−0.042	−5.506	−1.673	−0.065	−1.407	−1.557
Hispanic	−0.094	−7.143	−2.198	−0.122	−2.633	−2.776
Homeowner	−0.075	0.035	0.012	−0.070	−1.514	−1.775
Health	−0.069	−2.097	−0.753	−0.075	−1.640	−1.965
White collar	−0.067	0.083	0.026	−0.062	−1.335	−1.507

<sup>a</sup> Significant at the 1% level.<sup>b</sup> Significant at the 5% level<sup>c</sup> Significant at the 10% level.

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